Tacoma Water
Habitat Conservation Plan

Green River Water Supply Operations and Watershed Protection

VOLUME 1 of 2

Final - July 2001

TACOMA WATER

TACOMA PUBLIC UTILITIES

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Tacoma Water
Habitat Conservation Plan
Green River Water Supply Operations and Watershed Protection

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FINAL HCP

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ABBREVIATIONS AND ACRONYMS

ac-ft	acre-feet
AWS project	Additional Water Storage Project
BRT	Biological Review Team
cfs	cubic feet per second
CWT	coded-wire tags
dbh	diameter at breast height
DEIS	Draft Environmental Impact Statement
DFR	Draft Feasibility Report
DO	Dissolved Oxygen
DPS	Distinct Population Segment
Ecology	Washington Department of Ecology
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FDWRC	First Diversion Water Right Claim
fps	feet per second
FPTC	Fish Passage Technical Committee
FTU	Fahrenheit Temperature Units
GIS	Geographic Information Systems
GRFMC	Green River Flow Management Committee
GSI	Genetic Stock Inventory
HCM	Habitat Conservation Measure
HCP	Habitat Conservation Plan
Headworks	Tacoma Water Supply Intake at RM 61.0
HHD	Howard Hanson Dam
HPA	Hydraulic Project Approval
IA	Implementing Agreement
IFIM	Instream Flow Incremental Methodology
IHA	Index of Hydrologic Alteration
IRPP	Instream Resource Protection Program
ITP	Incidental Take Permit
LWD	Large Woody Debris
mgd	million gallons per day
MIT	Muckleshoot Indian Tribe

M&I	Municipal and Industrial
MSL	Mean Sea Level
MWMU	Mass Wasting Mapping Units
NAQWA	National Water Quality Assessment Program
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRF	nesting-roosting-foraging
NTU	Nephelometric Turbidity Units
P1	Pipeline No. 1
P5	Pipeline No. 5
PED	Pre-construction Engineering and Design
PHABSIM	Physical Habitat Simulation
PIT	passive integrated transponder
PSG	Pacific Seabird Group
RFM	Research Funding Measure
RM	River Mile
RMZ	Riparian Management Zone
ROI	Region of Impact
RSRP	Road Sediment Reduction Plan
SDWR	Second Diversion Water Right
Services	USFWS and NMFS
SNOTEL	Snowpack Telemetry
SSP	Second Supply Project
Tacoma	Tacoma Water
TL	total length
UMA	Upland Management Areas
USACE	U. S. Army Corps of Engineers
USFWS	U. S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
Ecology	Washington State Department of Ecology
WAC	Washington Administrative Code
WAU	Watershed Administrative Units
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WFPB	Washington State Forest Practice Board
WRIA	Water Resource Inventory Area
WWTIT	Western Washington Treaty Indian Tribes

STANDARD RIVER MILES

Location	River Mile
Upstream extent of estuary	RM 11.0
Lower Green River (lower end)	RM 11.0
Mill Creek confluence	RM 24.2
Green River near Auburn USGS gage	RM 32.0
Mueller Levee - Auburn Narrows	RM 32.9
Big Soos Creek confluence	RM 33.8
Lower Green River (upper end)	RM 33.8
Middle Green River (lower end)	RM 33.8
Active side channel area	RM 34.0-46.0
Newaukum Creek confluence	RM 41.2
Flaming Geyser State Park	RM 42.9-45.0
Green River Gorge – lower end	RM 45.6
Green River Gorge – upper end	RM 58.0
Signani Slough	RM 59.6
Site of Proposed Fish Restoration Facility	RM 60.1
Green River near Palmer USGS gage	RM 60.3
Tacoma Water Headworks	RM 61.0
Middle Green River (upper end)	RM 61.0
Upper Green River (lower end)	RM 61.0
Upstream inundation of headworks pool	RM 61.5
Howard Hanson Dam (HHD)	RM 64.5
North Fork Green River confluence	RM 65.5
Smay Creek confluence	RM 76.8
Friday Creek confluence	RM 83.9
Sunday Creek confluence	RM 86.2

Note: The landmark for boundary between Lower and Middle Green River is the Highway 18 bridge; for the boundary between the Middle and Upper Green River it is the Tacoma Water Headworks. The Duwamish River (below RM 11.0) will, in general, be considered the downstream boundary of the Lower Green River reach.

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ENDANGERED SPECIES ACT TERMS AND DEFINITIONS

The following terms and definitions may be helpful to you as you read Tacoma Water's Habitat Conservation Plan, and other publications about the Endangered Species Act.

Species

Any subspecies of fish, wildlife or plants, and any distinct population segment of any species or vertebrate fish or wildlife that interbreeds when mature.

Endangered Species

Any species in danger of extinction throughout all or a significant portion of its range. An exception to this rule is made for species of the Class *Insecta* if the Secretary of Interior (for U.S. Fish and Wildlife Service) or Commerce (for the National Marine Fisheries Service) determines the species is a pest whose protection under the provisions of the Endangered Species Act would present an overwhelming and overriding risk to man.

Threatened Species

Any species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Candidate Species

Any species under consideration by the Secretary of either Interior or Commerce for listing as an endangered or threatened species, but not yet the subject of a proposed rule. There are no substantive protections provided under the Endangered Species Act for candidate species. The designation serves to underscore National Marine Fisheries Service or U.S. Fish and Wildlife Service concern regarding the status of such species, short of listing.

Species of Concern

Species whose conservation standing is of concern to either the U.S. Fish and Wildlife Service or the National Marine Fisheries Service, but for which status information is incomplete.

Critical Habitat

The specific area with physical or biological features that are essential to the conservation of the species.

Section 4

The section of the Endangered Species Act that outlines procedures for (1) identifying and listing threatened and endangered species, (2) identifying, designating and revising critical habitat, (3) developing and revising recovery plans and (4) monitoring species removed from the list of threatened and endangered species.

Section 7

The section of the Endangered Species Act that outlines procedures for interagency cooperation to conserve federally listed species and critical habitat.

Section 9

The section of the Endangered Species Act that prohibits taking endangered fish and wildlife as well as most threatened fish and wildlife species. Additional prohibitions include import or export of endangered species or products made from endangered species, interstate or foreign commerce in listed species or their products, and possession of unlawfully taken endangered species.

Section 10

The section of the Endangered Species Act that provides exceptions to the section 9 prohibitions.

Take

To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect endangered or threatened species, or to attempt to engage in any such conduct.

Harm

Significant habitat modification or destruction that kills or injures listed wildlife by significantly impairing essential behavior patterns including breeding, feeding and sheltering.

Jeopardize

To engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers or distribution of that species.

Incidental Take

The take of a listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a federal agency or applicant.

Incidental Take Permit (ITP)

A permit issued by either the U.S. Fish and Wildlife Service or the National Marine Fisheries Service that allows an applicant to take listed species incidental to otherwise lawful activities, and in accordance with an agreed upon and signed Habitat Conservation Plan.

Habitat Conservation Plan (HCP)

A conservation plan for a threatened or endangered species, developed in conjunction with the National Marine Fisheries Service or the U.S. Fish and Wildlife Service. It is required for an incidental take permit.

Implementing Agreement (IA)

A bilateral contract that defines the terms of the Habitat Conservation Plan, including conservation, mitigation, monitoring and enforcement. An Implementing Agreement usually accompanies the Habitat Conservation Plan and is signed by all parties.

Biological Assessment (BA)

Information prepared on major construction activities by, or under the direction of, a federal agency to determine whether a proposed federal action is likely to adversely affect listed or proposed species, or designated or proposed critical habitat.

Biological Opinion (BO)

A document stating the opinion of the U.S. Fish and Wildlife Service or National Marine Fisheries Service on whether or not a federal action is likely to jeopardize the continued existence of a listed species, or result in the destruction or adverse modification of critical habitat.

These terms and definitions were compiled by Michael Grady of the National Marine Fisheries Service, Paul Hickey of Tacoma Water and Tim Romanski of the U.S. Fish & Wildlife Service.

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CONTENTS

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1. Executive Summary

Tacoma Water's Green River Habitat Conservation Plan

Tacoma has relied on the Green River as its primary source of water supply since 1913. It is contemplated that this reliance on the Green River will not only continue into the foreseeable future, but will also be increased with the construction of Tacoma's Second Supply Project, a major regional water supply project. The supply of water to 300,000 people places a strain on the natural environment associated with the Green River source of water supply. A forecast of continued growth in this region further complicates water supply versus natural resource protection issues. The Tacoma Water utility has listened and does care about the costs, negative effects, and hardships that our efforts to meet our responsibilities for water supply may cause in relation to natural resource preservation. This Habitat Conservation Plan puts forth the best program that Tacoma could develop to satisfy both water supply concerns and to protect the natural resources of the Green River system in the future.

Tacoma has pursued a number of projects, now known collectively as the Second Supply Project, because it involves the second supply pipeline from the Green River to Tacoma, for more than 20 years. Efforts by Tacoma to design and permit this project have recognized the importance of associated environmental considerations. The recent listing of Puget Sound chinook salmon and bull trout as threatened under the Endangered Species Act adds further weight to the environmental concerns associated with water supply operations. Tacoma Water and its project partners, whose primary mission is to protect public health and provide for the water supply needs of an expanding population in the Puget Sound area, now find themselves in a position where both future water supply and environmental protection must be considered in their actions.

Tacoma Water has taken the lead in the development of the Second Supply Project since its inception. As the largest utility in Pierce County, with both direct and wholesale services outside of the city limits of Tacoma and outside of Pierce County, Tacoma Water is an appropriate agency to lead the development of the Second Supply Project. Given Tacoma's mission to provide for future water supply for its existing and future customers, it would be irresponsible for Tacoma Water not to address these water supply and environmental preservation issues.

The growth projections for Pierce and South King Counties indicate that existing water utilities in those counties will be unable to meet future water demands with the current sources of supply available to them. This water supply shortage situation is most critical for the City of Kent, Lakehaven Utility District and Covington Water District. In addition, outlying communities served by the City of Seattle need additional water and the City of Tacoma and potential wholesale customers of Tacoma in Pierce County will require additional water in the future.

Throughout its efforts to design and permit the various elements of the Second Supply Project, Tacoma has attempted to address environmental issues associated with water supply development. The listings of Puget Sound chinook salmon and bull trout raised this recognition of environmental issues to a high level and resulted in the decision by Tacoma to implement a Habitat Conservation Plan for all Green River operations of its utility. It is believed that the development of a Habitat Conservation Plan superimposed upon the other permitting processes that Tacoma has participated in while resolving the issues associated with its operations on the Green River, provides a reasonable, sensible and responsible approach to addressing the dual responsibilities of water supply and environmental protection.

When Tacoma Water began diverting water from the Green River in 1913, its sole objective was to provide pure, clean, potable water to the citizens of Tacoma. At that time the City took early steps to protect water quality in the interest of protecting the public health of the citizens it served. These steps included limiting human access to portions of the watershed and acquiring land adjacent to the Green River and its major tributaries. At the time Tacoma also thought it necessary to limit fish access to the upper watershed to protect public health. This action reduced fish production in the basin, but at the same time attempts were made to make up the loss with the best tools available at the time – fish production from hatcheries. In retrospect, it is unfortunate that protection of public health and water quality also resulted in blocking access to up to 66 linear miles of quality stream habitat in the Upper Green River watershed.

Since 1974, Tacoma has been required to comply with the provisions of the federal Safe Drinking Water Act. The Act requires that unfiltered water systems, such as Tacoma’s, develop a Watershed Management Plan to protect water quality by controlling access to the watershed. This has the added benefit of protecting the watershed from human activities. Under this program, the City has developed agreements with landowners in the watershed upstream of Tacoma’s diversion dam to protect water quality. Tacoma has developed a Forest Land Management Program, which emphasizes the protection of water quality and natural systems. Although these efforts significantly improved the protection of the watershed and water quality in the interest of protecting public health, access to the upper watershed by anadromous fish remains blocked at the diversion dam.

During the 1980s and 1990s, a greater knowledge of disease transmission potential from fish began to reduce concerns regarding the public health impact of fish above Tacoma's diversion. In addition, a greater knowledge of fishery needs and requirements brought to the forefront the value of the contribution upper watershed habitat provides the Green River. Extensive scientific studies during the 1980s and 1990s, conducted by the City in pursuit of the Second Supply Project and the Additional Water Storage Project at Howard Hanson Dam, and an agreement with the Muckleshoot Indian Tribe, further supplemented the formidable body of data regarding Green River fisheries and potential approaches to its restoration and enhancement.

Since 1913, Tacoma has been the beneficiary of water from the Green River, both from the standpoint of protecting the health of the citizens of Tacoma and from the economic benefit which use of the water has brought to the City. Now the City is required by the Endangered Species Act and by the expectations of its customers to make a major commitment to contributing to the effort to reverse the trend of Puget Sound salmon stocks toward extinction by minimizing the effects of its actions on the ecosystem. Tacoma Water has a substantial arsenal of resources and knowledge at its disposal in making this contribution to fish and wildlife species.

- Tacoma owns approximately 10 percent of the Upper Green River watershed upstream of its diversion, with the ownership located in the valley floor and adjacent uplands around the mainstem and its major tributaries.
- The City has a substantial knowledge base of conditions in the Green River watershed as a result of studies pertaining to the Second Supply Project and the Howard Hanson Dam Additional Water Storage Project.
- Development of an agreement with the Muckleshoot Indian Tribe enhanced knowledge of the Green River fisheries and included major commitments by Tacoma to protection of that resource.
- Tacoma's Forest Land Management Plan emphasizes the protection of water quality and natural systems in the upper watershed.
- Agreements with landowners upstream of Tacoma's diversion provide supplemental protection to water quality in addition to that required by state law and regulations.

As a result of Tacoma's history on the Green River, as well as its plans for future use and its commitment to future protection of the upper watershed, Tacoma made the decision to pursue a Habitat Conservation Plan for its Green River operations. This Habitat Conservation Plan is a significant commitment to the restoration and rehabilitation of Green River fisheries. It is recognized that the use of the Green River for public water supply comes at a cost. It is the goal of this Habitat Conservation Plan to avoid adverse impacts where possible and to minimize and mitigate them where avoidance is not possible.

Tacoma's Habitat Conservation Plan was very difficult to develop because it required careful coordination between two major operating entities. The U.S. Army Corps of Engineers' facility at Howard Hanson Dam and Tacoma's diversion create fisheries impacts that can be addressed effectively only by working in a coordinated manner. This situation is further complicated by Endangered Species Act requirements that differ for Tacoma's and the U.S. Army Corps of Engineers' facilities. As a non-federal entity, Tacoma developed its Habitat Conservation Plan under the provisions of Section 10 of the Endangered Species Act. As a federal agency, the U.S. Army Corps of Engineers entered consultation with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service (Services) under Section 7 of the Act. Sections 7 and 10 have differing requirements, time horizons, and expectations for those who operate under their provisions. Resolution of coordination issues has been and will remain one of the major challenges to implementing the Endangered Species Act in the upper Green River basin.

The Plan relies on well-coordinated actions by Tacoma and the U.S. Army Corps of Engineers to address major fisheries issues. In addition, a number of habitat conservation measures also address potential impacts of Tacoma's land management operations on terrestrial species in the Upper Green River basin. Although not the primary focus of this habitat conservation planning effort, listed terrestrial species either are or may become present in the Upper Green River basin. Potential impacts to these species have been addressed separate from water storage and withdrawal.

As stated previously, the central aspect of this Habitat Conservation Plan is a coordinated effort, which relies on actions by Tacoma and U.S. Army Corps of Engineers to address major fisheries issues. Key issues include:

- Upstream fish passage around Tacoma's water diversion and U.S. Army Corps of Engineer's Howard Hanson Dam.

- Downstream fish passage through Howard Hanson Dam and past Tacoma's water diversion.
- Reintroduction of large woody debris downstream of Tacoma's diversion.
- Reintroduction of spawning gravels below Howard Hanson Dam.
- Fish habitat restoration both above Howard Hanson Dam and below Tacoma's diversion.
- Wildlife habitat conservation measures on Tacoma's lands in the upper watershed.
- Flow issues including minimum instream flows, storage of water for fisheries releases, and increased regulation of Tacoma's diversion for fisheries protection.

Upstream fish passage issues will be addressed by the development of a trap-and-haul facility at Tacoma's diversion dam. Some may argue that laddering the diversion dam and Howard Hanson Dam is a more natural method for providing upstream fish passage. However, the extreme difficulty of laddering Howard Hanson Dam has caused federal, state, and Tribal fisheries representatives to agree that the trap-and-haul facility is the best approach to restoring anadromy in the upper Green River watershed.

The facility itself will include water-to-water transfer of fish from a trap at the top of the diversion dam to transport trucks for release into the Green River upstream of Howard Hanson Dam. Fish sorting and laboratory facilities will be provided to support fish passage and transport activities.

The downstream fish passage facility at Howard Hanson Dam will be the single most expensive improvement to Green River fisheries associated with this Habitat Conservation Plan. Major problems with downstream fish passage at many dams include intake structures for fish that are located deeper than fish are accustomed to sounding, or too little water spilled over the top where fish tend to migrate. Hydroelectric dams have the additional problem of entraining fish into turbines. Howard Hanson Dam does not have turbines because it is not a hydroelectric dam; however, it currently traps fish behind the dam in the spring as water is stored for augmenting low river flows during the summer.

The downstream fish passage facility at Howard Hanson Dam is designed to collect fish near the surface of the water at all pool elevations by passing half or more of the water through a surface outlet designed to attract and pass fish. Downstream fish passage at

Tacoma's diversion will be assisted by the installation of fish screens and other improvements to the diversion dam itself.

The absence of large woody debris downstream of Howard Hanson Dam is a concern from two standpoints. First, woody debris provides cover to fish in the river. Second, the decay of woody debris provides nutrients and shelter for insects and lower-order animals, which serve as food for various fish species. Under this Habitat Conservation Plan, woody debris from the upper watershed will be collected in the reservoir and transported around Howard Hanson Dam and Tacoma's diversion, and either released into the river to find its own resting place, or anchored at desired locations.

Since its construction, Howard Hanson Dam has blocked the normal downstream movement of gravel from the upper Green River into the river below the dam. This has resulted in a gradual armoring of the riverbed that has worked its way downstream from Howard Hanson Dam as high winter flows carry gravels originating downstream of Howard Hanson Dam even farther downstream. This has reduced the areas available to salmon for spawning. Under the Habitat Conservation Plan, gravel will be placed within the floodplain during low flow conditions so that high winter flows can transport the gravel into the river to take the place of the gravels trapped behind Howard Hanson Dam. This effort should help arrest the loss of spawning gravels and begin to replace gravel in areas suitable for spawning.

Fish habitat restoration projects in the Green River watershed will be implemented in collaboration with the U.S. Army Corps of Engineers. One of the most valuable efforts may be the restoration of side channel habitats in the middle river to provide juvenile rearing areas during periods of high flow. Two areas have been identified where historical side channels can be reconnected with the river. In addition, Tacoma and the U.S. Army Corps of Engineers have conducted multiple years of studies of side-channel reaction to variations in flow and the use of side channels by salmonid species. This information will be used to identify the most productive side-channel habitat reconnection projects. In addition, habitat improvements will be implemented in the river itself both above Howard Hanson Dam and in the vicinity of Tacoma's diversion pool. These improvements primarily include placement of large woody debris and boulders.

Wildlife habitat conservation measures in the upper Green River watershed address several areas of concern – upland forest management, riparian management, road construction and maintenance, and specific wildlife habitat management. The Plan sets aside 39 percent of Tacoma's ownership in a natural reserve lying closest to the Green River where no active forest management will take place. Another 35 percent is designated to accelerate development of late seral forest habitat, and 26 percent is dedicated to sustainable timber production. In addition to the natural reserve, riparian buffers will be left in a natural state along all streams to maintain water quality and provide habitat. Road construction and maintenance measures are designed to minimize their impact on the environment and to keep the miles of roads on Tacoma's land at a minimum. The Plan seeks coverage of 32 fish and wildlife species for their incidental take during Tacoma's covered activities for 50 years. The Plan spells out 24 measures to protect 14 specific wildlife species' dens, nests, and foraging areas.

Tacoma Water's mission as a public water supply utility causes stream flow issues to be the most significant aspect of this Habitat Conservation Plan. Tacoma will voluntarily reduce its First Diversion Water Right claim from the 400-cfs claim established in 1912 to the currently developed water withdrawal of 113 cfs. Tacoma will also amend its water rights to incorporate the higher instream flows previously agreed to with the Muckleshoot Indian Tribe in a 1995 settlement agreement. Tacoma will provide funding support for a project at Howard Hanson Dam to store 5,000 acre-feet of water for stream flow augmentation during summer months. Tacoma will contract with the U.S. Army Corps of Engineers to support augmented flow releases from Howard Hanson Dam during low flow periods by reducing Tacoma's use of surface water during years when fall rains do not arrive when normally expected. This battery of actions is the result of more than 15 years of discussions with federal, state and local resource agencies, and the Muckleshoot Indian Tribe, to determine how Tacoma's operations on the Green River could best be carried out with minimal adverse impact on Green River fisheries.

Monitoring all of the habitat conservation measures to assure the Services and public that Tacoma is fulfilling its commitments is another important component of this Habitat Conservation Plan. Monitoring will be carried out most intensively during the first 10 years of the Plan, but will continue throughout the full 50-year duration of the Habitat Conservation Plan.

Tacoma Water's Habitat Conservation Plan will be funded primarily by revenues from water users. Existing ratepayers, future ratepayers, and Tacoma's partners in the Second Supply Project will all pay a share of the cost of implementing the Plan. Tacoma will seek federal participation at a substantial level based upon the U.S. Army Corps of Engineers' responsibilities under the Endangered Species Act that result from construction and operation of Howard Hanson Dam. Other grants or sources of revenue will be pursued as available in an attempt to lessen the impact of this effort on ratepayers.

Tacoma has assembled a package of habitat conservation measures that takes advantage of the shared reliance both the water utility and fish have on high quality water and watershed protection. In addition, Tacoma seeks to offset the impacts of water diversion. Tacoma has attempted to respond to concerns expressed by the federal Services, the Muckleshoot Indian Tribe, state resource agencies, and the public in the preparation of this Habitat Conservation Plan. It is recognized that not everyone will be completely satisfied by the package provided here. Consequently, Tacoma will continue to identify the costs, impacts and hardships that the operation of the utility may cause on other groups and interests. It will seek to resolve issues as they arise throughout implementation of the plan.

Tacoma Water relies on the conjunctive use of surface and groundwater supplies to meet the current water demands of its customers. A diversion on the Green River supplies approximately 85 percent of Tacoma Water's annual demand, and groundwater sources supply the remaining 15 percent. Over two decades ago, Tacoma Water recognized that a municipal water shortage would eventually impact the people who live and work in the City of Tacoma, Pierce County, and South King County. The utility responded by developing a long-range plan to acquire the additional water supplies it believed would be needed to meet the forecasted water demands of the region's expanding population.

After studying a range of surface and groundwater source alternatives, including water conservation and reuse, Tacoma Water concluded that the two most feasible options for future additional water supplies were the Second Supply Pipeline and the Howard Hanson Additional Water Storage Project.

Tacoma Water's Habitat Conservation Plan was developed to describe to the National Marine Fisheries Service and U.S. Fish and Wildlife Service how the water utility proposes to operate its Green River municipal water supply system in a manner that is consistent with the requirements of the federal Endangered Species Act. The Plan discusses the operation of the existing Headworks facility, as well as the proposed Second Supply and Additional Water Storage Projects.

The Plan contains both aquatic and terrestrial habitat conservation measures. It attempts to balance the habitat needs of the fish and wildlife species affected by Tacoma's water supply operations with the municipal water needs of the human population in Tacoma, Pierce County, and South King County.

The Plan is organized into eleven chapters and six appendices. Chapters 1 and 2 contain the Executive Summary and Introduction, respectively. Chapter 3 discusses the

Endangered Species Act with an emphasis on how it pertains to Tacoma Water's municipal water supply operations in the Green River watershed. This chapter also discusses Habitat Conservation Plans, the Incidental Take Permit, and other federal and state regulations addressed in the Habitat Conservation Plan.

The existing physical and biological conditions of the Green River basin are discussed in Chapter 4, along with the engineered infrastructure and operations, such as Howard Hanson Dam, that affects or is affected by Tacoma Water's Plan.

The 64 habitat conservation measures that Tacoma Water is committing to implement over the 50-year duration of its Habitat Conservation Plan are described in Chapter 5. Each commitment is inscribed within a box to indicate that it is a commitment. Immediately following each conservation measure, the rationale and ecosystem benefits of the measure are provided to explain to the reader why the measure is in the Plan, and how it will be funded.

Chapter 6 describes how Tacoma Water will monitor its commitment to implement each of the 64 habitat conservation measures described in Chapter 5. The monitoring program is divided into compliance and effectiveness monitoring, and a research effort that will provide funding to investigate downstream fish passage through Howard Hanson Reservoir, the fish outmigration passage facility, flow management, and the distribution and abundance of sediment and woody debris in the middle Green River.

The combined impacts of Tacoma Water's First Diversion Water Right claim, Second Diversion Water Right, and the Howard Hanson Additional Water Storage Project on the fish and wildlife species covered by this Habitat Conservation Plan are analyzed in Chapter 7. Discussion of the impacts on fish is organized by species, life stage, and lower, middle and upper watershed.

Chapter 8 discusses how Tacoma Water intends to fund implementation of the Habitat Conservation Plan. It provides estimated costs for the habitat conservation measures, as well as costs for the monitoring and research components. It also identifies the separation of funding responsibilities between Tacoma Water and the U.S. Army Corps of Engineers for those measures in the Plan that are components of the Howard Hanson Additional Water Storage Project.

Alternatives to both water withdrawal and management of Tacoma's lands in the upper Green River watershed are discussed in Chapter 9. The water withdrawal alternatives includes one that would divert most of Tacoma's water right from the Green River in the vicinity of Auburn (River Mile 29.2) rather than from the existing diversion at Palmer (River Mile 61.0). Another would remove the existing diversion dam altogether; three reduced-withdrawal alternatives examine limiting sales of water to Tacoma Water's wholesale customers. Under the alternatives that examine Tacoma Water's proposed land management in the upper watershed are a "no timber harvest" alternative and an alternative that would allow timber harvesting only for the purpose of creating or enhancing fish and wildlife habitat.

Following Chapters 10 (Literature Cited) and 11 (HCP Document Preparers) are six appendices: the life histories of the fish and wildlife species discussed in the Plan; excerpts from the 1995 agreement between the Muckleshoot Indian Tribe and City of Tacoma; excerpts from Tacoma's 1998 draft comprehensive water plan update; road surface erosion and hydrology prescriptions from the Lester Watershed Analysis; a memo describing Tacoma's response to six principles of project operation requested by natural resource agencies; and the legal description of lands owned by Tacoma and proposed for coverage under the Incidental Take Permit.

The elements contained within this Habitat Conservation Plan are the product of more than two decades of intense discussions with federal, state, and local resource agencies, as well as a decade of discussions with the Muckleshoot Indian Tribe. Diligent water resource planning, and numerous fisheries and habitat studies in the Green River basin were conducted with the intent of designing a municipal water supply project that addresses important natural resource needs as well as the water supply needs of a growing population.

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2. Introduction

2.1 Background

The City of Tacoma has delivered water from the Green River to its citizens and the surrounding region since 1913. Introduction of uncontaminated water from the Cascade Mountains brought an immediate reduction in the incidence of illness from waterborne diseases such as typhoid fever. Almost a century later, Tacoma and South Puget Sound must meet the demands for drinking and other water uses, while protecting and restoring a very important resource – our fish and wildlife populations. Tacoma Water (Tacoma) currently diverts up to 113 cubic feet per second (cfs) from the Green River for municipal and industrial water supplied to the City of Tacoma and surrounding communities. Tacoma plans to continue to exercise its First Diversion Water Right Claim (FDWRC) of up to 113 cfs, exercise a Second Diversion Water Right (SDWR) of up to 100 cfs, and make a number of needed improvements to the Headworks diversion facility.

Tacoma's water supply project affects anadromous fish on the Green River by interfering with passage at the Headworks diversion located at River Mile (RM) 61.0, and reducing instream flows in the river below the diversion. Tacoma has worked extensively in partnership with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Washington State Department of Fish and Wildlife (WDFW), the Washington State Department of Ecology (Ecology), and the Muckleshoot Indian Tribe (MIT) over the past several years to develop mitigation for the effects of the project on fish. Plans are already in place or under development to address fish passage and downstream flow augmentation.

The recent listing of Puget Sound chinook salmon (*Oncorhynchus tshawytscha)* stocks and Puget Sound bull trout (*Salvelinus confluentus)*, and imminent listings of other fish species under the Endangered Species Act (ESA) have created the need for Tacoma to seek an Incidental Take Permit (ITP) under Section 10(a) of the ESA. The ITP will allow Tacoma to operate its water supply operations in a lawful manner without threat of prosecution for any take that may occur to species covered by the ITP. In support of its application for an ITP in conformance with Section 10(a)(2)(A) of the ESA, Tacoma has prepared a multispecies Habitat Conservation Plan (HCP) to address fish and wildlife and water supply needs in compliance with the ESA (16 U.S.C. 1531 *et. seq*.). The plan covers the areas of the Green River affected by operation of Tacoma's water diversion and 14,888 acres of land Tacoma owns in the upper watershed.

An HCP is a long-term management plan authorized under the ESA to conserve threatened and endangered species. Section 10 of the ESA authorizes a landowner to negotiate a conservation plan to minimize and mitigate any impact to threatened and endangered species while conducting lawful activities such as supplying water to South Puget Sound residents.

This HCP is just one of many efforts being undertaken to support the conservation and recovery of fish and wildlife in the Green River watershed. This HCP will complement ongoing and future efforts by the MIT, King County, the U.S. Army Corps of Engineers (USACE), federal and state resource agencies, and private groups to protect our natural resources for future generations. Tacoma pursues this HCP in a spirit of partnership. We seek to develop a scientifically sound long-term public resource management plan that benefits people, fish and wildlife well into the 21st century.

2.2 Purpose and Need for the Habitat Conservation Plan

The listing of Puget Sound chinook salmon as threatened under the ESA affects the Green River, the City of Tacoma’s primary source of water for residents and industries in Tacoma, as well as portions of Pierce and King Counties. Continued withdrawal of water from the Green River could potentially lead to a “take” of listed salmon, as the term is defined under the ESA. Conversely, avoiding the risk of take could ultimately cause Tacoma to limit or cease water withdrawals from the Green River, thereby having a significant impact on the water users currently served by Tacoma. Securing an ITP for the chinook salmon for its water supply system through Section 10 of the ESA will ensure a continued, uninterrupted supply of water for Tacoma’s customers and benefit the fishery resource.

The HCP addresses a number of other listed and unlisted fish and wildlife species. While protection of these species do not currently constrain the operations of the project, the potential for future ESA listings and/or range expansions into the project area by those species that are already listed pose the threat of conflicts with project operations in the future. Given the costs of developing and maintaining the water supply project (including the proposed improvements to mitigate fish impacts) and the importance of assuring an uninterrupted water supply to Tacoma’s customers over the long term, it is essential that Tacoma receive assurances from the USFWS and NMFS that current and future listings under the ESA for species adequately covered by this HCP will not interrupt water withdrawal from the Green River. Tacoma considers implementation of an HCP and issuance of an ITP for listed species to be the most effective means of reconciling Tacoma's water supply operations with prohibitions against take under the ESA.

This HCP has been submitted to the NMFS and the USFWS (Services) for review. The MIT, the state of Washington, and King County have also been part of the review process. The federal agencies will prepare a Biological Opinion (BO) and Section 10 findings based on an analysis of the HCP to determine whether it complies with the ESA of 1973, as amended. If the permits are issued, they will allow the incidental take of species affected by Tacoma's water supply operations and related activities. Tacoma will implement the HCP to minimize and mitigate the impacts of any incidental take to the maximum extent practicable.

2.3 Overview of the Green River Basin and Tacoma's Water Supply Operations

2.3.1 Overview of the Green River Basin

The Green River basin is located in the southern portion of King County, Washington, and drains an area of 483 square miles (Figure 2-1). The Green River flows for 75 miles west and north from the Cascade Mountains to join with the Black River to form the Duwamish River. The Duwamish River then empties into Puget Sound 12 miles downstream at Elliott Bay. For the purposes of this HCP, the river has been divided into three reaches with associated subbasins. The upper Green River extends from the headwaters to the Tacoma water supply intake at RM 61.0 (Headworks), which is 3.5 miles downstream of Howard Hanson Dam (HHD) (Figure 2-2). The middle Green River is located between the Tacoma Headworks and the confluence with Big Soos Creek near Auburn at RM 33.8 (Figure 2-3). The lower Green River continues from RM 33.8 to RM 11.0, which is the upstream extent of the river's estuary (Figure 2-3). The tidally influenced river below RM 11.0 is often referred to as the Duwamish River or Duwamish Waterway.

The Green River is a valuable economic, cultural, recreational, and ecological resource that supports a diversity of uses. The MIT is a federally recognized Indian tribe that has rights and responsibilities for co-management with the WDFW of fish, wildlife, and other natural resources of the Green/Duwamish River system.

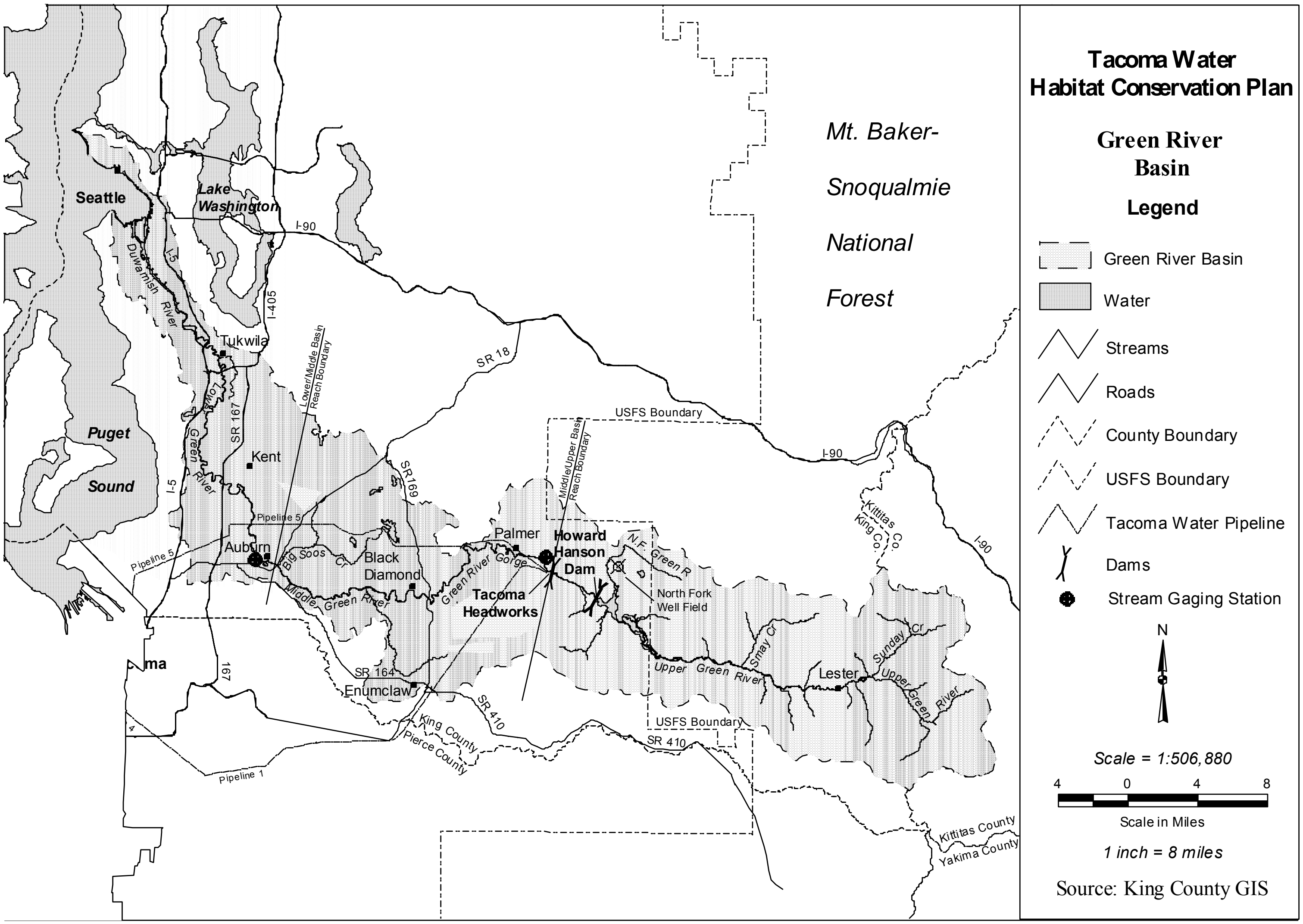

Figure 2-1. Map of Green River basin and surrounding area.

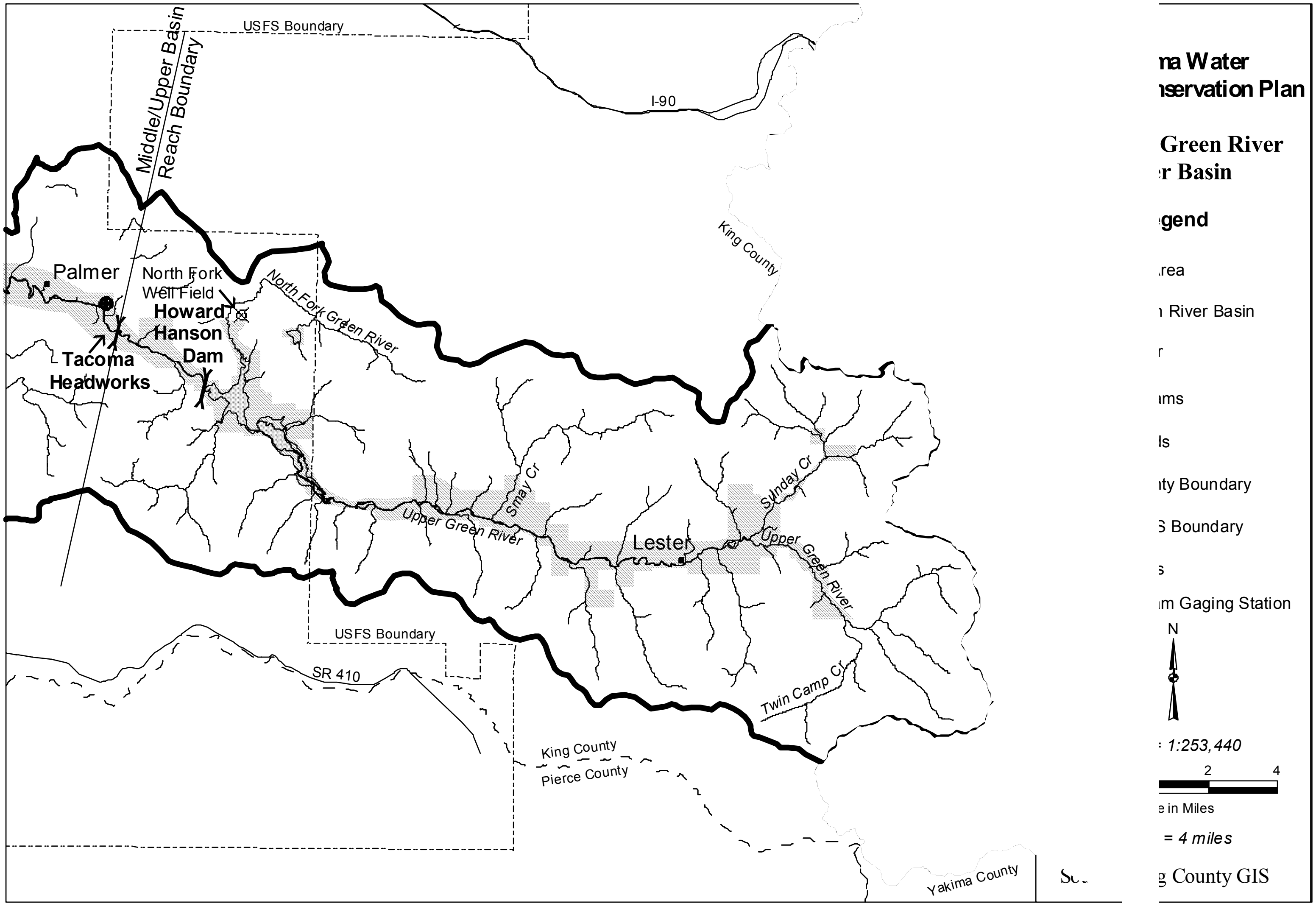

Figure 2-2. Map of ITP area within upper Green River basin.

Figure 2-3. Map of ITP area within lower and middle Green River basin.

The Green River is a non-glacial system originating at the crest of the Cascade Mountains near Stampede Pass, Washington. At its headwaters, the river generally flows through steep, mountainous terrain, restricted by narrow valley walls. Tributary streams in the headwaters are steep channels dominated by bedrock and boulders, eventually giving way to lower gradient, alluvial streams that cross the narrow upper valley before joining the main river. The mainstem river then braids and shifts across the valley floor until it enters the upstream end of the HHD reservoir at about RM 69.0. The flow regime of the upper mainstem and tributaries exhibit seasonal, bimodal peaks indicative of fall rain events and runoff of spring snowmelt.

In the middle Green River below the Headworks, the river gradient decreases until the river enters the Green River Gorge at about RM 58.5. The river drops quickly through the 13 miles of the gorge where the channel is well confined and bedrock ledges and large boulders dominate the channel. The gorge is cut through sandstone and mudstone of the Puget Group, a series of soft and erodable rock units. Below the Green River Gorge, the river decreases its overall slope to become a much gentler, lower gradient river. In this reach, the Green River travels through glacial outwash and alluvium deposited during the most recent advance of continental glaciers. The sediment carried by the river drops out below the gorge. The middle Green River has a mobile channel and currently supports at least 59 side channels (USACE 1998, Appendix F, Section 7).

The lower Green River channel and floodplain have formed in sedimentary, volcanic, and glacial deposits. The lower basin (downstream from the Soos Creek confluence to Elliott Bay) has been almost entirely leveed or revetted to provide flood protection. The levees have reduced channel migration rates by over 60 percent in some reaches (Perkins 1993). As a result, much of the former off-channel fish habitat has been lost. The mouth of the river at Elliott Bay and the lower portion of the river have been dredged and channelized to facilitate navigation.

Those portions of the upper Green River watershed not under jurisdiction of the U.S. Forest Service (USFS) (RM 83.9 to RM 61.0) are closed to public access to protect the quality of the drinking water supply. Access to the non-federally owned portion of the watershed is restricted to watershed landowners, which include private timber companies and Washington Department of Natural Resources (WDNR). Tacoma owns approximately 15,000 acres in this portion of the upper watershed primarily along the river in riparian areas and manages these lands to protect water quality.

Plum Creek Timber Company has developed an HCP for its lands in the upper watershed, and Weyerhaeuser Company currently operates under a special management agreement with the USFWS for spotted owls. The USFS lands north of the Green River lie within the Snoqualmie Pass Adaptive Management Area, while the majority of USFS lands south of the Green River are designated as matrix lands. These lands are managed under the provisions of the Northwest Forest Plan (USDA and USDI 1994). The USFS has conducted a watershed analysis on the entire upper Green River watershed following federal protocol. State watershed analyses are being conducted on five of the six Watershed Administrative Units in the upper watershed by non-federal owners following WDNR methodology. Forest management prescriptions developed through watershed analyses are in place on one of the units in the upper watershed covering private and state lands.

The middle Green River watershed is rural in nature and land use is predominantly forestry and agriculture. This section of the river is used extensively for recreational boating, swimming, sport fishing, and irrigation. The lower (western) one-third of the basin is largely industrialized and includes portions of the cities of Seattle, Tukwila, Renton, Kent, and Auburn.

Over 30 species of fish inhabit the Green River, including both resident and anadromous stocks. Resident fish such as cutthroat trout (*O. clarki*), mountain whitefish (*Prosopium williamsoni*), and sculpin (*Cottus spp.*) are present throughout the Green River basin. Up to nine anadromous salmonid species historically or currently use the Green River system. These species include chinook, coho (*O. kisutch*), chum (*O. keta*) and sockeye salmon (*O. nerka*), steelhead trout (*O. mykiss*), sea-run cutthroat trout (*O. clarki clarki*), Dolly Varden (*Salvelinus malma*), and bull trout (*Salvelinus confluentus*). Pink salmon (*O. gorbuscha*) are believed to be present in the system, however, not in large numbers. Races of salmon and steelhead historically or currently present include spring, summer and fall chinook, and winter and summer steelhead. Construction of Tacoma's Headworks eliminated adult salmon passage above the Headworks diversion dam (RM 61.0); however in recent years, some adult steelhead have been transported into the upper watershed.

Since 1962, HHD, a federally owned and operated facility constructed at RM 64.5, has been operated for flood control to protect agricultural lands, businesses, and other private as well as municipal property in the middle and lower Green River basin. Howard Hanson Dam was originally authorized and built without fish passage facilities. Above the dam are approximately 220 square miles of watershed area and up to 66 miles of stream that were historically accessible to salmon and steelhead. Since 1982, juvenile anadromous fish (coho salmon, chinook salmon, and steelhead) have been reintroduced into the upper watershed under state and tribal fish management. Since 1992, Tacoma, the MIT, Trout Unlimited, and WDFW have cooperatively administered a temporary adult fish trap at the Headworks. Trapped adult steelhead are either released above HHD for natural spawning, or a selected few are used to rear fry for outplanting in the upper watershed. Adult salmon are not currently released above HHD, but such releases are planned to begin when downstream passage facilities at HHD are completed as part of the proposed Additional Water Storage (AWS) project.

2.3.2 City of Tacoma's Water Supply Operations

Under its FDWRC, the City of Tacoma has withdrawn up to 113 cfs of water from the Headworks diversion facility at RM 61.0 since 1913. The Headworks consists of a diversion, intake, fish screens, and a temporary adult salmon trap-and-haul facility. A pipeline (hereafter referred to as Pipeline No. 1 [P1]) with a capacity of 113 cfs (72 million gallons per day [mgd]) carries water from the Headworks south and west to Tacoma (Figure 2-1). Present withdrawal of 113 cfs from the Green River is based on historic water right claims dating from 1906 and 1908. The North Fork well field, a series of wells located near the North Fork of the Green River at RM 1.0 (Figure 2-2), is collectively capable of pumping 110 cfs. The well field is used as an alternate water source during turbid river conditions, but the combined withdrawal from the wells and the Headworks diversion never exceeds the FDWRC of 113 cfs.

Tacoma plans to improve its water supply system with construction of the Second Supply Project (SSP) (also referred to as the Pipeline No. 5 Project [P5]). In 1986, Ecology acknowledged Tacoma's need for water by granting an additional water right of 100 cfs (65 mgd). Construction and operation of the SSP will allow diversion and transmission of an additional 100 cfs of water from the Green River to the Tacoma Regional Water Supply Area, including south King County, to meet future water needs. The SSP will consist of two primary features: 1) improvements to the existing Headworks on the Green River; and 2) construction of a new 33.5-mile-long pipeline (P5) (Figure 2-1).

Improvements at the Headworks will include:

- raising the existing diversion dam by approximately 6.5 feet, which will extend the inundation pool to 2,570 feet upstream (RM 61.5) of the Headworks diversion;

- realigning and enlarging the existing intake and adding upgraded fish screens and bypass facilities for downstream passage;
- reshaping the Green River channel downstream of the existing diversion to accommodate the future installation of an efficient trap-and-haul facility for upstream fish passage; and
- replacing approximately 700 feet of existing concrete pipe with a larger steel pipe.

2.3.3 Howard Hanson Dam

2.3.3.1 Current Operation of Howard Hanson Dam

The USACE completed construction of the HHD at RM 64.5 in 1962. The congressionally authorized purpose of this dam is flood control, with both municipal and industrial water supply, fisheries conservation, and irrigation water supply as further authorized purposes. The project is currently operated to provide winter and spring flood control and summer low flow augmentation for fish resources. The existing HHD project has never been operated for municipal and industrial water supply. Howard Hanson Dam is operated for flood control so that the sum of the dam release and local inflow between the dam and the town of Auburn will not exceed a flow of 12,000 cfs as measured at the Auburn U.S. Geological Survey (USGS) gage (RM 32). The dam provides storage of 106,000 ac-ft for flood control from approximately October through March.

Operation of HHD during the winter is determined by flood control requirements. The only flexibility in the congressional authorization lies in the operation of HHD during spring refill for conservation storage. During the spring, the project switches from flood storage to its secondary role of conservation storage for low flow augmentation. The existing reservoir provides for 25,400 ac-ft of summer/fall storage; 24,200 ac-ft is active storage available for enhancing instream flows below the project. During the switch from flood to conservation storage the amount of water released from HHD is reduced below the level of inflows, allowing the project to refill. Refill timing and release rates are based on target instream flows that are adjusted yearly in response to the existing weather conditions, snowpack, amount of forecasted precipitation, and input on biological conditions from other resource managers. Refill is conducted in a way that attempts to provide flows beneficial to downstream fisheries while balancing the need for refill of the reservoir to a full summer conservation pool elevation of 1,141 feet above mean sea level (MSL[1]).

2.3.3.2 Additional Water Storage Project

The AWS project will provide up to an additional 37,000 ac-ft over existing storage by raising the existing summer conservation pool by 36 feet (from 1,141 feet to 1,177 feet). The AWS project will be implemented in two phases. In Phase I, the fish passage facility will be constructed at the dam and storage will be increased by up to 25,000 ac-ft, (up to 20,000 ac-ft of which will be stored for municipal water supply). Phase I includes the option to store up to 5,000 ac-ft of water for low flow augmentation purposes to benefit downstream fishery resources. In Phase II, an additional 12,000 ac-ft of storage will be added to the Phase I conditions (9,600 ac-ft will be available for fisheries, and 2,400 ac-ft will be available for municipal and industrial water supply) (Table 2-1).

Table 2-1. Comparison of Howard Hanson Dam summer conservation pool between the existing project and the AWS project Phase I and Phase II.

	Summer Conservation Pool	
Project Condition	Volume	Elevation
Existing HHD Project	25,400 ac-ft (normal year)	1,141 ft
AWS project Phase I	50,400 ac-ft	1,167 ft
AWS project Phase II	62,400 ac-ft	1,177 ft

The AWS project, a combined water supply and restoration project, was subjected to extensive agency review and a collaborative decision-making process involving NMFS, Ecology, WDFW, USFWS, MIT, Tacoma, and USACE. This process resulted in the phased adaptive management plan that provides early outputs of water supply and restoration benefits with an opportunity to review and adjust the project as experience is gained. The key elements of the plan include experimentation and monitoring and analysis, followed by adjustment to the management and operation practices responsive to the monitoring information. Details of the environmental effects analyses associated with the AWS project are contained in the National Environmental Policy Act (NEPA) project documentation (USACE 1998).

[1] Elevations referenced in this document refer to a mean sea level datum.

The acceptance of the Phase II storage by the MIT and reviewing agencies will be based on the successful performance of Phase I as determined through the Phase I monitoring. Phase II of the AWS project will only proceed with the approval of the MIT and resource agencies. The storage of an additional 12,000 ac-ft in Phase II would raise the inundation pool at HHD from 1,167 feet to 1,177 feet. During the spring refill period, up to 32,000 ac-ft of water would be stored behind HHD; in addition, during this time up to 100 cfs (65 mgd) of water would be withdrawn through P5. This withdrawal of additional water would require additional water rights and would be subject to greater instream flow requirements.

The determination of adequacy of the proposed Phase II mitigation and restoration actions to mitigate Phase II actions is currently based on assumptions that will be verified by monitoring of Phase I mitigation and restoration actions. Therefore, Phase II activities are not covered in this HCP. A separate ESA review of Phase II will be conducted after mitigation proposed for Phase I is determined to be adequate.

Under Phase I, in addition to optional storage of up to 5,000 ac-ft of water for low flow augmentation, up to an additional 20,000 ac-ft of municipal and industrial water will be stored in the spring for release during the summer and fall to supply up to 100 cfs (65 mgd) for Tacoma's SDWR. The water surface elevation of the HHD pool will be raised by 26 feet (from elevation 1,141 feet to 1,167 feet). Tacoma will not divert SDWR water when municipal water is being stored during spring reservoir refill, but will allow it to be stored for use in summer and fall when there is a greater need for the water.

Phase I will include all structural features required to provide a downstream fish passage facility at HHD, as well as a number of habitat restoration and mitigation projects. As part of the basin restoration program, upstream migrating wild salmon and steelhead will be trapped at Tacoma's Headworks and transported upstream and released in, or upstream of, the HHD reservoir.

Goals for operation of HHD under Phase I are to meet springtime reservoir refill objectives while providing dam releases that mimic natural flow variation and:

- maximize smolt survival through the HHD reservoir;
- maximize attraction and entrance of outmigrating salmonids to the surface intake of the HHD downstream fish passage facility;

- initiate efforts to reestablish runs of historical upper Green River anadromous fish stocks;
- evaluate benefits and potential risk of artificial freshets to downstream fisheries resources;
- establish flow management guidelines to optimize use of stored low flow augmentation for downstream fishery benefits; and
- establish the baseline conditions for middle and lower Green River anadromous salmonid fish stocks through inventory and monitoring.

Habitat restoration and mitigation projects associated with Phase I include:

- a downstream fish passage facility at HHD;
- flow adjustments to:
  - ▷ maximize outflow capacity of the fish passage facility by minimizing the reservoir refill rate during smolt outmigration and potential use of periodic artificial freshets that mimic natural freshets;
  - ▷ increase downstream survival of outmigrating salmonids by maintaining a base flow target during spring refill, and provide the option to release periodic freshets during peak outmigration;
  - ▷ provide adequate baseflows through the steelhead incubation period that protect eggs deposited during higher spawning flows; and
  - ▷ provide optional storage of 5,000 ac-ft for low flow augmentation.
- management of riparian forests to maintain forest succession on major streams above HHD (such management would occur in Tacoma's Natural, Conservation, and Commercial Forest Management Zones);
- reconnection of approximately 3.4 acres of side-channel habitat to the mainstem middle Green River;
- habitat rehabilitation including large woody debris (LWD) placement and excavation or reconnection of off-channel habitats to selected streams between the elevations of 1,177 feet and 1,240 feet;
- return of the river to its historic channel between RM 83.0 and 84.0 using one or more debris jams/flow deflectors;

- maintenance of stream and riparian corridor habitat in lower Page Mill Creek, creation of a series of new, smaller ponds, and addition of woody debris to the ponds and stream channel;
- replacement of culverts that constitute barriers to upstream or downstream fish passage in tributaries to the Green River (locations to be identified from a culvert inventory);
- improvement of stream habitat in upper watershed tributaries by adding logs and limited excavation to recreate meanders or backwater habitats;
- wildlife habitat mitigation including: 1) creation of elk forage habitat; 2) upland forest management to promote late-successional and old-growth forest habitat conditions; and 3) wetland and riparian habitat improvements in the reservoir inundation zone (elevation 1,141 feet to 1,167 feet) including construction of two sub-impoundments and sedge plantings over 60 acres;
- annual release of spawning gravel in the middle Green River; and
- transport and/or placement of woody debris in the middle Green River.

All Phase I restoration and mitigation projects will be monitored for at least 10 years after implementation, and up to 50 years after implementation depending on the project. Some of the activities also require pre-construction studies and monitoring, which are currently underway or planned. Alternate measures will be implemented if any of the habitat enhancement measures are determined to be infeasible or not cost-effective during the final design. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the Services. Tacoma and the USACE will cost-share fish passage and restoration project monitoring, and Tacoma will entirely fund monitoring and maintenance of the fish and wildlife mitigation projects. Responsibility for implementation of the monitoring efforts will be shared by Tacoma and USACE, with the work being conducted by either Tacoma staff, USACE staff, or contractors. All monitoring activities will be conducted in cooperation with the MIT and federal and state agencies.

2.3.4 Tacoma Water Land Management in the Upper Watershed

Most non-federal lands in the watershed upstream of Tacoma's diversion are closed to the public in order to protect the drinking water supply. Tacoma's watershed lands are currently managed for water quality, fish habitat and/or wildlife habitat. Commercial timber harvest is conducted only where it will not conflict with any of these objectives.

Approximately 39 percent of Tacoma's lands is identified as lying within the Natural Management Zone as defined in Tacoma's Forest Land Management Plan (Ryan 1996). No regulated timber harvest occurs within this zone. Another 35 percent lies within the Conservation Management Zone, where timber harvest occurs only to accelerate the development of late-successional forest conditions and/or to accomplish other fish and wildlife habitat objectives. The remaining 26 percent of the lands is designated as Commercial Management Zone. These lands are managed for timber production on an even-aged basis with a rotation age of approximately 70 years. A maximum of less than two percent per year is harvested in the Commercial Zone. Some of the restoration activities conducted for Phase I of the AWS project will be implemented on Tacoma lands.

2.4 Proposed Habitat Conservation Plan

This HCP represents more than a decade of planning, scientific studies and work with Tribal, federal, state, and local resource agencies to develop a management plan for continued municipal water supply activities in the Green River watershed. The plan is explained in detail in subsequent chapters.

The main features of the HCP include:

- an upstream fish passage facility that will provide adult anadromous fish access to up to 106 miles of previously blocked stream habitat;
- sponsorship and funding for a downstream fish passage facility at USACE HHD;
- instream flow measures;
- improved riparian forest management on Tacoma's lands; and
- several major habitat restoration projects.

One of the essential elements of this HCP is its monitoring and adaptive management framework. Monitoring and adaptive management includes experimentation, monitoring and analysis, and synthesis of results. Based on this information, changes in project design, management, and operations will be implemented. The adaptive management framework provides an ongoing process to ensure continued protection for fish and wildlife. Tacoma has committed to ongoing coordination with the MIT, federal and state resource agencies, and members of the scientific community, to ensure that management strategies and decision making are based on sound scientific principles.

2.5 Areas Proposed for Coverage Under the Incidental Take Permit and the Habitat Conservation Plan

The proposed ITP area consists of: 1) areas affected by the operation of Tacoma's diversion; 2) areas in the watershed where mitigation and restoration activities will occur in association with Phase I of the AWS project and the SSP; and 3) all lands owned by Tacoma in the upper watershed above the Headworks as described in Appendix F (Figures 2-2 and 2-3). The HCP area is inclusive of the ITP area and the HHD downstream fish passage facility.

2.5.1 The Incidental Take Permit Area

The proposed ITP area for this HCP (as shown in Figures 2-2 and 2-3) includes:

- the mainstem and all side channels of the Green River, inundated at flows of 12,000 cfs as measured at the Auburn USGS gage (RM 32.0), from the upstream end of the new Headworks pool (RM 61.5) downstream to the area of tidal influence (RM 11.0) (Figure 2-3);
- the Headworks structures including the new intake, downstream fish bypass facilities, and trap-and-haul facilities for upstream passage;
- the North Fork well fields and the North Fork of the Green River from RM 1.5 downstream to the HHD reservoir pool;
- the HHD reservoir (up to elevation 1,167 feet);
- City of Tacoma lands upstream of the Headworks and in the Green River watershed above the HHD as identified in Appendix F (Figure 2-2); and
- the locations of the HHD AWS project Phase I mitigation and restoration projects, as listed under the HCP area description, exclusive of the HHD downstream fish passage facility.

2.5.2 The Habitat Conservation Plan Area

The HCP area covers all locations where actions will take place to minimize the effects of Tacoma's first diversion and second diversion water withdrawals on fishery resources. The HCP area includes:

- the mainstem and all side channels of the Green River, inundated at flows of 12,000 cfs as measured at the Auburn USGS gage (RM 32.0), from the upstream end of the new Headworks pool (RM 61.5) downstream to the area of tidal influence (RM 11.0) (Figure 2-3);
- the Headworks structures including the new intake, downstream fish bypass facilities, and trap-and-haul facilities for upstream passage;
- the North Fork well fields and the North Fork of the Green River from RM 1.5 downstream to the HHD reservoir pool;
- the HHD reservoir (up to elevation 1,167 feet);
- all City of Tacoma lands upstream of the Headworks and in the Green River watershed above HHD (Figure 2-2);
- the downstream fish passage facility proposed for Phase I of the AWS project; and
- the locations of the instream, riparian and in-reservoir restoration/rehabilitation projects to be implemented during Phase I of the AWS project:
    - ▹ within or above the HHD reservoir:
        - – reservoir inundation area (Phase I: elevation 1,141 feet to 1,167 feet);
        - – stream and riparian habitat between elevation 1,177 feet to 1,240 feet (above Phase II inundation zone);
        - – riparian forest above 1,240 feet within Tacoma’s Natural, Conservation, and Commercial Zones;
        - – Page Mill Pond and Page Mill Creek;
        - – Green River mainstem from RM 83.0 to RM 84.0; and
        - – culvert replacement locations on Tacoma’s ownership (tributaries to be identified from the basin-wide culvert inventory).
    - ▹ below the HHD reservoir:
        - – one side-channel reconnection project currently proposed for AWS project Phase I (RM 58.6-RM 59.6); however, if another location(s) is found to be more suitable (i.e., provides more resource value) during final project design, side-channel reconnection efforts would be shifted

from the currently identified side-channel project to the newly identified alternative(s) as appropriate; and

– the lower 3,000 feet of Bear Creek (RM 63.0).

Although specific restoration and mitigation project sites have been identified for environmental review of the proposed Phase I of the AWS project, a broader area where some of these projects could be implemented has been included in the HCP area. This allows for flexibility during the final planning stages to incorporate other rehabilitation sites that may be more beneficial to the aquatic resources than some of the projects currently under review.

2.6 Activities Proposed to be Covered by the Incidental Take Permit

Activities proposed to be covered by the ITP include the following:

- water withdrawal at Tacoma's Headworks (associated with FDWRC and SDWR):
  - ▹ reduction of flows, with concomitant habitat effects downstream;
  - ▹ bypass of fish at the Headworks intake; and
  - ▹ inundation of the impoundment area;
- water withdrawal from the North Fork well field:
  - ▹ potential reduction of flows in the North Fork Green River from RM 1.5 downstream to HHD reservoir;
- construction of Headworks improvements:
  - ▹ raising of the existing diversion dam by approximately 6.5 feet, which will extend the inundation pool to 2,570 feet upstream (RM 61.5) of the Headworks diversion;
  - ▹ realignment and enlargement of the existing intake and adding upgraded fish screens and bypass facilities for downstream passage;
  - ▹ reshaping of the Green River channel downstream of the existing diversion to accommodate the installation of an efficient trap-and-haul facility for upstream fish passage;
  - ▹ installation of a new trap-and-haul facility for upstream fish passage; and
  - ▹ installation, monitoring and maintenance of the instream structures in the impoundment as fisheries mitigation for the Headworks modification;

- operation of the downstream fish bypass facility at the Headworks;
- Tacoma watershed forest management based on the Green River Watershed Forest Land Management Plan (Ryan 1996);
  - ▹ watershed patrol and inspection;
  - ▹ forest road construction, maintenance, and use;
  - ▹ forest road culvert removal, replacement, and maintenance (an average of approximately 0.5 mile of new road will be built each year, and approximately 12 miles of new and existing roads will be abandoned over the 50-year term of the HCP);
  - ▹ timber harvest and hauling; and
  - ▹ silvicultural activities (e.g., planting, thinning, and inventorying trees).
- monitoring of downstream fish passage through the HHD reservoir and fish passage facility;
- monitoring and maintenance of AWS project fish habitat restoration projects and AWS project fish and wildlife habitat mitigation projects;
- potential restoration of anadromous fish above HHD;[2] and
  - ▹ trap-and-haul of adults returning to the Headworks; and
  - ▹ possible planting of hatchery juveniles if found to be beneficial to restoration.
- all other mitigation measures described in Chapter 5 of this HCP.

2.7 Relationship Between the Tacoma Water ITP and Activities of the U.S. Army Corps of Engineers on the Green River

A portion of the water to be withdrawn from the Green River by Tacoma will be made available through the AWS project, which is a modification to the operation of HHD by the USACE. As noted in Chapter 2.3.3.2 of this HCP, the USACE will store additional water behind HHD in the spring, and release the water in the summer and fall. Some of the additional stored water will be used to benefit fish by augmenting low flows in the

[2] Note: The Muckleshoot Fish Restoration Facility, which is supported by Tacoma, will proceed through the necessary Tribal, federal and state regulatory process separate from the Tacoma Water HCP.

Green River, but most will be withdrawn by Tacoma Water to meet municipal water supply needs.

While Tacoma Water is the local sponsor for the AWS project, the USACE will be the lead federal agency. As a federal action, the AWS project cannot be covered by the ITP that Tacoma is requesting under Section 10 of the ESA. Consequently, the effects of the AWS project are not addressed in this HCP. Incidental take coverage for the AWS project will be secured by the USACE through the process prescribed in Section 7 of the ESA. The USACE will prepare the necessary documentation and consult with the Services, who will then determine whether incidental take coverage can be provided and under what conditions. The USACE activities to be addressed through the Section 7 process are listed in Table 2-2.

Because Tacoma Water will be dependent on the AWS project to exercise a portion of its SDWR on the Green River in the late summer and early fall, these withdrawals will not occur unless and until the USACE obtains incidental take coverage for the AWS project. Similarly, the mitigation measures in this HCP related to the impacts of the AWS project will not occur unless and until the AWS project receives all federal approvals, including incidental take coverage under Section 7 of the ESA. These mitigation measures include construction and operation of downstream passage facilities, and implementation of certain fish and wildlife habitat restoration activities. This interdependence between Tacoma and the USACE will ensure that the environmental effects of all activities will be addressed, and incidental take coverage will be secured for any and all anticipated take of federally listed species, before the AWS project is implemented.

2.8 Other Tacoma Water Activities not Covered by this HCP

Tacoma will construct two pipelines in association with the SSP. One will be a replacement for the 700-foot section of concrete pipe at the Headworks, and the other will be a new 33.5-mile pipeline to carry the additional water to Tacoma's distribution system. Both activities will take place outside the defined ITP area, and both were subjected to ESA review prior to the issuance of a Section 404 permit under the Clean Water Act (Section 404 coverage was required because of minor impacts to wetlands). Neither of the pipelines will be covered by the new ITP, and neither is addressed in this HCP. Any additional ESA review that might be necessary for these pipelines because of new listings (e.g., Puget Sound chinook) will be conducted by the USACE as lead agency for the Section 404 program.

Table 2-2. Section 7 (Incidental Take Statement) ESA coverage for USACE activities related to operation of the HHD under the AWS project, and USACE activities under the SSP.

Storage of Water Behind HHD (existing and proposed AWS project Phase I) [1]

- inundation of reservoir
- alteration of downstream flows
- effects on water quality and sediment, and LWD transport

Release of Water From HHD (existing and proposed AWS project Phase I) [1]

- alteration of downstream flows
- alteration of reservoir level
- effects on water quality and sediment and LWD transport

Construction, Operation and Monitoring of Downstream Fish Passage Facility at HHD [1]

Mitigation and Restoration Activities Above and Below Reservoir Associated with AWS project Phase I (implementation and monitoring) [1]

- annual gravel placement in the Middle Green River
- large woody debris release in the Middle Green River
- flow adjustments
- side-channel improvements
- maintenance of stream corridor habitat within the inundation pool
- wetland and riparian habitat improvements in the reservoir inundation pool and along the pool perimeter
- stream habitat improvements above the inundation pool
- creation of elk forage habitat
- manage upland and riparian forests to promote late-successional forest conditions

USACE Permitting (404/10) of Mitigation Activities Associated with SSP

- placement of fish habitat structures (boulders/logs) in the Headworks pool
- creation/enhancement of wetland along Green River at RM 32.9

USACE Permitting (404/10) of Construction of P5

[1] Through USACE consultation

1

2.9 Proposed Term of the Incidental Take Permit and Habitat Conservation Plan

Tacoma is seeking an ITP for an initial period of 50 years, with the possibility of permit extension under the terms and conditions specified in the Implementing Agreement. This HCP will be implemented for 50 years and the actual renewal periods to run concurrent with the term of the ITP.

2.10 Species Proposed for Coverage Under the Incidental Take Permit

City of Tacoma Green River Habitat Conservation Plan
Fish And Wildlife Species Covered by this HCP and ITP

ENDANGERED SPECIES	**SPECIES OF CONCERN**
Gray wolf (*Canis lupus*)	Coho salmon *(Oncorhynchus kisutch)*
	Sockeye salmon *(Oncorhynchus nerka)*
THREATENED SPECIES	Chum salmon *(Oncorhynchus keta)*
Bald eagle (*Haliaeetus leucocephalus*)	Pink salmon *(Oncorhynchus gorbuscha)*
Marbled murrelet (*Brachyramphus marmoratus*)	Steelhead *(Oncorhynchus mykiss)*
Northern spotted owl (*Strix occidentalis caurina*)	Coastal cutthroat trout *(Oncorhynchus clarki clarki)*
Grizzly bear (*Ursus arctos*)	Pacific lamprey *(Lampetra tridentata)*
Chinook salmon *(Oncorhynchus tshawytscha)*	River lamprey *(Lampetra ayresi*)
Bull trout *(Salvelinus confluentus)*	Cascades frog (*Rana cascadae*)
Canada lynx (*Lynx canadensis*)	Cascade torrent salamander (*Ryacotriton cascadae*)
	Van Dyke's salamander (*Plethodon vandykei*)
PROPOSED THREATENED SPECIES	Larch Mountain salamander (*Plethodon larselli*)
Dolly Varden (*Salvelinus malma*)	Tailed frog (*Ascaphus truei*)
	Northwestern pond turtle (*Clemmys marmorata*)
CANDIDATE SPECIES	Northern goshawk (*Accipiter gentilis*)
Oregon spotted frog (*Rana pretiosa*)	Olive-sided flycatcher (*Contopus borealis*)
	Vaux's swift (*Chaetura vauxi*)
	California wolverine (*Gulo gulo*)
	Pacific fisher (*Martes pennanti*)
	OTHER SPECIES
	Common loon (*Gavia immer*)
	Peregrine falcon (*Falco peregrinus*)
	Pileated woodpecker (*Dryocopus pileatus*)

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3. Regulatory Requirements and Processes

3.1 Endangered Species Act

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. §1531) provides, "...a means whereby the ecosystems upon which endangered species depend may be conserved" (16 U.S.C. §1521[b]). The U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) (collectively the "Services") survey the status of species and list those species determined to be threatened or endangered (16 U.S.C. §1533). Once a species is listed, the statute prohibits take of the species (16 U.S.C. §1538).

Under Section 7 of the ESA, all federal agencies are required to further the purposes of the ESA and consult with the Services to ensure any federal action is not likely to adversely affect a listed species or designated critical habitat (16 U.S.C. §1536[a][1] and [2]). Section 7 prohibits the destruction or adverse modification of designated critical habitat of listed species by federal agency actions, and this section includes within the term "federal action" not only direct or indirect actions affecting the environment but also less obvious activities like granting permits, entering contracts or leases, or participating in easements or making grants-in-aid (50 C.F.R. §402.02).

Section 9 of the ESA prohibits unauthorized taking of listed species (16 U.S.C. §1538[a][1] 16 U.S.C. §1538[a][1][B]). The statute broadly defines "take" to include any activity that would or would attempt to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a species covered by the ESA (16 U.S.C. §1532[19]). The Services' regulations broadly define the take prohibition to encompass both direct taking of the species (through wounding, killing, trapping, etc.) and indirect taking (through harm arising from habitat alteration or destruction or otherwise) (50 C.F.R. §17.3 [1993]).

The regulatory definition says "harm" to species includes habitat modification, and this definition has been upheld (Sweet Home Chapter of Communities for a Great Oregon v. Babbitt, 515 U.S. 687, 132 L.Ed. 597 [1995]). In Sweet Home, including indirect harm resulting from habitat modification as part of "harm" was found consistent with the ESA's statutory language and legislative history. The direct application of force to a species is not needed for harm to occur within the meaning of the ESA. Further, "the broad purpose of the ESA supports the Secretary's decision to extend protection against activities that cause the precise harms Congress enacted the statute to avoid" (emphasis added).

Section 10 authorizes the Services to issue permits for "incidental take." An Incidental Take Permit (ITP) allows a non-federal landowner to avoid Section 9 liability for any taking that might occur "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (16 U.S.C. §1539[a][1][B]; 50 C.F.R. §17.3 [1993]). Without an ITP, individuals and non-federal agencies like Tacoma Water (Tacoma), who undertake otherwise lawful actions that may take a listed species, risk violating the Section 9 take prohibition. Congress established the ITP to resolve this dilemma. To obtain an ITP, the applicant must submit a "conservation plan" that specifies, among other things, the impacts that are likely to result from the taking and the steps that will be undertaken to minimize and mitigate such impacts (16 U.S.C. §1539[a][2][A]; 50 C.F.R. §17.22[b][1]).

Although recovery of listed species is not the primary objective of the conservation planning process, the criteria for approval of a Habitat Conservation Plan (HCP) help to ensure that approved HCPs do not preclude recovery of listed species. The HCP must show that the applicant's conduct "will not appreciably reduce the likelihood of the survival and recovery of the species in the wild." If there is no recovery plan for a species, an HCP should ensure that recovery opportunities are thoroughly "considered" based on known limiting factors for the species. At the same time, an HCP is not a replacement or substitute for a recovery plan. An HCP is only a small but consistent part of efforts to "recover" a species.

3.2 Habitat Conservation Plan Requirements

3.2.1 Criteria for Issuance of a Permit for Incidental Taking

In deciding whether to issue a Section 10(a) permit for the taking of federally listed species, the Services must consider the following criteria (16 U.S.C. §1539[a][2][A]). If the applicant submits an HCP that satisfies these five criteria, the Services shall issue the ITP. The criteria are:

The taking will be incidental – All taking of listed fish and wildlife species as detailed in the HCP must be incidental to otherwise lawful activities and not the purpose of such activities.

The applicant will, to the maximum extent practicable, minimize and mitigate the impact of such taking – Under this criterion, the Services will determine whether the mitigation program the applicant proposes in the HCP is adequate to "protect" the species and meets statutory requirements.

The applicant will ensure adequate funding for the HCP – Funding sources and levels proposed by the applicant must be adequate to meet the purposes of the HCP.

The taking will not appreciably reduce the likelihood of survival and recovery of the species in the wild – This criterion involves the effects of the project on the likelihood of survival and recovery of affected species.

The applicant will ensure that other measures that the Services may require as being necessary or appropriate will be provided – This criterion gives the Services flexibility to negotiate additional measures as necessary or appropriate among many different proposals affecting many different species. Region 1 of the USFWS (the West Coast region) believes it is generally necessary and appropriate to prepare an Implementation Agreement (IA). The purpose of an IA is to ensure that each party understands its obligations under the Conservation Plan and Section 10(a)(1)(B) permit and to provide remedies should any party fail to fulfill their obligations. Therefore, an Implementing Agreement has been prepared for this Conservation Plan. No other measures have been identified by the Services.

3.2.2 Unforeseen Circumstances and No Surprises

The legislative history of the ESA mentions a need to address "unforeseen circumstances" during the term of an ITP; that is, unforeseen circumstances that might jeopardize a listed or threatened species while the permit is in force. Planning for and becoming contractually bound to a method for dealing with some unforeseen future event is not easy. However, the uncertainty and unknown cost of dealing with an unforeseen occurrence or an event of unknowable dimensions happening at some unknown time cannot be allowed to curtail all human activity affecting the environment and/or forestall helpful efforts to protect threatened or endangered species.

The uncertainty problem is the subject of "No Surprises," formerly a Services policy and now a regulation, issued 17 February 1998. The No Surprises concept is simply that "a deal is a deal." Under a properly functioning HCP, the Services will not come back later and ask the applicant for more mitigation or funding, even if the affected species should continue to decline. Even in "extraordinary" or "unforeseen" circumstances, the permit holder can only be asked to explore available alternatives for making previously agreed mitigation measures more effective, but no additional cost can be mandated once a deal has been done. While certainty is provided, different or additional mitigation is not, but such mitigation becomes the responsibility of the Services. The terms of the No Surprises regulation will be built into the contractual language of the IA (50 CFR, Part 17). Without some meaningful certainty of the type provided by a concept like No Surprises, reaching a bargain of the type represented by an HCP is doubtful in the extreme. As a result, endless disputes will confound any meaningful progress for species that need help and, in this specific instance, will disrupt or curtail the water supply of Tacoma's customers.

3.2.3 Changed Circumstances

This HCP covers Tacoma’s water supply operations in the Green River and management of the Green River watershed under ordinary circumstances. In addition, Tacoma and the Services foresee that circumstances could change during the term of this HCP, by reason of such natural events as wildfire, floods, and landslides. Such changed circumstances are described in this section, along with the measures Tacoma and the Services will implement in response to a changed circumstance. The ITP will authorize the incidental take of covered species under ordinary circumstances as well as these changed circumstances, so long as Tacoma is operating in compliance with this HCP, the ITP and the IA. If additional mitigation measures or costs beyond those provided in this HCP are deemed necessary to respond to any changed circumstances, the Services will not require any such measures or costs of Tacoma without Tacoma's prior consent.

3.2.3.1 Wildfire

Wildfire is a natural event in western Washington, and the continued threat of its occurrence will influence the management of the Upper HCP Area. Low- to mid-elevation forests on the west slope of the Cascade Mountains have natural fire regimes characterized by infrequent, extensive, high-intensity and high-mortality fires (Agee 1993). Most remaining old-growth forests in this zone originated after catastrophic fires less than 750 years ago, suggesting a fire frequency shorter than 750 years. Hemstrom and Franklin (1982) found the majority of forests within Mount Rainier National Park to be over 350 years old, and estimated fire frequency in that area to average 434 years. Natural fire frequencies in the upper Green River watershed are likely less than 434 years because the Green River is lower in elevation than Mount Rainier National Park, and more exposed to dry east winds during the summer.

Lightning is the primary source of wildfire ignition in western Washington. July through September are the months of greatest lightning activity (Agee 1993) and least precipitation in western Washington, and are therefore the most conducive to fire activity, especially if combined with dry east winds of the type common to the Green River watershed. Intensive forest management and aggressive fire suppression have reduced the frequency of large wildfires over the past 100 years, but they have simultaneously increased the risk and frequency of small fires. Logging, slash disposal, recreation, transportation (e.g., roads and railroads) and vandalism all combine with lightning to maintain the presence of forest fire. Fire prevention and suppression will continue in the Upper HCP Area because of the severe economic, biological and water quality implications of losing large patches of forest habitat, but these activities will not eliminate wildfire altogether.

Tacoma's actions to prevent and suppress wildfires in the Upper HCP Area will be covered activities under the ITP, and Tacoma will respond to wildfire consistent with the mitigation measures described in Chapter 5 of this HCP. No measures beyond those listed below will be required to respond to the occurrence of wildfire in the HCP Area:

- Tacoma will take all necessary steps to suppress wildfires that originate on or near the HCP Area. Fire suppression activities conducted by Tacoma will be consistent with the mitigation measures of this HCP to the extent that such compliance does not materially hamper or prevent efforts to suppress fires.
- In accordance with measure HCM 3-01F, Tacoma will conduct no post-wildfire salvage logging in the Natural Zone, in conifer stands over 100 years old in the Conservation Zone, in Upland Management Areas (UMA) or in no-harvest riparian and wetland buffers.
- Burned areas in the Commercial Zone will be salvaged in accordance with measure HCM 3-01F (Salvage Harvesting) and measure HCM 3-01G (Snags, Green Recruitment Trees and Logs).
- Burned areas in the Commercial Zone that resemble even-aged harvests (i.e., fewer than 50 healthy dominant or codominant conifers per acre, on average) will be reforested in accordance with measure HCM 3-01M.
- Tacoma will reforest burned areas in the Natural Zone, the Conservation Zone, no-harvest riparian buffers, and UMAs if Tacoma, the USFWS or NMFS determines reforestation is necessary to protect water quality or achieve the mitigation objectives of the HCP for one or more covered species.

- Tacoma will inspect all stream-crossing structures (e.g., culverts and bridges) in the HCP Area downstream of burned areas to ensure the structures are appropriately sized, constructed and maintained to accommodate any anticipated increases in flows resulting from wildfire.
- Temporary roads and trails constructed for fire suppression will be regraded and revegetated within 1 year of creation, unless Tacoma determines a fire road should be made permanent. Temporary fire roads that are made permanent will conform to all HCP requirements for permanent roads.

3.2.3.2 Wind

Wind is an ever-present factor in the HCP Area. Daily winds control the climate, growing conditions, and fire danger in the HCP Area, while seasonal storms can damage or destroy capital improvements, interrupt electrical power and uproot trees. In forested portions of the HCP Area, wind can create habitat for fish and wildlife by killing live trees and/or toppling trees to create logs or large woody debris (LWD) in streams. Extreme winds can eliminate habitat, however, by blowing down all or most trees in a given area. Tacoma will minimize the impact of wind on the effectiveness of the HCP through the following measures:

- Tacoma's facilities for water withdrawal and fish mitigation will continue to be built to withstand all windstorm events that can reasonably be expected over the term of the HCP. No additional measures are necessary to prepare for or respond to wind damage to Tacoma facilities.
- All Tacoma facilities requiring the use of electrical power, including those to maintain fish flows and facilitate fish passage in the Green River, will be provided with emergency generators. Temporary local power failures will not prevent Tacoma from fulfilling the mitigation requirements of this HCP.
- In accordance with measure HCM 3-01F, Tacoma will conduct no salvage logging of trees damaged or toppled by wind in the Natural Zone, in conifer stands over 100 years old in the Conservation Zone, in UMAs or in no-harvest riparian and wetland buffers.
- Trees damaged or toppled by wind in the Commercial Zone will be salvaged in accordance with measure HCM 3-01F (Salvage Harvesting) and measure HCM 3-01G (Snags, Green Recruitment Trees and Logs).
- Areas damaged by wind in the Commercial Zone that resemble even-aged harvests (i.e., fewer than 50 healthy dominant or codominant conifers per acre, on average) will be reforested in accordance with measure HCM 3-01M.

- Tacoma will reforest areas damaged by wind in the Natural Zone, the Conservation Zone, no-harvest riparian buffers, and UMAs if Tacoma, the USFWS or NMFS determines reforestation is necessary to protect water quality or achieve the mitigation objectives of the HCP for one or more covered species.

3.2.3.3 Landslide

Landslides occur naturally in the HCP Area, but the size and frequency of landslides can be increased by human activities that remove stabilizing vegetation from hillsides, alter patterns of surface water run-off and/or alter surface contours. Several of the mitigation measures in this HCP have been specifically designed to minimize the rate of human-caused landslides in the Upper HCP Area and to minimize the environmental damage from natural and human-caused landslides. No additional measures will be necessary in the event of a landslide during the term of the HCP. Measures in the HCP to minimize the occurrence and impact of landslides are:

- Watershed Analyses are being conducted for the Upper HCP Area as stated in measure HCM 3-03A. Included in the Watershed Analyses is a module to identify potential mass-wasting areas and develop prescriptions for minimizing any management-related increases in the rate of landsliding.
- As noted in measure HCM 3-03C, Tacoma will construct no temporary or permanent roads across unstable soils in the Upper HCP Area, as identified through Watershed Analysis.
- Tacoma will use full bench construction (with no side-casting) when constructing new roads on side slopes of more than 60 percent (measure HCM 3-03D), to minimize the potential of destabilizing slopes and causing landslides.
- Tacoma will mulch and/or seed road cuts and fills on slopes over 40 percent, cuts and fills near water crossings and in any other locations where there is a potential for erosion and/or slumping (measure HCM 3-03E).
- Tacoma will abandon roads in the Upper HCP Area that are no longer needed (measure HCM 3-03I), to eliminate the risk of erosion and slope failure associated with these roads.
- Tacoma will maintain the no-harvest Natural Zone around Howard Hanson Reservoir and along the Green River and its major tributaries (measure HCM 3-01B), and an extensive network of no-harvest and partial-harvest buffers along all other streams in the HCP Area (measures HCM 3-02A and 3-02B). These buffers will, among other things, capture sediment and debris from landslides and slumps before this material reaches surface waters.

- Tacoma will conduct no timber harvesting in the Natural Zone (measure HCM 3-01B), limited harvesting in the Conservation Zone (measure HCM 3-01C) and harvesting on an extended 70-year rotation in the Commercial Zone (measure HCM 3-01D). This extremely conservative approach to forestland management will result in a significant portion of the watershed in mature forest at all times, and minimize the effects of timber harvesting and roads on the hydrologic regime of the upper Green River watershed.
- Tacoma will implement a culvert inspection and replacement program (measure HCM 3-03J), to ensure that under-sized or improperly placed culverts do not contribute to landslides or slope failures.

3.2.3.4 Flood

The Green River has a history of flooding that was significantly reduced with the construction of Howard Hanson Dam (HHD) in 1962. The congressionally authorized purpose of this dam is flood control. By providing up to 106,000 acre-feet (ac-ft) of flood storage from approximately October through March, the dam has nearly eliminated the threat of flood (i.e., the dam is designed to prevent flows from exceeding 12,000 cubic feet per second [cfs] at the U.S. Geological Survey [USGS] gage at RM 32.0 in Auburn).

All physical structures needed for Tacoma to carry out the fish mitigation measures of this HCP (e.g., upstream fish passage, bypass facilities, etc.) will be located at or below HHD, where they are at little risk of flooding. No special measures will be needed to respond to the effects of flooding in these areas. Similarly, instream fish mitigation measures to be implemented downstream of HHD (e.g., wetland and floodplain restoration, maintenance of minimum flows, and placement of LWD in the river) will be designed to accommodate the maximum flows released by the dam (12,000 cfs at River Mile [RM] 32.0). They also will be monitored to ensure they remain effective after peak flows. No additional measures are necessary.

Natural floods can occur in the Upper HCP Area, upstream of the influence of HHD. The effects of natural floods in the Upper HCP Area will be minimized by measures to maintain properly sized culverts (measure HCM 3-03J), measures to limit the removal of mature forest vegetation (measures HCM 3-01B, 3-01C, 3-01D, 3-01H and 3-01I), and measures to maintain no-harvest and partial-harvest buffers along streams (measures HCM 3-02A and 3-02B). No additional measures will be necessary to respond to floods during the term of the HCP.

3.2.3.5 Forest Health

A significant portion of the mitigation for covered activities in the Upper HCP Area involves the management and retention of mature forest habitat on Tacoma lands. While insects and tree diseases are natural components of the coniferous forest ecosystems of western Washington, severe outbreaks of either can threaten the health of these forestlands, and influence the effectiveness of the related mitigation measures. Tacoma will allow insects and tree disease pathogens to persist as natural elements of the HCP Area, but Tacoma also will take reasonable steps to prevent widespread tree mortality in the event of a serious outbreak.

- Tacoma may choose to use forest pesticides and fungicides to reduce or stop an outbreak of insects or pathogens in the HCP Area, where such use does not result in the incidental take of a listed species or impact the municipal water supply. The use of pesticides and fungicides is not a covered activity under the ITP. Such use will be at the discretion of Tacoma, subject to obtainment of all necessary permits and approvals.
- In the event that forest insects or disease pathogens result in the widespread death of trees in the HCP Area, Tacoma will salvage dead and damaged timber consistent with measures HCM 3-01F (Salvage Harvesting) and HCM 3-01G (Snags, Green Recruitment Trees and Logs). Such salvage harvesting will occur only in the Commercial Zone (outside no-harvest riparian/wetland buffers and UMAs), or in stands less than 100 years old in the Conservation Zone.
- Affected areas in the Commercial Zone that resemble even-aged harvests (i.e., fewer than 50 healthy dominant or codominant conifers per acre, on average) will be reforested in accordance with measure HCM 3-01M.
- Tacoma will reforest affected areas in the Natural Zone, the Conservation Zone, no-harvest riparian buffers, and UMAs if Tacoma, the USFWS or NMFS determines reforestation is necessary to protect water quality or achieve the mitigation objectives of the HCP for one or more covered species.

3.2.3.6 Changes in the Structure and/or Operation of Howard Hanson Dam

Howard Hanson Dam is currently operated to provide flood control to the Green River below RM 64.5. Under the terms of agreements between Tacoma and the U.S. Army Corps of Engineers (USACE), the dam will also be operated in the future to store and release water for municipal water supply and instream fish flows. It is not anticipated that HHD will be prevented from fulfilling its flood control or flow management commitments over the term of this HCP, but legal or natural forces could intervene. If the operation of HHD is altered by a natural occurrence (e.g., earthquake), accident, act of war or terrorism, change in USACE policy or management direction, act of Congress, or decision of the courts, Tacoma will only be obligated to fulfill the provisions of the HCP to the extent it is capable of under the changed operating circumstances without jeopardizing its obligation to protect public health and safety through the supply of water.

3.2.3.7 Eminent Domain Affecting Lands within the HCP Area

The Green River HCP Area is surrounded by private and public lands, and crossed by multiple transportation and utility corridors, including roads, railroads, powerlines, and pipelines. It is likely one or more parties having the power of eminent domain may acquire or affect lands within the HCP Area for the purpose of creating or extending an existing road, railroad, public utility, or other public purpose. This could occur through eminent domain, or through voluntary transfer by Tacoma under threat of eminent domain. In the event lands within the HCP Area are acquired or affected by any exercise of the power of eminent domain, Tacoma will not be obligated by the HCP or ITP to replace any mitigation provided by such lands. The incidental take coverage for such lands and corresponding HCP obligations may, at the discretion of the Services, be negotiated with and transferred to the recipient of such lands.

3.2.4 Changes in the Status of Covered Species

The Services may from time to time list additional species under the federal ESA as threatened or endangered, de-list species that are currently listed, or declare listed species as extinct. In the event of a change in the federal status of one or more species, the following steps will be taken.

- ***New Listings of Species Covered by the ITP.*** The ITP covers several species that currently are not listed as threatened or endangered under the federal ESA. All unlisted species covered by this HCP have been addressed as though they are listed. The ITP will take effect for listed covered species at the time it is issued. Subject to compliance with all other terms of this HCP, the ITP will take effect for any unlisted covered species upon the listing of such species.
- ***New Listings of Species Not Covered by the ITP.*** If a species that is present or potentially present in the HCP Area becomes a candidate for listing, is proposed for listing, is petitioned for listing, or is the subject of an emergency listing under the federal ESA, Tacoma will survey the HCP Area to the extent it deems necessary, after coordinating with the Services, to determine whether the species

and/or its habitat(s) are present. If the survey results indicate the species or its habitat(s) are present in the HCP Area, Tacoma will report the results of surveys for the species to the Services. If the Services determine there is a potential for incidental take of the species as a result of Tacoma's otherwise lawful activities, Tacoma may choose to continue to avoid the incidental take of the species, or request the Services to add the newly listed species to the HCP and ITP in accordance with the provisions in the IA and HCP, and in compliance with the provisions of Section 10 of the ESA. If Tacoma chooses to pursue incidental take coverage for the species by amending this HCP or by preparing a separate HCP, all parties (Tacoma, USFWS, and NMFS) will enter into discussions to develop necessary and appropriate mitigation measures to meet ESA Section 10(a) requirements for incidental take coverage. All parties will endeavor to develop mutually acceptable mitigation measures and secure incidental take coverage prior to final listing of the species. In determining adequate mitigation for the species, the Services will give Tacoma full mitigation credit for any and all benefits to the species that have accrued from the time the ITP was signed and this HCP was first implemented, although it is recognized that additional mitigation measures may be necessary to satisfy the requirements of the ESA.

- ***De-listings of Species Covered by this HCP.*** If a species covered by this HCP is de-listed at both the state and federal levels, the Services and Tacoma will review the mitigation measures being implemented for that species to determine if they are still necessary to protect the species from being re-listed. If continued mitigation by Tacoma is necessary to avoid re-listing the species, mitigation by Tacoma will continue as specified in this HCP. If cessation or modification of the mitigation for that species would not lead to the re-listing of the species, the Services and Tacoma will revise the HCP to eliminate or otherwise modify the mitigation measures in question. However, if elimination or modification of mitigation measures initially implemented for the species being de-listed would materially reduce the mitigation for another covered species, the mitigation measures will not be eliminated.

- ***Extinction of Species Covered by this HCP.*** If a species covered by this HCP becomes extinct, the Services and Tacoma will review the mitigation measures being implemented for that species to determine if they are still necessary to meet the requirements of the ESA for the remaining covered species. If Tacoma and the Services mutually agree that elimination or modification of mitigation measures initially implemented for the extinct species would not materially reduce the mitigation for another covered species, the mitigation measures will be eliminated or modified.

3.2.5 The Process and Timing

From a process and timing perspective, the Section 10 permit process has three phases. During the preapplication phase, the applicant communicates with the Services and other affected interests seeking to ensure that the conservation plan will minimize and mitigate the effects of the proposed project on listed species, the applicant then prepares an HCP intended to satisfy the ESA requirements. In addition, an IA is prepared that represents a binding contract between the permittee and the government by which the HCP is implemented. This phase is complete when the application package is submitted to the Services. Typically, an application package includes the permit application (Form 3-200), a completed draft HCP, a draft National Environmental Policy Act (NEPA) document, and a draft IA.

The second phase in the process is the formal processing of the application. During this phase, the Services review the application package for biological and statutory completeness; announce in the *Federal Register* the availability of the draft HCP, IA, and NEPA documents for a public review and comment period; and conduct the internal consultation required under Section 7 of the ESA. Once the documents are determined to be complete, and the public comments are received and considered, the Services determine whether the Section 10 permit criteria have been satisfied, finalize the NEPA documents, and issue or deny the permit.

In the post-application phase, notice of the result of the permit application is given to the public and entered into the administrative record. The Services may publish notice of the permit in the *Federal Register*, although this is not required in the ESA. This phase also includes monitoring of the implementation of the conservation plan, if required by the HCP or IA, and any adaptive actions that may be stipulated.

3.3 Other Legal Requirements

3.3.1 National Environmental Policy Act

Although not directly required from the applicant for an incidental take permit, the Services must comply with the NEPA of 1969, as amended, and the regulations of the Council on Environmental Quality in evaluating the impacts of issuing the incidental take permits. The requirements of NEPA, described in Section 102 of the statute (42 U.S.C.A. Section 4332[C]), are normally triggered by any major federal action that significantly affects the quality of the human environment. Under the Department of Interior's departmental manual, any ITP is categorically excluded from NEPA; unless issuing the permit may have cumulative or adverse effects on federally listed species; or unless the permit has or may have significant environmental, economic, social, historical, cultural, or cumulative impacts; or unless environmental effects are controversial.

In the context of this HCP, the NEPA process is intended to foster an appropriately complete and full disclosure of the environmental issues surrounding the proposed federal action (i.e., issuance of an ITP); to encourage public involvement in planning, identifying, and assessing a range of reasonable alternatives; and generally to explore all practical means to enhance the quality of the human environment and avoid or minimize adverse environmental impacts that may arise from the issuance of the permit.

The Services determine through both an internal and public scoping process the appropriate course of action relating to a proposed action and NEPA. Depending upon the scope and impact of the action, NEPA requirements can be satisfied in one of three ways: 1) categorical exclusion; 2) Environmental Assessment; or 3) Environmental Impact Statement. Compliance with NEPA was accomplished in the Tacoma's HCP process through the development of an *Environmental Impact Statement (EIS)*.

The NEPA requires an evaluation of environmental impacts to inform the federal decisionmaker. Also required by NEPA is an examination of environmental effects, including those not specifically addressed by other laws. This integrative assessment is an important aspect of the relationship between NEPA and HCPs. Together, these processes allow federal agencies and applicants to evaluate environmental impacts as a part of their planning and decisionmaking process.

3.3.2 Washington State Forest Practices Act

The Washington Forest Practices Act (RCW 76.09) and the implementing Forest Practices Rules and Regulations (WAC 222-08) are the principal means of state regulation of activities on private forestlands in Washington. Administered and enforced by the Washington Department of Natural Resources (WDNR), the Forest Practices Rules and Regulations address most issues of concern on forested lands, including harvest practices, regeneration, pesticide application, road construction, and the protection of other public resources such as water quality, fisheries, and wildlife. All harvest activities on private forestlands require a Forest Practices Notification or Approval from the WDNR, the issuance of which is contingent upon compliance with provisions of the Forest Practices Act and regulations. Most or all provisions within the Forest Practices Rules and Regulations ultimately influence fish and wildlife habitat by regulating how and when certain activities may take place on forestlands. Those with specific relevance to threatened and endangered fish and wildlife are contained in WAC 222-16-080, where critical habitats are defined and regulatory processes for conducting forest practices in critical habitats are described. Landowners with an approved HCP are exempt from the requirements of WAC 222-16-080 for the species covered in the HCP. All other provisions of the Forest Practices Rules and Regulations pertain to HCP holders. Management of forestlands in Tacoma's Upper HCP Area falls under the jurisdiction of the Forest Practices Act and will continue to comply with the Forest Practices Rules and Regulations under the HCP.

3.3.3 Clean Water Act

The City intends to seek Clean Water Act coverage from the Environmental Protection Agency (EPA) for this HCP. The fish and wildlife mitigation and Tacoma's management under this HCP is expected to meet or exceed the requirements of the Clean Water Act. When ESA and Clean Water Act activities and requirements have been coordinated and integrated through coordination with the appropriate state and federal agencies, the City will seek Clean Water Act coverage.

Section 303(d) of the federal Clean Water Act requires the states to identify and list threatened and impaired waterbodies. Every 2 years, the Washington State Department of Ecology (Ecology) prepares a list of these "water quality limited" waterbodies and submits them to the EPA for review and approval. In order to protect water quality, Ecology may also assess current water quality and recommend a Total Maximum Daily Load of problem pollutants. A major goal of a Total Maximum Daily Load study is to develop waste load allocations and load allocations for point and nonpoint sources of pollutants based on summer low flow conditions. Tacoma intends to cooperate with Ecology during Total Maximum Daily Load studies of the Green River. Implementation of the ITP is not expected to reduce Tacoma's participation in future Total Maximum Daily Load requirements that may be appropriate.

3.3.4 Migratory Bird Treaty Act

For those covered species that are listed as threatened or endangered under the ESA and that are also protected by the Migratory Bird Treaty Act, a Special Purpose Permit must be obtained. Such Special Purpose Permit shall be valid for a period of 3 years from the effective date of the permit, provided that the Section 10(a)(1)(B) permit remains in effect for that period. Such Special Purpose Permit shall be reviewed provided that the permittee continues to fulfill its obligations under the HCP and IA. Each such renewal shall be valid for the maximum period of time allowed by 50 CFR Section 21.27 or its successor at the time of renewal.

3.3.5 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act establishes prohibited acts and penalties to protect bald eagles and golden eagles. It is a violation of the act to, "…take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or in any manner, any bald eagle commonly known as the American eagle, or golden eagle, alive or dead, or any part, nest, or egg thereof…" For purposes of the Act, take is defined to include pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, and disturb. In 1996, the USFWS clarified that incidental take authorization provided under Section 7 or Section 10 of the ESA can include authorization for take under the Bald and Golden Eagle Protection Act. An ITP issued under Section 10 of the ESA covering bald eagles will include the following language:

> "The U.S. Fish and Wildlife Service will not refer the incidental take of any migratory bird or bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. ϶703-712), or the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. ϶668-668d), if such take is in compliance with the terms and conditions (including amount and/or number specified herein)."

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4. Existing Condition of the Green River Basin

4.1 Environmental Setting

4.1.1 Climate

The climate of the Green River basin is dominated by maritime influences of the Pacific Ocean and topographic effects of the Cascade Mountains. Regional climate is characterized by cool, wet winters and mild, dry summers. Precipitation is mostly derived from cyclonic storms generated in the Pacific Ocean and Gulf of Alaska that move inland in a southwest to northeast direction across western Washington. Over 80 percent of precipitation falls between the months of October and April. During summer months a regional high pressure system generally resides over most of the Pacific Northwest, which diverts storms and associated precipitation to the north.

This regional climatic pattern is modified by the presence of the Cascade Mountains, which rise to an elevation of approximately 5,000 feet at the eastern margin of the Green River basin. Moist, maritime air cools and condenses as it moves up in elevation from west to east through the basin, resulting in decreasing temperatures and increasing precipitation up this elevation gradient. Consequently, there is a considerable difference in both temperatures and precipitation from the lower to the higher elevations of the basin (Table 4-1). In addition, there is more snow in the upper portion of the basin. Melting of snow and the resulting surface runoff in spring is a major source of water to streams. The seasonality of rainfall combined with this snowmelt pattern results in streams having most of their discharge in winter and spring months. The climatic pattern and topography interact to determine a runoff pattern that results in wet winters and dry summers. This runoff pattern affects the strategy of storing water for augmenting low summer instream flows and municipal water supplies (see Chapter 4.3 below).

Table 4-1. Temperatures and precipitation in the Green River basin.

Location	Elevation (feet)	Period of Record	Mean July Max. Temperature (ºF)	Mean Jan. Min. Temperature (ºF)	Mean Annual Precipitation (inches)	Mean Annual Snowfall (inches)
Sea-Tac Airport	400	1931-1998	75	35	38	0
Palmer	900	1931-1998	75	31	91	43
Stampede Pass	3,300	1944-1998	65	20	88	442

Source: Western Regional Climate Center, 1998.

4.1.2 Geology and Soils

4.1.2.1 Geological History

The Green River basin is primarily comprised of four types of geological deposits: sedimentary rocks of the Puget Group, volcanic rocks forming the Cascade Mountains, glacial deposits from the Pleistocene, and alluvium deposited by rivers since the last glaciation.

The oldest deposits are Tertiary sandstones and mudstones of the Puget Group, a series of soft and erodable rock units that were deposited in a large coastal plain around 50 to 60 million years ago. These deposits are exposed in the Green River Gorge and in hills near the confluence of the Green and Black rivers near Tukwila, but are elsewhere overlain by younger formations (Fuerstenberg et al. 1996). The sandstones and mudstones are easily broken down into fines and do not persist as cobble- and gravel-sized particles after entering the river.

From 50 to 6 million years ago during the Tertiary period, repeated volcanic activity, with intervening periods of erosion, created the Cascade Mountains in the eastern portion of the basin. These rocks are predominantly andesite flows, andesitic tuffs, and breccias with subordinate amounts of basalt and basaltic, pyroclastic, and felsitic rocks (USACE 1995). Volcanic deposits cover most of the basin east of Palmer. More resistant volcanic rocks are an important source of gravels and cobbles to the upper Green River channel. Prior to major landscape alterations from glacial activity, the Green River flowed from the area where the Howard Hanson Dam (HHD) is now located through a valley emerging near the present community of Selleck, Washington.

During the Pleistocene, from about 1 million years to approximately 12,000 years ago, large lobes of glaciers up to 3,000 feet thick extended south from British Columbia and covered the lowlands around Puget Sound. These glacial advances and retreats scoured existing bedrock and left a complex array of glacial outwash, till, alluvium, and lacustrine deposits. Glacially derived, unconsolidated sediments cover most of the basin west of Palmer and are a contributor of gravels to the middle Green River. The watershed of the Green River above HHD includes terraces formed in the underlying lava and bedrock by glacial scouring, as well as lacustrine terraces formed when a glacially impounded lake had stable water levels for extended periods.

Since the Pleistocene, the Green River incised a new meandering route through the middle basin to around Auburn. During this time, it carved the Green River Gorge, one of the most notable geological features in the basin. The White and Cedar rivers also found new channels after the last glacial advance and converged with the Green River into an embayment of Puget Sound that extended up the present Duwamish/Green River Valley, each river creating its own delta. In addition, around 5,000 years ago, the Osceola Mudflow swept down from the slopes of Mount Rainier through the valley of the White River. This major geological event covered the lowlands from Enumclaw to approximately 4 miles north of Auburn with mudflow deposits up to 75 feet thick, well into the present lower Green River basin. The combined effects of these depositional processes eventually filled in the embayment to form a broad lowland characterized by meandering river channels and extensive wetlands.

At the beginning of the 19th century, the Green River flowed into the White River near Auburn. The Cedar River joined the Black River in the Renton area. The Black River was also the outlet of Lake Washington and its associated watershed. The Black River merged with the White River near Tukwila to form the Duwamish River and its associated estuary.

The channels and routes of all these rivers in their lower reaches have undergone major alterations since settlement of the area by Euroamericans. As a result of several large floods, the effects of major log jams, and direct human intervention, the White River now flows south into the Puyallup River, and the Green River has become the major tributary to the Duwamish River (i.e., the previous White River below the confluence of the Green River was renamed as the Green River). With the lowering of Lake Washington that resulted from the creation of the Ship Canal through Lake Union, the Black River no longer carried the outflow of Lake Washington into the White River. The Cedar River was rerouted into Lake Washington to provide the flow needed to operate the Ship Canal. The Green River was also rerouted in places and largely channelized in the lower basin. These alterations have resulted in a reduction in the drainage area of the Duwamish River to about one-third its original extent and a reduction in the drainage area of the lower Green River above the Duwamish River to about one-half its original extent (Dunne and Dietrich 1978).

4.1.2.2 Soils and Topography

Soils in the upper Green River basin are largely derived from volcanic parent material and occur on mountainous slopes that become quite steep toward the crest of the Cascade Mountains. The upper basin also includes terraces in the underlying lava and bedrock created by glacial scouring and by wave action in large Pleistocene lakes that developed between the glacial lobe and the Cascade Mountains. Many locations of bedrock outcrop also exist. The upper Green River and its tributaries have relatively narrow to nonexistent floodplains that are confined by the steep valley sides.

The potential for erosion hazard is high or severe on many soils where the slopes are greater than 35 percent (USFS 1996). These soils often slump or slide in rainy periods after vegetation has been removed. Soil depths range from shallow soils associated with rock outslopes and talus slopes to very deep (>12 feet) valley bottom soils.

In the middle Green River basin from Palmer to near Auburn, soils are largely derived from unconsolidated glacial material and occur on more gradual slopes characterizing the rolling topography in this area (SCS 1973). Soils in the Everett association, which are gravelly sandy loams formed in glacial outwash deposits, dominate the uplands surrounding the Green River floodplain. Floodplain soils in the middle basin are in the Oridia-Seattle-Woodinville association, which consists of somewhat poorly drained to very poorly drained silt loams, mucks, and peats. There are also strips of gravel and sand deposited along channels, which are typically quite narrow but average nearly 1,000 feet in width (nearly one-third of the floodplain) near the confluence of Newaukum Creek (Mullineaux 1970).

The floodplain of the middle Green River varies considerably in width. The Green River Gorge has virtually no floodplain, due to the rapid downcutting through relatively weak sandstones and mudstones. Downstream of the Gorge, the river has developed a broad floodplain in a valley that is typically about 0.5 mile in width.

In the lower Green River basin, soils are also in the Oridia-Seattle-Woodinville association developed from fine-textured alluvial material deposited by the Green, White, and Cedar rivers, with organic soils in depressional areas. Soils in the lower Green River basin have high agricultural potential, although urban development has now eliminated much of the previous agricultural land use in the area.

Prior to settlement by Euroamericans, the floodplain of what was once the lower White River probably covered most of the floor of what is now the Green River Valley north of Auburn, which averages about 2 miles in width. Due to the construction of levees, dredging of channels, and flood control by HHD, this floodplain is now essentially inactive.

4.1.3 Water Quality

Washington State Surface Water Quality Standards

The Washington State Department of Ecology (Ecology) has established surface water quality standards pursuant to Chapter 90.48 (Water Pollution Control Act) and Chapter 90.54 RCW (Water Resources Act of 1971) to protect uses of water beneficial to wildlife and humans. Water quality standards affected by forest practices are addressed by the Washington Forest Practices Board Manual, which states that "whereas Ecology is solely responsible for establishing water quality standards for waters of the state, both the Forest Practices Board and Ecology shall jointly regulate water quality issues related to silviculture in the State of Washington (RCW 90.48.420)." As a result, WAC 173-202, Washington Forest Practices Rules and Regulations to protect Water Quality, was jointly developed and adopted by the Forest Practices Board and Ecology so that compliance with Forest Practices Rules and Regulations would in turn achieve compliance with water pollution control laws.

Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC) classify the Green River as Class "AA" (extraordinary) upstream of River Mile (RM) 42.3 (Flaming Geyser State Park), Class "A" (excellent) between Flaming Geyser State Park and the Duwamish River confluence (RM 42.3 to 11.0), and Class "B" (good) within the Duwamish River (WAC 173-201A-130). These specific classifications are meant to define present and potential uses of these waters and do not necessarily define natural conditions. For example, WAC 173-201A-030 states that Class B waters shall meet or exceed the requirements for most uses (beneficial uses, as described in WAC 173-201A-030, include, but are not limited to: agricultural and industrial water supply; stock watering; fish and shellfish habitat; wildlife habitat; and secondary contact recreation). Class AA waters shall markedly and uniformly exceed the requirements for all or substantially all uses (identical to those listed for Class B waters, but in addition include domestic water supply and primary contact recreation). These classifications indicate that the Green River has sufficient water quality to support current uses of the river; however, several areas (primarily below Auburn) have been identified where water quality may be limiting to beneficial uses of the river during certain times of the year (USACE 1995 and discussed below).

Different sets of water quality criteria apply to Class AA, Class A, and Class B waters to ensure that the different beneficial uses of these waters are protected. Table 4-2 presents the criteria, as established in WAC 173-201A-030, that apply to Class AA, A, and B

Table 4-2. Water quality standards applicable to the Green River (WAC 173-201A-030).

Freshwater Class AA (extraordinary) Water Quality Standards	
Fecal coliform	Organism levels shall both not exceed a geometric mean value of 50 colonies/100 ml and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 ml.
Dissolved oxygen	Shall exceed 9.5 mg/L. Total dissolved gas shall not exceed 110% of saturation at any point of sample collection.
Temperature	Shall not exceed 16.0 degrees Celsius (ºC) due to human activities. When natural conditions exceed 16.0ºC no temperature increases will be allowed that will raise receiving water temperatures by greater than 0.3ºC.
PH	Shall be within the range of 6.5 to 8.5 with a human-caused variation within a range of less than 0.2 units.
Turbidity	Shall not exceed 5 Nephelometric Turbidity Units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background turbidity is more than 50 NTU.
Toxic substances	Shall be below those that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department (toxic substances include metals and ammonia nitrogen).
Freshwater Class A (excellent) Water Quality Standards	
Fecal coliform	Organism levels shall both not exceed a geometric mean value of 100 colonies/100 ml and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 ml.
Dissolved oxygen	Shall exceed 8.0 mg/L. Total dissolved gas shall not exceed 110% of saturation at any point of sample collection.
Temperature	Shall not exceed 18.0 degrees Celsius (ºC) due to human activities. When natural conditions exceed 18.0ºC no temperature increases will be allowed that will raise receiving water temperatures by greater than 0.3ºC.
PH	Shall be within the range of 6.5 to 8.5 with a human-caused variation within a range of less than 0.5 units.
Turbidity	Shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background turbidity is more than 50 NTU.

Table 4-2. Water quality standards applicable to the Green River (WAC 173-201A-030).

Toxic substances	Shall be below those that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department (toxic substances include metals and ammonia nitrogen).
Freshwater Class B (good) Water Quality Standards	
Fecal coliform	Organism levels shall both not exceed a geometric mean value of 200 colonies/100 ml and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 400 colonies/100 ml.
Dissolved oxygen	Shall exceed 6.5 mg/L. Total dissolved gas shall not exceed 110% of saturation at any point of sample collection.
Temperature	Shall not exceed 21.0 degrees Celsius (ºC) due to human activities. When natural conditions exceed 21.0ºC no temperature increases will be allowed that will raise receiving water temperatures by greater than 0.3ºC.
PH	Shall be within the range of 6.5 to 8.5 with a human-caused variation within a range of less than 0.5 units.
Turbidity	Shall not exceed 10 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 20% increase in turbidity when the background turbidity is more than 50 NTU.
Toxic substances	Shall be below those that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department (toxic substances include metals and ammonia nitrogen).

waters. These state standards must be maintained as designated by Chapter 173-201A WAC.

Section 303(d) of the federal Clean Water Act requires states to identify and list threatened and impaired waterbodies. The purpose of the 303(d) listing is to identify waterbody segments that are not expected to meet state surface water quality standards after implementation of technology-based pollution controls. Every 2 years, Ecology prepares a list of these “water quality limited” waterbodies and submits them to the U.S. Environmental Protection Agency (EPA) for their review and approval.

In 1998, Ecology prepared a proposed list of water quality limited waterbodies for the state. To date this list has not received final approval by the EPA. Segments of the Green River on the 303(d) list that are within influence of the proposed action and all alternatives include the following: 1) the Green River between RM 11 and 42.3 (waterbody segment WA-09-1020), listed as limited for mercury, fecal coliform bacteria, and temperature; and 2) the Green River between RM 42.3 and 64.5 (waterbody segment WA-09-1030), listed as limited for temperature (Ecology 1998). Stream segments that are not monitored on a consistent basis may be water quality limited but would not be considered for inclusion on the 303(d) list.

Water quality standards are also maintained through the state's riparian policy, which is aimed at providing adequate physical components to maintain functions necessary to water quality, fish, and wildlife. Forest Practices Rules and Regulations require that Riparian Management Zones (RMZs) of specified widths must be maintained along each side of WDNR Type 1, 2, and 3 streams during timber harvest operations. Leave-tree requirements for RMZs have also been established for WDNR Type 1 through 3 waters. Established RMZs are required to provide adequate stream shade, as defined in WAC 222-30-040. Riparian buffer requirements under Tacoma's Forest Management Plan afford greater water quality protection than the state's standard forest practices as well as rules proposed by Timber/Fish/Wildlife that are currently being considered by the state legislature.

To protect the City of Tacoma water supply, discharges of waste into the upper Green River basin are prohibited by the state. The City of Tacoma limits public access into much of this area. However, sediment input to the river resulting from high flow events is known to occur and sometimes causes turbidity problems at the Tacoma Water Supply Intake at RM 61.0 (Headworks). Drawdown of the HHD reservoir for flood control may resuspend fine sediments behind HHD and increase downstream turbidity. Water quality in the Green River below the Headworks is affected by a range of impacts including agriculture, forestry practices, stormwater runoff from urbanized areas, and contaminated sediments and groundwater from industrialized areas and landfills (USACE 1998).

Specific water quality data for temperature, dissolved oxygen (DO), turbidity, fecal coliform bacteria, and metals and toxics levels in the Green River are discussed below. This characterization is based on a 1985 study commissioned by King County, as reported by the USACE (1995, 1998) and on more recent monitoring by Ecology and King County.

4.1.3.1 Temperature

Summer water temperatures in the Green River increase progressively as the water travels downstream. Based on data reported by the USACE (1995), water temperatures in the Green River above HHD were found to be generally below 16ºC (60ºF). However, inflows into the HHD reservoir did exceed 16ºC (60ºF) during the summer in most years. Such periods were generally brief and did not appear to greatly affect reservoir temperatures. Temperatures in the lower levels of the reservoir during the summer were found to be between 10ºC and 12.8ºC (50ºF and 55ºF), which was 9.4°C (15ºF) below surface temperatures during the same time period. Surface temperatures fluctuate more than deeper layer temperatures, and reservoir stratification was generally weaker than in natural lakes (USACE 1998). A more thorough assessment of temperature conditions in the Green River can be found in the Additional Water Storage (AWS) project DFR/DEIS, Appendix D3, Section 1 (USACE 1998).

Low flow releases from HHD during the summer conservation period are made through a 48-inch bypass intake located about 35 feet above the bottom of the pool. The 48-inch bypass pipe is located below the level of typical reservoir stratification. As a result of drawing water from the lower, colder stratum, releases from HHD during the early summer are usually below expected natural temperatures. Later in the summer and in early fall, as cooler water is depleted and warmer surface water is released, temperatures are higher than would be expected under a natural, unimpounded flow regime (USACE 1998). These artificially higher temperatures can adversely affect salmon spawning behavior and may accelerate maturation of developing salmon eggs.

High temperatures in the lower and middle Green River probably result from solar heating of the river during summer low flow periods. The factors responsible for this warming include extensive paved areas in the lower Green River basin that reduce groundwater recharge and subsequent discharge of cool groundwater into the river, low summer flows, and lack of shade along the lower river (USACE 1998).

Caldwell (1994) studied temperatures between HHD and the confluence with the Duwamish River. Between HHD and the Headworks, summer water temperatures averaged 13.9ºC to 18.3ºC (57ºF to 65ºF). Caldwell found water temperatures at the Headworks, 3.5 river miles below the dam, to be independent of HHD outfall temperatures.

Between the lower end of the Green River Gorge and the City of Tukwila, maximum temperatures between 22.5ºC and 24ºC (72.5ºF and 75.2ºF) were observed in the summer months. These reported temperatures exceed the state criterion and caused the middle Green River (waterbody segments WA-09-1020 and –1030) to be placed on the state's 303(d) list for temperature.

King County and the Ecology have also measured numerous instances of high water temperatures in the lower Green/Duwamish rivers, particularly at water quality stations located immediately upstream of the confluence of the Green and Duwamish rivers.

Water temperatures above 15.5ºC (60ºF) are limiting for coldwater-adapted fish, such as salmon and steelhead and also contribute to low DO, another potentially limiting water quality parameter. Elevated temperatures may also result in algae blooms, a particular concern in the lower Green River and in the Duwamish River. It is also thought that high water temperatures affect the movement of migrating adult salmonids, particularly during August and early September and may affect salmon egg viability and survival (Caldwell 1994).

4.1.3.2 Dissolved Oxygen

Dissolved oxygen can be severely limiting to aquatic organisms, and species differ in their abilities to tolerate low DO levels. Since DO levels in clean waters are inversely related to temperature, low DO levels have the highest potential to occur during periods of high temperatures. In the Green River above HHD, DO levels were found to be relatively high and stable (USACE 1995), consistent with the generally cool temperatures recorded in this reach. The low level of stratification in the HHD reservoir allows DO to disperse to the bottom layers, and the reservoir is oligotrophic with no significant algae blooms or macrophytes that might decay and result in low DO. There have been no recorded observations in the Green River or in the HHD reservoir where DO has fallen below the standard for Class "AA" waters (9.5 mg/l), although there has been little sampling in these waters.

In the middle and lower Green River, levels of DO are generally satisfactory to support fisheries resources. However, samples collected by King County in the lower Green River show a few occasions where DO levels were measured below the state Class "A" criterion (USACE 1995). However, these violations of the state criterion were not frequent enough to warrant listing the lower Green River as water quality-limited for DO. Low DO can impair successful migration by fish and may affect reproductive success, especially during periods when eggs and hatchlings are within the gravel strata.

4.1.3.3 Turbidity

Turbidity is the only water quality parameter that has seasonally exceeded Class "AA" standards in the Green River above HHD (USACE 1995). Periods of high turbidity are generally associated with winter storms and snowmelt. Evaluation of fine sediment production in the Green River by O'Conner (1995, as cited in USFS 1996) shows that sediment production increased from the period 1958-1967 to 1968-1978, but decreased from 1968-1978 to 1979-1995. O'Conner found that mass wasting was the largest source of fine sediment to the river. Timber harvest and road construction increased dramatically in several subwatersheds of the upper Green River in the late 1960s and early 1970s. Large runoff events in association with these management activities are a likely cause of higher sediment production in the 1968-1978 period. With recovery of vegetation and better forest management practices, sediment production in the Green River watershed has since been declining.

The U.S. Forest Service (USFS) has estimated that 824 miles of road access exists in the upper Green River basin (USFS 1996), of which approximately 34.5 miles are decommissioned roads. Roads, especially older roads, can contribute significant quantities of sediments to the streams and the upper Green River. Additionally, roads on steep slopes can cause mass-wasting events, which may cause large debris flows into streambeds. Suspended sediments in upper basin streams eventually enter the HHD reservoir. According to the USACE, studies have shown a net accretion of sediment in the reservoir, since large, heavy particles settle in the reservoir while small particles are carried downstream of the dam (USACE 1998).

In the lower and middle Green River, turbidity is not generally limiting to fish, though it may limit other uses such as water supply and recreation. Turbidity is of greatest concern during flood events and when HHD reservoir levels are low, both of which can result in river water at the Headworks being too turbid for use by Tacoma Water (Tacoma). When this occurs, Tacoma uses water from the North Fork well field located in the upper North Fork Green River basin until turbidity levels fall to acceptable levels. A detailed discussion of turbidity effects from operation of the HHD can be found in Appendix D3, Section 2 of the AWS project DFR/DEIS (USACE 1998).

4.1.3.4 Fecal Coliform

Human fecal coliform sources in the Green River basin above HHD are minor, because of restricted development in this portion of the watershed. Animal fecal coliform sources in the basin above HHD are limited to wildlife populations in the immediate vicinity of the mainstem and tributaries. The City of Tacoma's Forest Land Management Plan for the Green River watershed manages lands to attract elk and deer away from areas near waterbodies to reduce potential fecal coliform input from those sources (Ryan 1996).

Water quality standards for fecal coliform are frequently exceeded in parts of the lower and middle Green River and its tributaries. The state water quality standard established for fecal coliform was exceeded 204 times during the period from July 1987 to January 1992 in the lower Green/Duwamish River, including tributaries (USACE 1995). More recent monitoring between 1991 and 1997 conducted by King County and Ecology have documented enough failures of the fecal coliform standard to place the lower and middle Green River (overlapped by waterbody segment WA-09-1020) on the state's 303(d) list. Livestock access to streams is thought to be the primary cause of high fecal coliform levels, and exceedances are most common during significant storm events when storm runoff washes fecal material from agricultural lands. In addition, the functional lifespans of the septic systems for some of the early developments along the river have been exceeded. As a result, failing septic systems may be contributing to the elevated coliform levels measured between Auburn and Kent (USACE 1995).

4.1.3.5 Metals and Toxics

In the upper Green River above HHD, heavy metals such as arsenic, lead, and zinc have been identified in preliminary results from sediment and tissue samples from resident fish taken at Twin Camps Creek, which were collected as part of the U.S. Geological Survey's (USGS) National Water Quality Assessment Program (USACE 1998). The Puget Sound Basin, including the Green River basin, is 1 of 15 water quality study units initiated in 1994 under the National Water Quality Assessment Program. The source of these heavy metals is unclear as there has been very limited resource development in the area besides timber management.

Ecology has measured levels of mercury, copper, lead, and zinc above state-established standards in the Duwamish River (USACE 1995). However, concentrations of most of these metals have not exceeded state standards frequently enough to warrant placement on the state's 303(d) list for 1998. The metal of most concern in the Green River is mercury. King County and Ecology have reported mercury at levels above state standards in the lower Green River. These sampling results have put the lower Green River (waterbody segment WA-09-1020) on the state's 303(d) list for mercury. One source of mercury was the Renton Treatment Plant, which discharged wastewater into the Black River/Springbrook Creek until 1987. An additional source of metals into the river may be leachate from the now closed Kent Highlands Landfill.

Toxic contaminants have been identified in bottom sediments and surface water in the lower Green River and especially in the Duwamish River (USACE 1995). Chemical testing of bottom sediments in the lower 5 miles of the Duwamish River revealed contamination by oil and grease, sulfides, pesticides, and polychlorinated biphenyls. More recently, Ecology cited excursions beyond criteria in sediment for polychlorinated biphenyls and polyaromatic hydrocarbons. Potential contamination sources are common along industrialized sections of the Duwamish River, which is currently being addressed as part of the EPA's *Elliott Bay Toxics Action Plan* as well as other programs addressing remediation and source control for toxic contaminants. Runoff from agricultural and other developed areas are also thought to be sources of toxic contaminants in the lower Green River.

4.1.4 Hydrology

4.1.4.1 Surface Water

The Green River originates in the high Cascades and flows northwest for approximately 93 miles, draining an area of over 460 square miles before emptying into Puget Sound at Elliott Bay. Forty-eight tributaries enter the system above HHD, feeding both the mainstem and reservoir. Large headwater tributaries include the North Fork of the Green River, and Sunday, Smay, Charley, Gale, Twin Camp, Sawmill and Friday creeks. These tributaries lie within the snow zone and exhibit two distinct discharge peaks due to fall rainstorms and spring snowmelt.

Below HHD, major tributaries include Newaukum and Soos creeks, which enter the middle Green River near RM 41.0 and RM 34.0, respectively. The Soos Creek system consists of Big Soos Creek and approximately 25 tributaries. The Soos Creek system contains over 60 miles of streams and drains an area of nearly 70 square miles. Heavily wooded riparian corridors interspersed with pastures and increasing residential development characterize the upper sections of Big Soos Creek. Existing development in the basin ranges from rural to high density urban. A number of flow-related problems have been associated with the increasing urban development in the Soos Creek basin (King County 1995). With increasing impervious surface area, water runs off more quickly and less is captured and stored by wetlands or alluvial aquifers, reducing groundwater contributions that maintain summer low flows. As a result, peak flood flows have increased and summer low flows have decreased.

Other tributaries to the lower and middle Green River include Mill and Springbrook creeks. The Mill Creek and Mullen Slough drainage covers a combined area of about 22 square miles to the west of the lower Green River. The Mill Creek subbasin extends into portions of the cities of Kent, Auburn, Federal Way, and Algona, in addition to unincorporated parts of King County. Springbrook Creek arises near the city of Kent and flows roughly parallel to the Green River for approximately 12 miles before emptying into the former Black River, and thence into the Green River near Tukwila.

Tributary basins to the middle and lower Green River contain three different types of landforms: the very flat Green River valley floor, steep bluffs that formed as the Green River cut down through glacial deposits following the last glacial episode, and rolling upland plateaus with numerous lakes and wetlands that form the headwaters of many small tributary streams. Runoff from the upland plateaus flows down to the Green River valley through a series of steep, well-incised ravines. On the valley floor, the watercourses flatten, and in the more developed Mill and Springbrook subbasins, a complex network of ditches drains the valley floor. As noted in Soos Creek, contributions of surface flow during storm events have increased dramatically in the smaller tributaries as a result of urban development, while groundwater contributions have decreased.

Floods in the Green River are generally the result of heavy rainstorms during the months of October to February, which may be substantially augmented by rain-on-snow events. The highest flows occur during the winter in response to rainfall and rain-on-snow events, and are followed by a series of smaller, secondary peaks resulting from snowmelt during the spring (Figure 4-1). Prior to the construction of HHD, the highest flow recorded at the Auburn gage was 28,100 cubic feet per second (cfs) on 23 November 1959 (USGS 1996), and the 2-year recurrence interval flow was approximately 12,000 cfs (Dunne and Dietrich 1978). Since construction of HHD in 1964, no flows greater than 12,000 cfs have occurred at the Auburn gage (Figure 4-2). High flows during the spring were generally lower than those that occurred during the fall and winter; the highest flow recorded for the period between February to May was 15,500 cfs.

There are currently a number of USGS gages in the Green River Basin. The most important gages from the standpoint of this Habitat Conservation Plan (HCP) are those located on the mainstem Green River at RM 32.0 near Auburn (121130000) and at RM 60.3 near Palmer (12106700), 0.7 miles downstream of Tacoma's Headworks (Figure 2-1).

No record of daily flows is available for the late 1800s prior to completion of Tacoma's Headworks at RM 61.0 in 1913. Therefore, natural, or unregulated, flow conditions in the Green River were approximated using modeled data to estimate flows in the absence

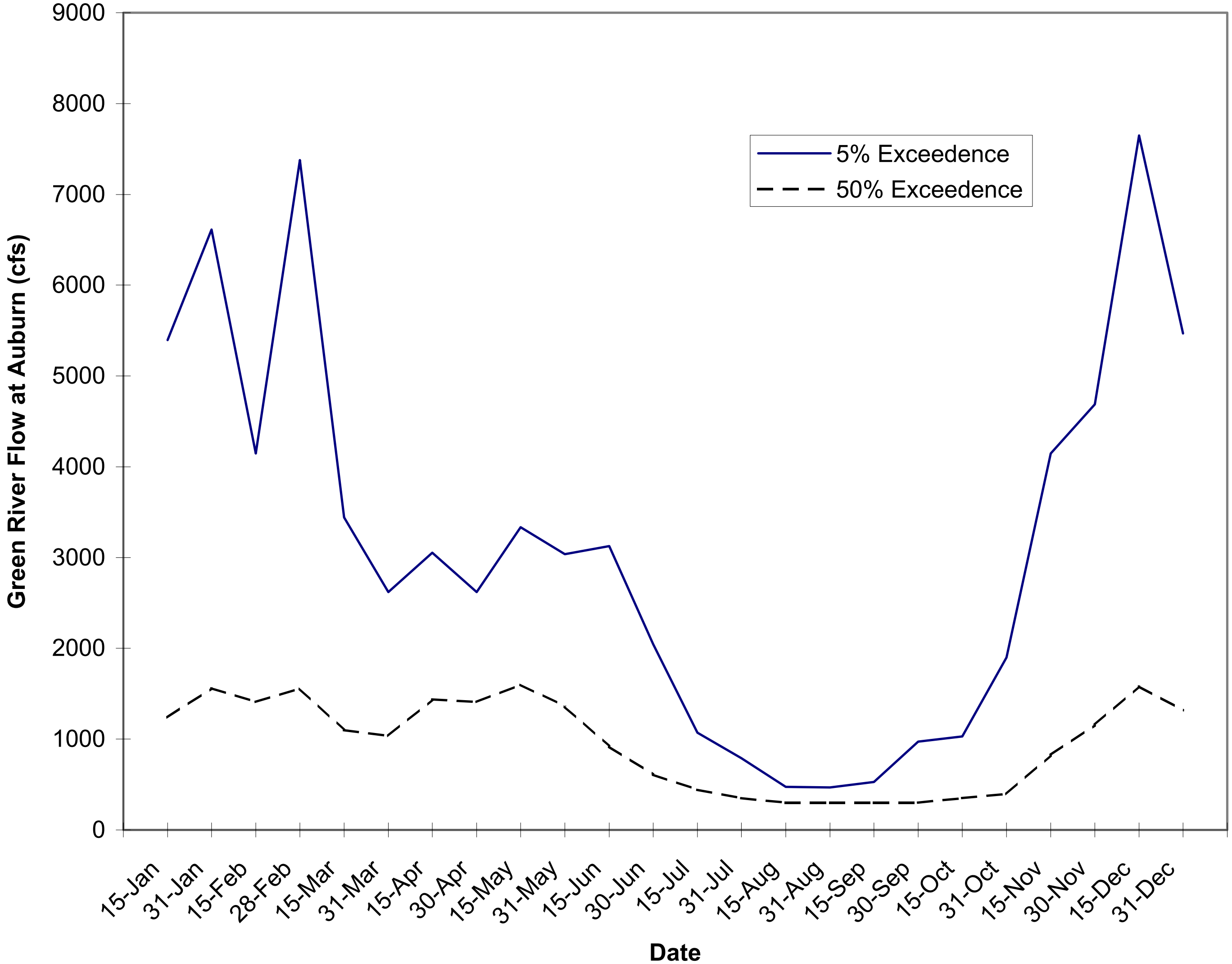


Figure 4-1. Five and 50 percent exceedance flows in Green River near Auburn, WA, 1964-1995 (Source: CH2M Hill 1997).

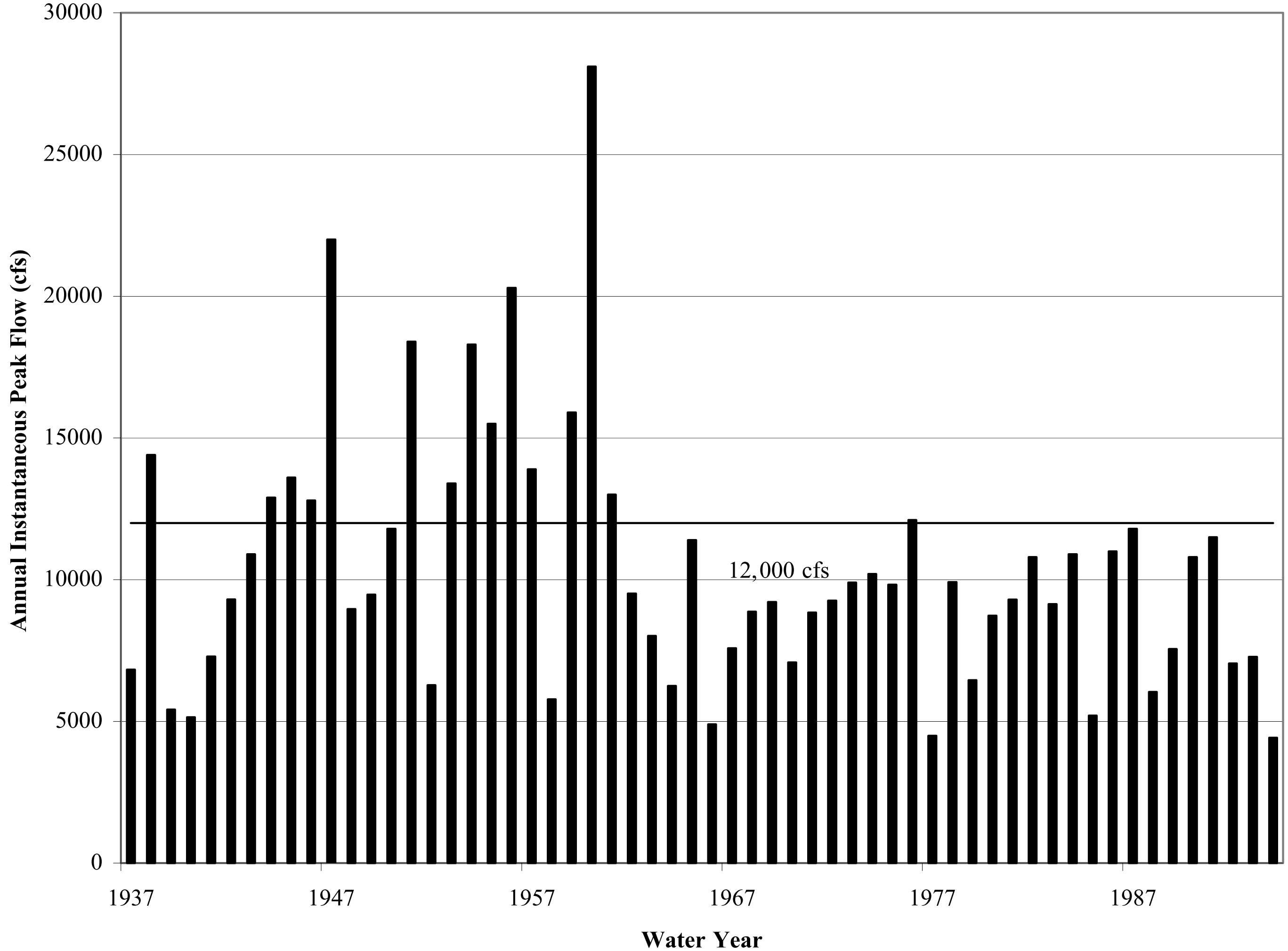


Figure 4-2. Annual instantaneous peak flows, USGS Gage 12113000, Green River near Auburn, WA (Source: AWS project DFR/DEIS, Appendix F1, Section 4b)

of both HHD and Tacoma's diversion (CH2M Hill 1997). The model was used to develop a 32-year record of daily flows for the period between 1964 and 1995, which is believed to be representative of typical annual and seasonal flow variations in the Green River. Results are characterized as unregulated rather than true "natural" conditions since the model does not incorporate information on potential variations in flows due to climatic conditions, forest harvest activities in the upper watershed, or other land use activities, although these factors might be expected to influence the flow regime.

The unregulated flow regime of the Green River was described using several hydrologic parameters calculated using the modeled data. The unregulated flow regime of a river varies on time scales of hours, days, seasons, years and longer. Hydrologists and aquatic ecologists have recently begun to realize that the full range of intra- and inter-annual variation in hydrologic regimes is necessary to sustain the native biodiversity and function of aquatic and riparian ecosystems (Richter et al. 1996; Poff et al. 1997). The selected parameters, while by no means a complete set of all possible hydrologic statistics, represent three of the five groups identified by Richter et al. (1996) (magnitude of monthly means, magnitude and duration of annual extremes; and frequency and duration of pulses). These statistics are believed to represent aspects of the flow regime of primary importance to salmonid fishes and their habitats in the Green River. For example, annual high flows (annual 3-day maximum) generally represent flows that are responsible for maintaining channel morphology and floodplain functions such as groundwater recharge and riparian succession. Spring freshets (defined here as flows greater than 2,500 cfs, the flow at which the majority of existing side channels become connected to the mainstem) may be instrumental in stimulating the downstream movement of juvenile salmonids. Extended periods of low flow in the Green River may occur as a response to summer droughts or prolonged periods of sub-freezing weather during the winter. Extreme summer low flows occurring between 15 July and 15 September reflect limitations in juvenile rearing habitat, while extreme low flows that occur during the winter may dewater redds, reducing reproductive success. Average daily flows for each month provide a general measure of habitat availability or suitability.

Modeling suggested that the largest unregulated 3-day maximum flow between 1964 and 1995 in the absence of both HHD and Tacoma's diversion would have been approximately 17,759 cfs in January 1965. Extreme high flows are important for creating off-channel habitat and recharging groundwater aquifers, as discussed in Chapter 4.5.3.1. Because of the way the model is constructed, individual daily values may not reflect actual flow conditions. However, values averaged over periods longer than 2 days are accurate, thus annual extreme high flows are represented by the 3-day maximum flow.

The modeled unregulated flow data indicated that without HHD and Tacoma's First Diversion Water Right claim (FDWRC) withdrawals spring flows at the USGS Auburn gage during the period between 1964 and 1995 were generally less than 4,000 cfs, although freshets up to 11,400 cfs would have occurred periodically. Unregulated baseflows in the spring were sometimes higher than unregulated baseflows in the fall and winter, especially in wet years with a heavy snowpack (Figure 4-3). Flows at the Auburn gage in April and May generally exceeded 1,000 cfs under unregulated conditions (Figure 4-4). The average 7-day low flow between 1 April and 31 May during the 1964 to 1995 model period was 982 cfs; the lowest spring 7-day low flow measured during that period was 270 cfs (Table 4-3).

Spring freshets (defined as a single continuous flow event exceeding 2,500 cfs) were most common in February, followed by April and May. The timing, magnitude, and duration of freshets is important, as downstream migration by juvenile salmonids may be triggered by such events, and because high flows during the spring allow young fish to move downstream more rapidly, reducing the time they may be exposed to predators. During the period February through June, an average of 4.6 freshets per year were estimated to occur under the unregulated flow regime, with monthly averages for the months of February through June ranging from 1.3 to 0.28 freshets per month (Table 4-4). The average freshet duration was approximately 5 days, although the duration of individual events was highly variable, ranging from 1 to 28 days.

Under the unregulated flow regime, flows were generally lowest in August and September. The 7-day low flow represents the average daily flow during the 7 consecutive days with the lowest flows, and is conventionally used in evaluating low flow impacts because shorter flow durations have much greater variability. The model data suggests that the average 7-day low flow at the Auburn gage for the period of 15 July to 15 September was approximately 290 cfs, ranging from 203 to 462 cfs (Table 4-3). The average 7-day low flow for the remainder of the year was 268 cfs, ranging from 172 to 462 cfs (Table 4-3). Although the average monthly flow was lowest in August, extreme low flows generally occurred in mid- to late September or early October, and may have dropped to below 150 cfs.

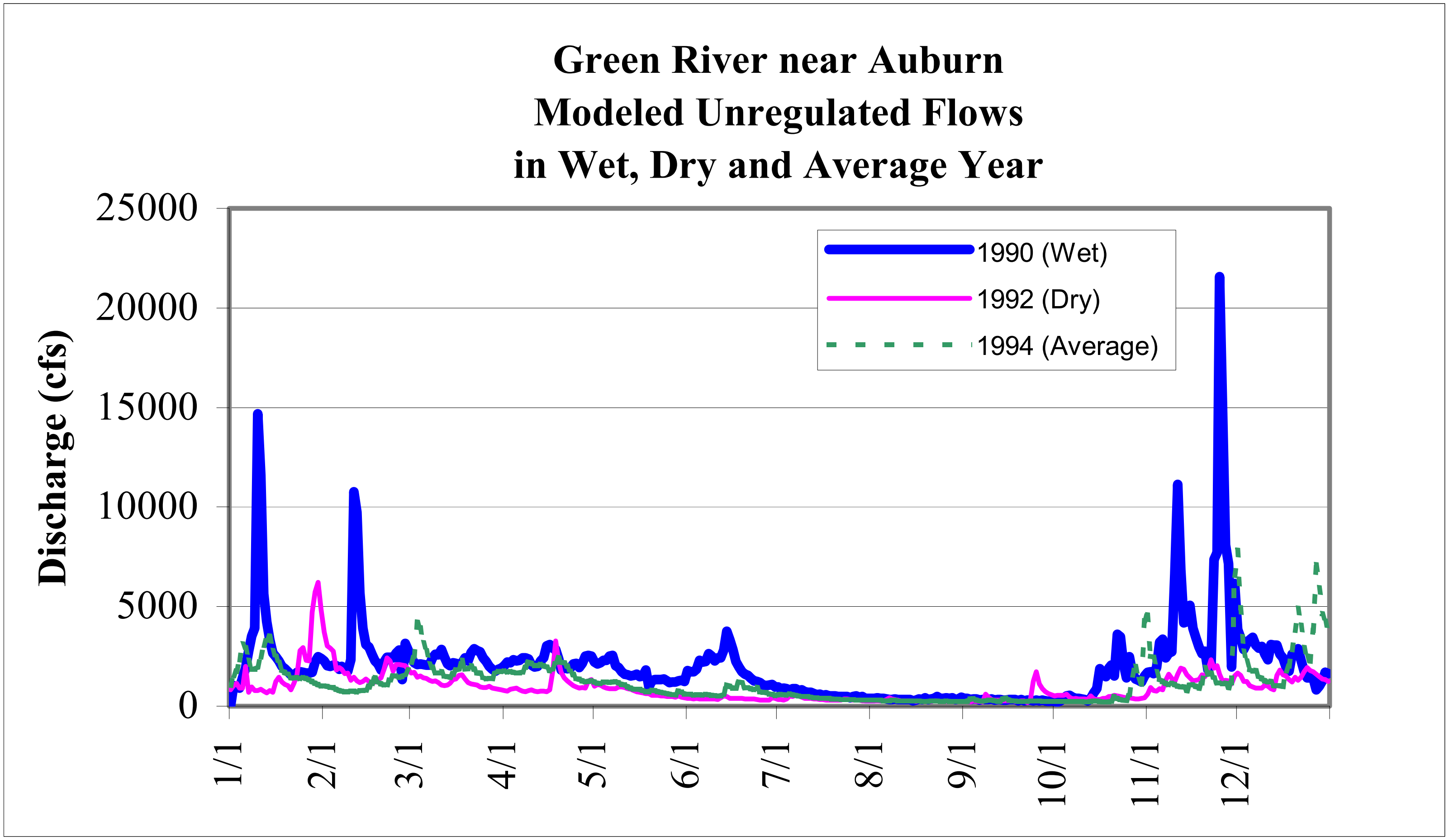


Figure 4-3. Modeled unregulated flows at the Green River Near Auburn USGS gage (12113000) in selected wet, dry, and average flow years (Source: CH2M Hill 1997).

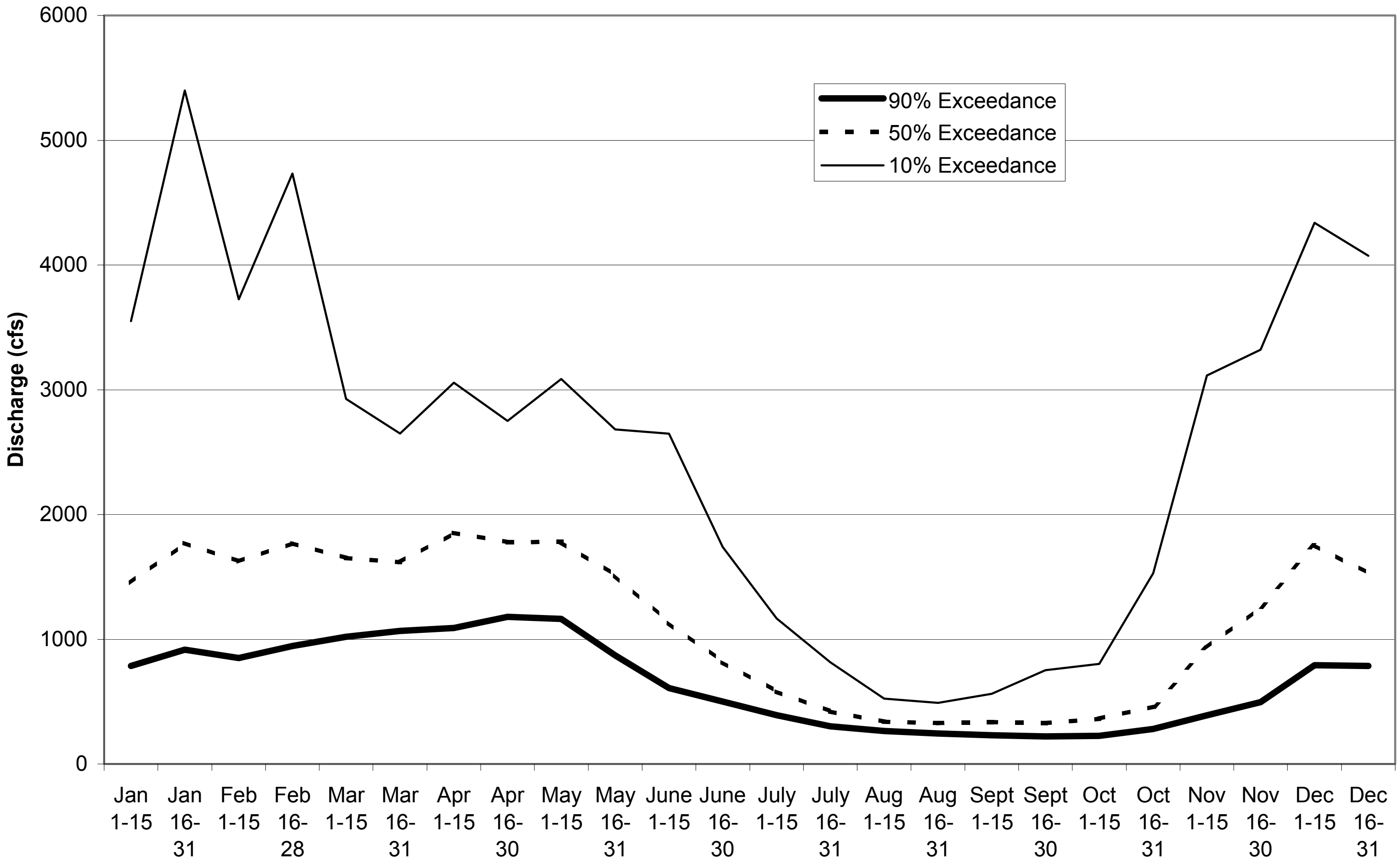


Figure 4-4. Half-monthly flow exceedance values for modeled unregulated flows at Green River near Auburn USGS gage (12113000) for the period from 1964 through 1995 (Source: CH2M Hill 1997).

Table 4-3. Selected hydrologic characteristics of flows in the Green River at the USGS Auburn gage under the modeled unregulated flow regimes for the period from 1963 to 1995 (Source: CH2M Hill 1997).

	Min	Mean	Max
Annual 3-day Maximum	3,447	8,498	17,759
Annual Number of Spring Freshets[1]	0	4.6	10
Duration of Spring Freshets	1	5	28
7-day Low Flow			
April 1-May 30	447	1,178	2,123
July 15-Sept 15	203	290	462
Annual	172	268	462
Average Monthly Flows			
January		2,309	
February		2,162	
March		1,819	
April		1,922	
May		1,806	
June		1,208	
July		586	
August		364	
September		401	
October		596	
November		1,587	
December		2,208	

[1] Spring freshets are defined as distinct periods of continuous flow greater than or equal to 2,500 cfs that occur between 1 February and 30 June.

Table 4-4. Number of flow events in the Green River greater than or equal to 2,500 cfs at Auburn under the modeled unregulated flow regimes for the period from 1963 to 1995. One flow event defined as a single continuous flow exceeding the specified value regardless of duration (Source: CH2M Hill 1997).

Year	Feb	Mar	April	May	June
1964	2	1	2	3	2
1965	3	1	2	0	0
1966	0	0	1	1	0
1967	4	0	0	1	0
1968	2	1	0	0	1
1969	0	1	3	4	1
1970	1	0	1	2	0
1971	2	1	1	3	0
1972	1	1	1	4	1
1973	0	0	0	0	0
1974	2	3	2	2	1
1975	2	1	0	3	1
1976	2	0	2	3	0
1977	0	0	1	0	0
1978	0	0	0	0	0
1979	1	1	1	0	0
1980	2	1	3	0	0
1981	1	0	1	0	1
1982	2	1	0	1	0
1983	1	2	0	0	0
1984	2	1	1	3	0
1985	0	0	3	1	0
1986	1	0	0	0	0
1987	1	2	1	1	0
1988	1	0	3	0	0
1989	1	2	2	0	0
1990	2	2	2	0	1
1991	2	1	1	1	0
1992	2	0	0	0	0
1993	0	2	1	2	0
1994	0	1	0	0	0
1995	2	0	0	0	0
Total	42	26	35	35	9
Average	1.31	0.81	1.09	1.09	0.28

1

4.1.4.2 Groundwater

The upper Green River basin is mantled primarily by volcanic rocks, which are too fine-grained to yield much groundwater. This area acts primarily as a groundwater discharge system (Ecology 1994; USACE 1998). In valley bottom areas of the upper Green River basin, however, relatively high-yielding aquifers occur within glacial and alluvial deposits (Noble 1969). The North Fork well field occurs in such an area. The aquifer in the vicinity of the North Fork Green River is fairly narrow (500-800 feet wide) with saturated thickness of less than 80 feet.

In the lower and middle Green River basin west of Palmer, thick glacial and alluvial deposits form aquifers with high water yields. The 1989 King County Ground Water Management Plan divides the lower and middle Green River basin into four hydrogeologic sub-areas. These are the Covington Upland, Des Moines Upland, Federal Way Upland, and Green River Valley.

The Covington Upland is drained by Soos Creek. It contains five principal aquifers, with the highest groundwater elevations within the Black Diamond and Lake Youngs areas. This sub-area receives groundwater recharge from the Lake Youngs reservoir, and discharges groundwater primarily to the Cedar and Green rivers. The Des Moines Upland and Federal Way Upland occupy the north and south halves, respectively, of the upland drift plain bounded by the Green River on the east and Puget Sound on the west. This sub-area also contains five principal aquifers, which discharge either to Puget Sound or to the Green/Duwamish rivers. The Green River valley separates the Covington Upland from the Des Moines and Federal Way uplands, and contains two primary aquifers.

Water level declines have been observed in aquifers in the Covington, Des Moines, and Federal Way Uplands. In addition, preliminary results from a 1989 King County study concluded that pumping even from deep aquifers in the region impacts surface waters within the Green River basin (USACE 1998).

4.1.5 Land Use

Most of the land (99 percent) in the upper Green River basin is managed as a water supply area for the City of Tacoma and for timber production (Table 4-5). Ownership in the upper basin is divided among several private and public entities, including Plum Creek Timber Company (36 percent), USFS (21 percent), Washington State Department of Natural Resources (WDNR) (14 percent), and City of Tacoma (10 percent) (City of

Tacoma GIS database, April 1998) (Figure 4-5). The remaining 19 percent is mostly owned by other private companies and government agencies.

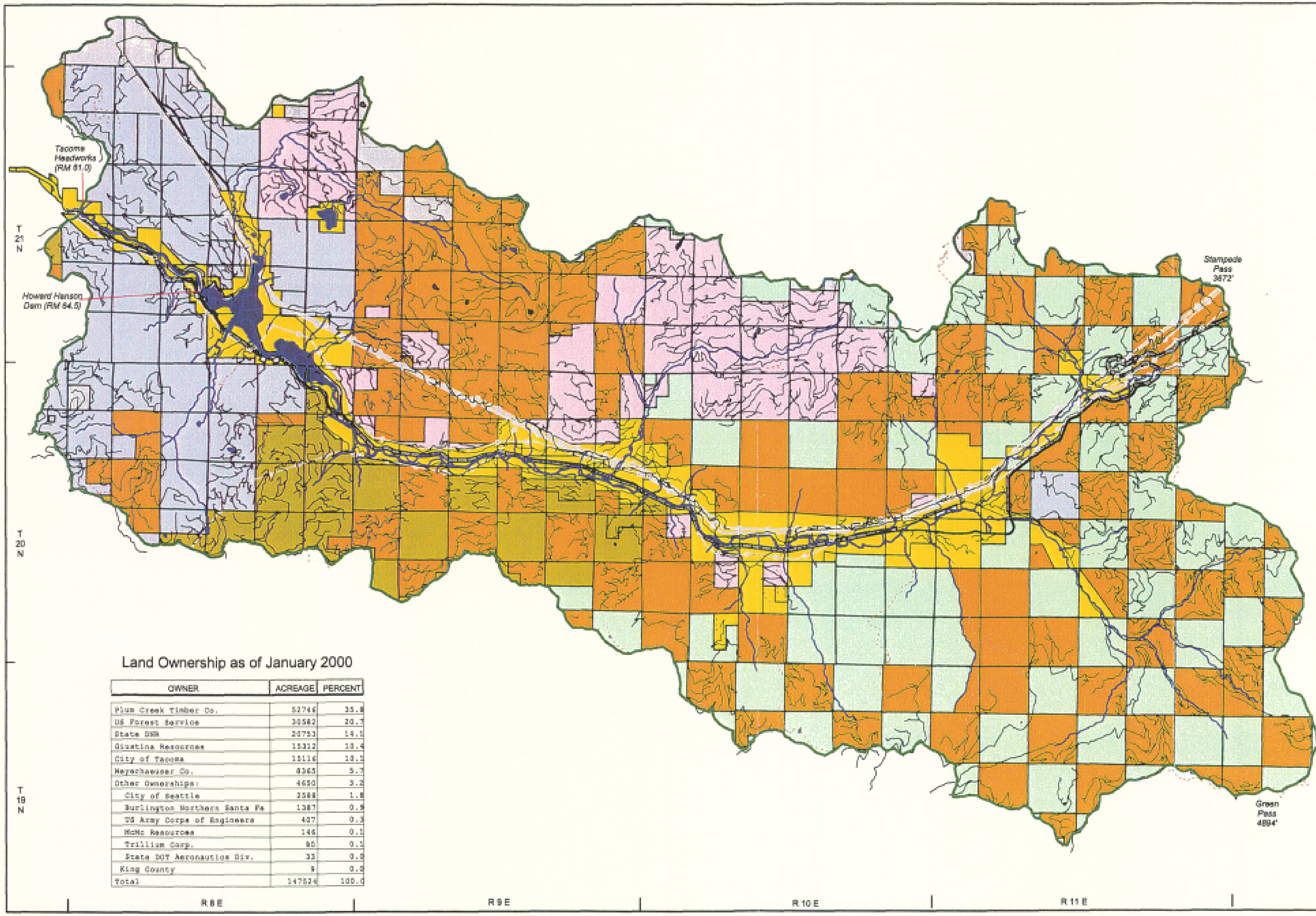
Table 4-5. Land use in the Green River basin.

Land Use Category	Subbasin of Green River			
	Upper (% of area)	Middle (% of area)	Lower (% of area)	Duwamish (% of area)
Rural	1	34	30	21
Forest	99	32	3	2
Agricultural	0	9	7	2
Urban/Residential	0	22	59	75
Parks	0	3	1	<1

Source: King County 1995, City of Tacoma GIS database (4/98).

The City of Tacoma owns 10 percent of the upper watershed, and has intentionally concentrated its holdings in lands adjacent to the Green River and the HHD reservoir. The city has an ongoing policy to acquire land within 0.5 mile of the mainstem Green River and its tributaries as it becomes available (Ryan 1996). The city manages these lands according to Tacoma Water's Green River Watershed Forest Land Management Plan in three forest management zones: Natural, Conservation, and Commercial. The Natural Zone is made up of surface waters and lowland forest adjacent to the Green River, HHD, lakes, and major tributaries. This zone serves as a buffer to protect waters from sediment input and other impacts. The Conservation Zone is adjacent and upslope of the Natural Zone and is managed for fish and wildlife habitat, which includes habitat manipulation to attract wildlife away from areas near the water supply. Upslope of the Conservation Zone, lands are in the Commercial Zone, which is under uneven and even-aged forest management directed at producing merchantable timber at a sustainable level. Income from management of these lands is used for management of the upper watershed, including securing additional lands to be managed under the Forest Land Management Plan.

Lands owned by other entities, such as the USFS and Plum Creek Timber Company, are also managed for timber production. U.S. Forest Service land is managed under the June 1990 Land and Resource Management Plan for the Mt. Baker-Snoqualmie National Forest as amended by the April 1994 Record of Decision for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (i.e., the Northwest Forest Plan). Private and state timber lands are managed according to the Washington State Forest Practices Rules and Regulations (Title



Land Ownership as of January 2000

OWNER	ACREAGE	PERCENT
Plum Creek Timber Co.	52746	35.8
US Forest Service	30582	20.7
State DNR	20753	14.1
Giustina Resources	15312	10.4
City of Tacoma	15116	10.2
Weyerhaeuser Co.	8365	5.7
Other Ownerships:	4650	3.2
City of Seattle	2588	1.8
Burlington Northern Santa Fe	1387	0.9
US Army Corps of Engineers	407	0.3
McMc Resources	146	0.1
Trillium Corp.	80	0.1
State DOT Aeronautics Div.	33	0.0
King County	9	0.0
Total	147524	100.0

Figure 4- 5.

Tacoma City Water Green River Watershed Land Ownership.

Legend

- Upper Watershed Boundary
- Public Land Survey
- Railroad
- Road
- Trail
- Streams
- Water Body
- Pipeline
- Powerline
- Weyerhaeuser Co.
- U.S. Forest Service
- City of Tacoma
- Plum Creek Timber Co.
- Giustina Resources
- State DNR
- Others

N

Scale = 1:126,720

1 0 1 2

Scale in Miles

1 inch = 2 miles

Source: Tacoma Water GIS

222 WAC) and other management directives (i.e., HCPs) developed to comply with the federal Endangered Species Act (ESA) of 1973 as amended.

In the middle Green River basin, almost 80 percent of the land use is rural, forest production, and urban/residential. It has one of the largest remaining agricultural communities in King County and is of increasing importance as an affordable area for suburban and rural residences and hobby farms. There is also some mining in the middle subbasin.

The majority of the lower Green River basin is urban residential, but there is also a substantial amount of rural and agricultural land use. Land use in the Duwamish River subbasin is predominantly urban-residential, with heavy industrial use along the river. However, even in this urban/industrial setting, over 20 percent of the land is classified as rural.

4.2 Structural Setting

The two most obvious structural features that have been built on the Green River are the HHD in the upper basin and the Headworks at the boundary between the middle and upper basin. Other structural features that affect the flow of water in the Green River include the Burlington Northern Santa Fe Railroad line in the upper basin and the levee system in the lower basin. In this section, these structural features are described; in Chapter 4.3 the operational characteristics of these structural features are specified.

4.2.1 Howard Hanson Dam

Howard Hanson Dam is a subsidiary earth-filled structure composed of rolled rock fill, sand and gravel core, drain zones, and rock shell protection (USACE 1998). A plan view of the dam is shown in Figure 4-6. The embankment is 235 feet high and 500 feet long and has an inclined core of sand and gravel material. The dam is 960 feet thick at the base decreasing to 23 feet thick at the crest. The total length of the dam is 675 feet. The intake structure also includes trashrack bars, a deck for debris removal, one tractor-type emergency gate, and gate hoist equipment located in the gate tower.

The outlet structure consists of a gate tower and intake structure with two tainter-type gates, a concrete horseshoe-shaped outlet tunnel, a gate-controlled bypass, and a stilling

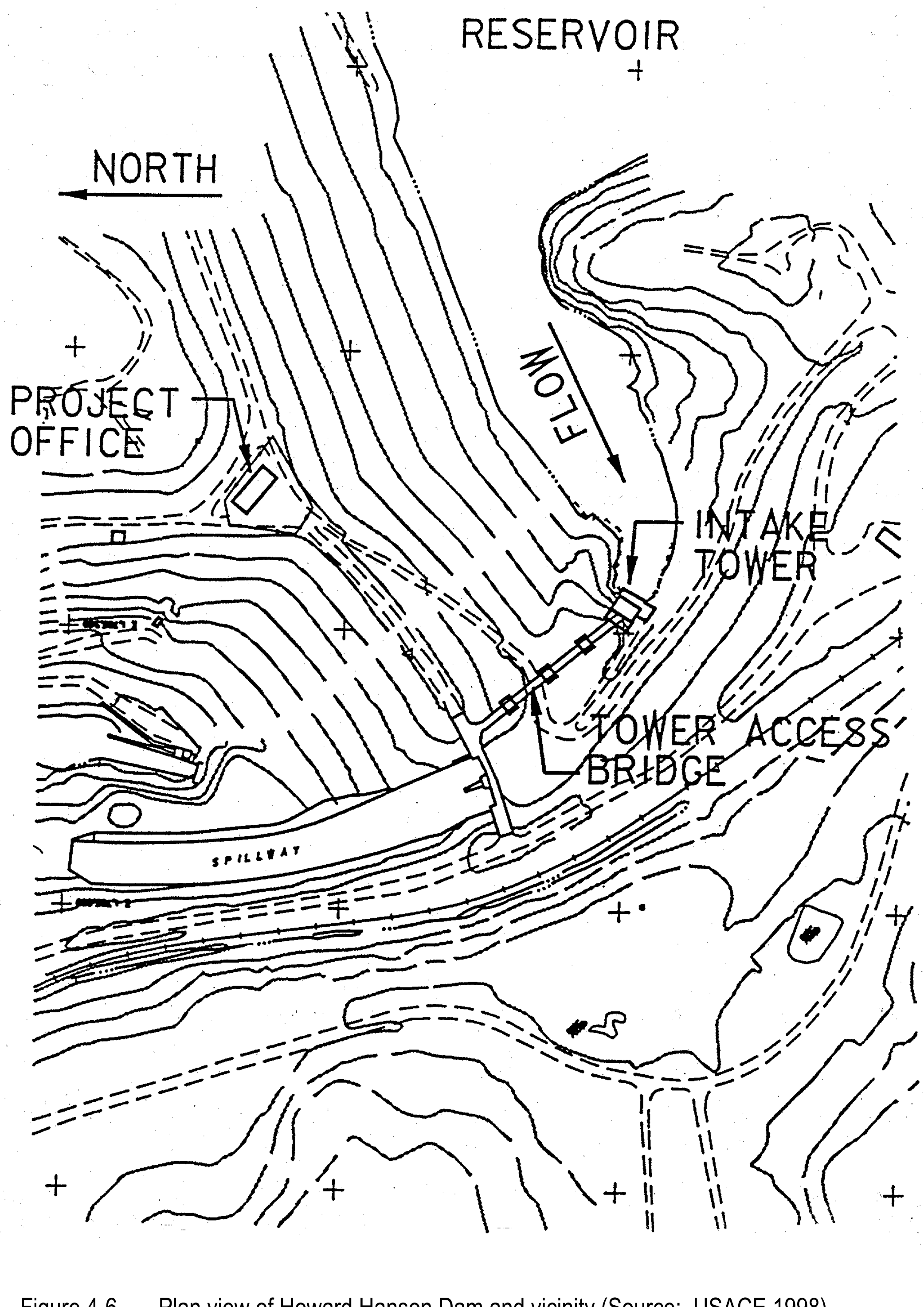


Figure 4-6. Plan view of Howard Hanson Dam and vicinity (Source: USACE 1998).

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basin. No upstream or downstream fish passage facilities were included in the original project design.

The 900-foot-long, 19-foot-diameter flat bottom horseshoe-shaped outlet tunnel passes normal flow released for project regulation. The tunnel is controlled by two 10-foot-wide by 12-foot-high regulating tainter gates at the bottom of the reservoir pool (invert elevation 1035 feet) above mean sea level (MSL).[1] Low flow releases during the summer conservation period are made through a 48-inch bypass intake located about 35 feet above the bottom of the pool. This outlet has a capacity of approximately 500 cfs at maximum conservation pool (elevation 1,069 feet). A cross-section of the dam with elevations of important features is shown in Figure 4-7.

The gate-controlled spillway is anchored in rock on the left abutment and in a concrete monolith adjacent to the embankment. The spillway is a concrete ogee overflow section with two 30-foot-high by 45-foot-wide tainter gates to control major flood flows and prevent overtopping of the dam. The lowest elevation of the gates is 1,176 feet. The downstream chute has a curved alignment and is paved for a distance of 712 feet downstream from the weir. The tainter gates permit storage to elevation 1,206 feet without spillway discharge. The reservoir provides 106,000 acre-feet (ac-ft) of flood control storage at elevation 1,206 feet. The highest pool elevation attained was 1,183.5 feet in 1996. The maximum spillway discharge is 115,000 cfs at the spillway design flood pool elevation. Floating debris is collected during periods of high water by three stationary booms in the reservoir just upstream of the dam.

The dam and reservoir area includes various gravel-surfaced roads that provide access to the dam, stilling basin, intake structures, and the reservoir. An administration building is located in a fenced compound on the right dam abutment, and a fuel dispensing station and flammable materials storage building are located approximately 200 feet north of the administration building on Access Road A.

Subsequent modifications of the dam structure were made following the emergence of a spring during a highwater period (up to elevation 1,161 feet) that occurred in February 1965. The spring broke out about 350 feet downstream from the downstream right abutment toe. The spring was controlled by a gravel blanket supported by a crib wall. In

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[1] Elevations referenced in this document refer to a mean sea level datum.

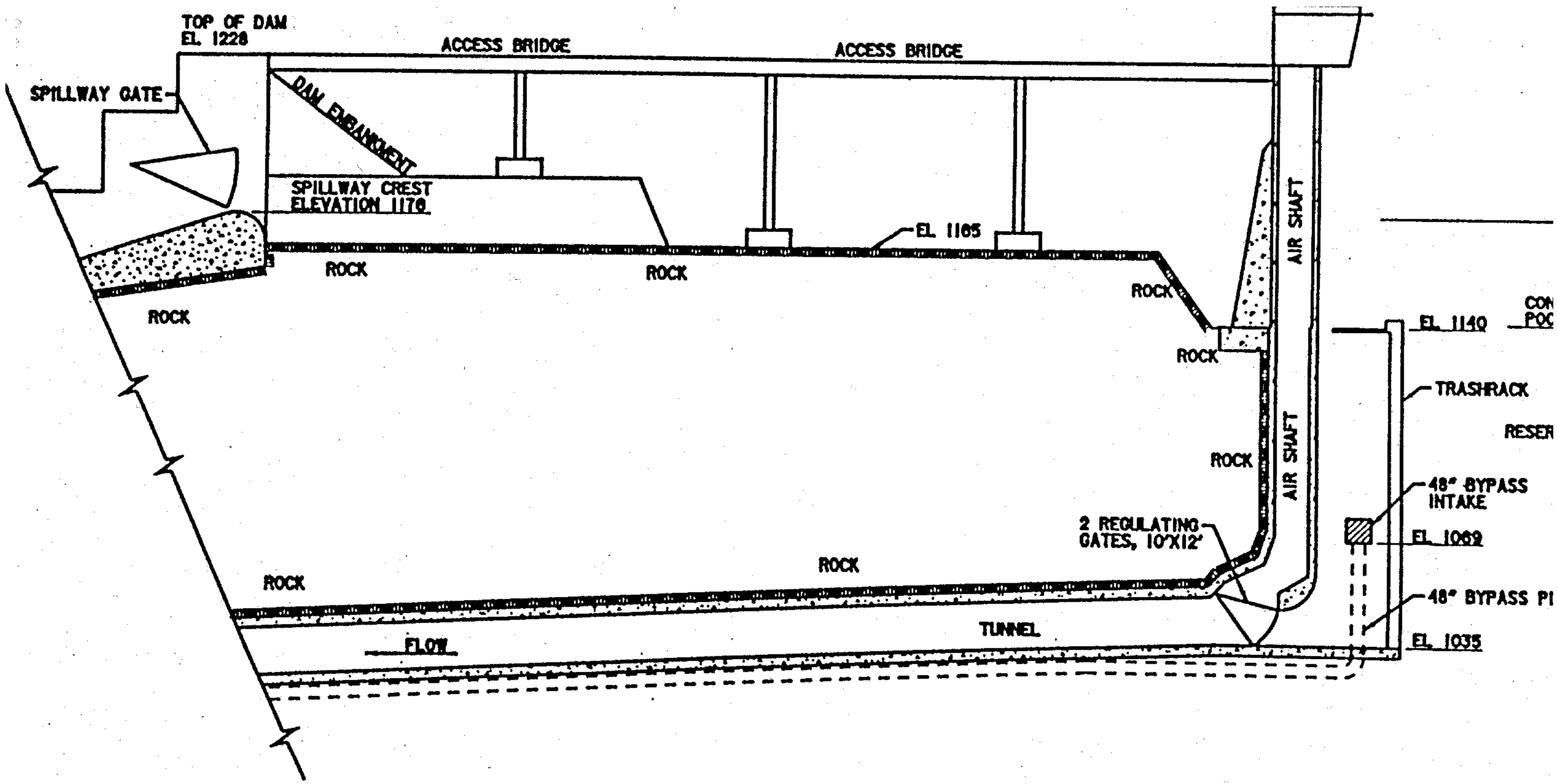

Figure 4-7. Cross section of Howard Hanson Dam (Source: USACE 1998).

1968, a drainage tunnel was constructed at elevation 1,100 feet and extending 640 feet into the right abutment. Twelve relief wells were drilled to intersect and extend 20 feet below the tunnel floor. This system appears to have adequately controlled abutment leakage during the flood pools experienced to date.

4.2.1.1 Structural Changes to HHD Resulting from AWS Project

The HHD AWS project was initiated by the U.S. Army Corps of Engineers (USACE) in August 1989 to address the water supply needs of Puget Sound residents; it was expanded in 1994 to include environmental (ecosystem) restoration objectives. The AWS project at has undergone NEPA review and Phase I of its implementation is being assumed for purposes of the Green River HCP. The primary structural change to be made in Phase I will be the addition of a downstream fish passage facility. Other modifications proposed in the AWS project include: remediation of right abutment drainage; new access bridge and access road; and new buildings or additions to existing buildings including an administration, a maintenance, and a generator building.

The proposed fish collection facility (Figure 4-8) will be a new structure that is intended to pass migrating juvenile fish downstream through HHD. It is not intended to pass migrating adult fish upstream through the dam. Adult fish would be trapped downstream of HHD at the Headworks and transported for release above HHD via a trap-and-haul operation. Currently, the entire Green River flow must pass through the existing outlet works intake structure. Upon completion of the new fish passage facility, which will be located adjacent to the existing outlet works, flows will pass through either the existing intake structure or the new fish passage facility. The new fish passage facility is designed to pass up to the median daily flow for the period March through May.

The main features of the fish passage facility are:

- a new intake tower;
- a wet-well;
- a floating fish collector;
- a dual-chamber fish lock;
- a discharge conduit; and
- a fish transport pipeline.

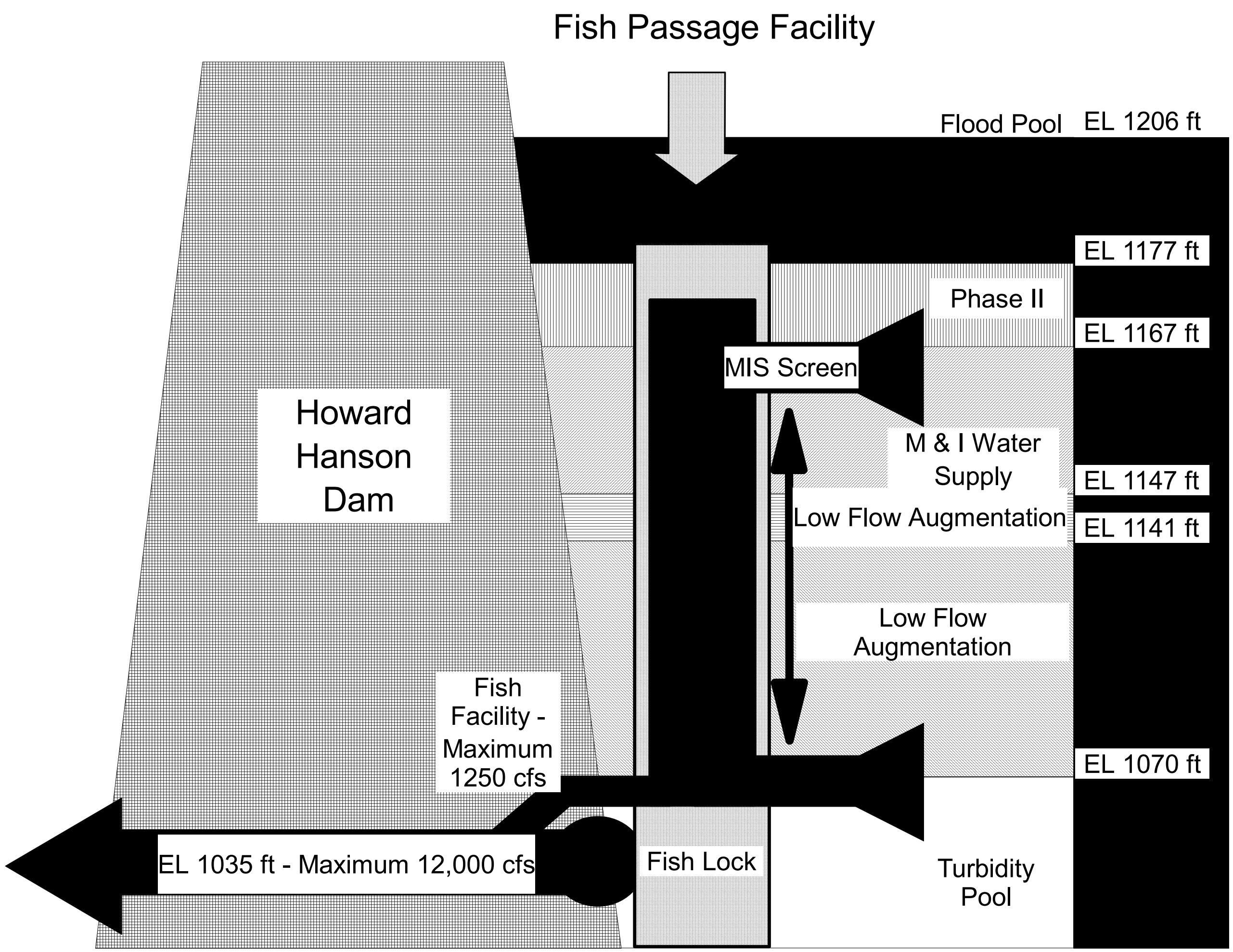

Figure 4-8. Schematic of fish passage facility planned for HHD (Source: USACE 1998)

The following description of the downstream fish passage facility was provided by the USACE. A more complete description of the facility can be found in the DFR/DEIS, Appendix D, Section 2, Hydraulic Design.

New Intake Tower

The new intake tower will be located to the left of the existing intake tower. The new intake tower will house the gate chamber, vent shaft, and access shaft. The gate chamber is about 30 feet by 20 feet in plan, has a base elevation of 1,035 feet, and an upper elevation of about 1,085 feet. It will house a single radial gate and an operating hydraulic actuator. A guide slot for the emergency tractor gate for the attraction-water discharge will be located just upstream of the radial gate.

Wet-Well

The wet-well structure is a 105-foot-long by 30-foot-wide by 150-foot-deep open-end box structure. Approximately 105 to 115 feet of the structure will be embedded in rock. The structure has a top elevation of 1,185 feet and a floor elevation of 1,035 feet. The upstream end, or intake horn, of the wet-well structure is flared to a width of about 45 feet, and the right edge abuts the left side of the existing intake tower trashrack structure. The floating trashrack is attached at the flared end of the wet-well structure.

Floating Fish Collector

The fish collector assembly is, essentially, a floating container for a modular-inclined screen. The modular-inclined screen will be mounted in the center of the collector housing, and will have hinges along its center of rotation that attach it to the housing framework. The modular-inclined screen is held in position by hydraulic actuators, and may be rotated to allow accumulated debris to be washed off the screen. Various instrument sensors will be installed to monitor water flow and debris accumulation. The purpose of the modular-inclined screen system is to safely separate the fish from the majority of the flow. The screen will allow most of the water to pass into the wet well while the fish and a small portion, approximately 5 percent, of the water will be diverted to the fish chamber.

Fish Lock

The fish lock structure is a 35-foot-long by 30-foot-wide by 135-foot-deep closed-end box, dual-chamber structure. Approximately 90 to 100 feet of the structure will be embedded in rock. The structure has a top elevation of 1,185 feet and a floor elevation of 1,049 feet. It is to be constructed monolithically with the wet-well structure. The common wall that separates the fish lock from the wet-well will contain the guide slot for the stoplog set that serves the same purpose. Integral with the right-hand wall is the guide slot for the fish lock regulating-well stoplog set and floating weir. This vertical slot will have a full-height screen, made of the same wedge-wire fabric as the modular-inclined screen, to prevent fish from entering the regulation well. At the bottom of the fish lock is a full-coverage fish screen, made of the same wedge-wire fabric as the modular-inclined screen. This screen will be sloped to funnel fish into the fish transport pipe inlet at the base of the right-hand wall. A removable steel framework and grating will be installed on top of the fish lock structure to provide a work deck for safety, operation, and maintenance functions.

Discharge Conduit

The discharge conduit is a new tunnel that connects the new wet-well structure to the existing outlet works tunnel. The new conduit is to be designed to pass flows ranging from 400 to 1,600 cfs, although under normal operating conditions a maximum flow of 1,250 cfs will be used, as higher flows reach velocities that may cause unacceptable smolt injury. These flows will be regulated by a radial gate. Upstream of the gate, the flow regime is pressurized, and downstream of the gate the flow will be open-channel.

The new conduit will enter the existing flood control tunnel just downstream of the location of the existing splitter wall. It will enter the existing tunnel with a floor elevation of about 1,034 feet (the existing tunnel's floor elevation is about 1,023 feet at this point so that the exit opening will be above the flow line in the flood control tunnel at all flood control operating conditions). The new conduit begins at the downstream end of the wet-well structure, with a base elevation that matches the wet-well base elevation of 1,035 feet, and has an alignment that is parallel with the new wet-well centerline. Although its alignment is currently shown on the drawings as turning 90 degrees toward the existing facility, the conduit will be realigned during pre-construction engineering and design (PED) to eliminate this curvature upstream of the control gate.

Fish Transport Pipeline

The fish transport pipeline is a 24-inch-diameter steel pipe that will run continuously from the fish lock to the Green River at an appropriate location downstream from the flood control tunnel stilling basin to provide acceptable entrance conditions back into the river. This pipeline will be suspended along the roof of the new discharge conduit and along the crown of the existing outlet works tunnel. The pipeline will be attached to the tunnel crown with a suitable anchor bolt and saddle assembly. At the present time, it is envisioned that the fish transport pipeline will be supported along the right-hand side of the stilling basin, in the vicinity of the existing 48-inch bypass line.

Possible Changes to Fish Collection and Transport Facility

Some revisions to the recommended plan presented in the Hydraulic Design Report (USACE 1998, Appendix D, Section 2) will be accomplished during the PED phase of the AWS project.

4.2.2 Tacoma Water Supply Intake at RM 61.0 (Headworks)

The City of Tacoma's Headworks was completed in 1913 and is located at RM 61.0, which is 3.5 miles downstream of HHD. This diversion is the primary source of Tacoma's FDWRC. The diversion supplies water to a pipeline (Pipeline No. 1 [P1]) that carries water from the diversion dam south and west to Tacoma (see Figure 4-9). The pipeline has a capacity of 113 cfs (72 million gallons per day [mgd]). Tacoma is in the process of constructing another pipeline (Pipeline No. 5 [P5]) from the diversion toward Tacoma over a more northerly route by way of south King County and Federal Way. The new P5 will have a discharge capacity of 100 cfs (65 mgd) and carry Tacoma's Second Diversion Water Right (SDWR) to Pipeline No. 4 near the Portland Avenue Reservoir in Tacoma. The operation of the SDWR diversion is subject to conditions specified in an agreement between Tacoma and the Muckleshoot Indian Tribe (MIT) (see Chapter 4.3.2).

The existing Headworks will be modified to allow diversion and transmission of water to the new pipeline and to improve fish passage and screening facilities. Construction activities proposed at the Headworks include: raising the existing diversion dam, realigning the existing intake and trashracks, constructing a new pipeline from the existing settling basin to the portal of Tunnel No. 2 (approximately 700 feet downstream of the diversion dam), adding fish/debris screening and bypass facilities (to include an adult fish ladder leading to a trap, holding, and transfer facility), and reshaping the river channel downstream of the dam to accommodate the fish bypass facilities. The existing building will be razed and replaced at the same location with an insulated equipment storage building approximately 25 feet by 20 feet in size.

The existing concrete gravity diversion dam is 17 feet high with a crest length of 155 feet. The dam is founded on bedrock and both abutments are keyed into rock. Proposed construction at the dam includes raising the crest and abutments 6.5 feet, removing part of the existing variable depth spillway apron and replacing it with a level apron. During

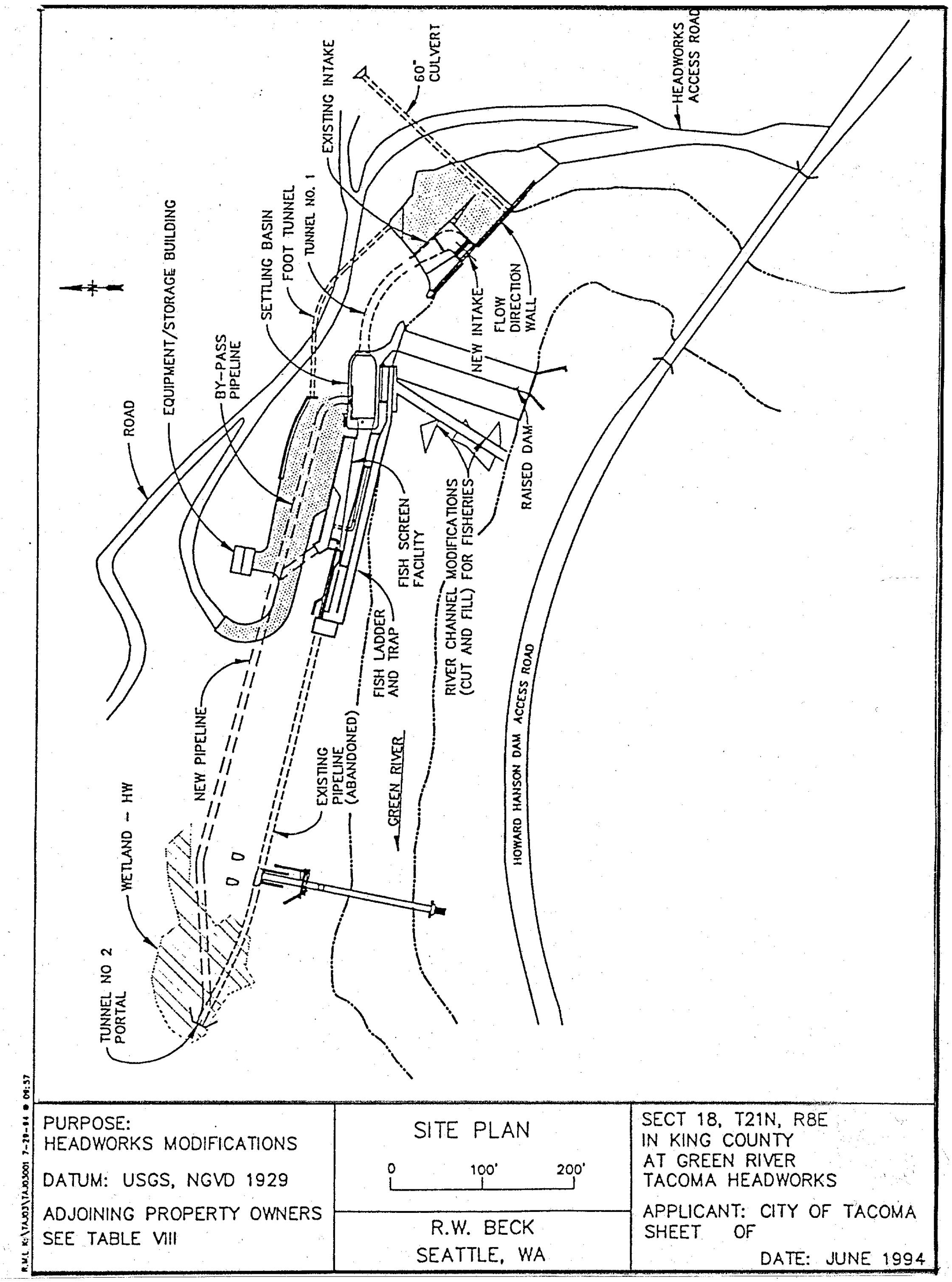

Figure 4-9. Site plan for modified Tacoma Headworks as designed for Second Supply Project (Source: Draft Supplemental EIS for SSP).

construction of the dam, Tacoma's water supply will temporarily be collected and conveyed through a conduit running from the diversion dam to the settling basin about 70 feet away or, alternatively, by pumping water from the pool behind the diversion dam into the nearby North Fork pipeline.

The existing intake is 20 feet wide and located in the right abutment immediately upstream of the existing diversion dam. Proposed construction at the intake includes cofferdam construction, extending and raising the existing intake, new trashracks, trash raking equipment, stoplogs, and dual slide gates. The new top of the intake will be 6.5 feet higher than the existing intake structure to accommodate higher water surface elevations resulting from raising the dam crest.

The existing Headworks has minimal fish screening facilities. The modified Headworks will incorporate a nonrevolving screen design at the west end of the existing stilling basin and will involve the following construction activities: demolition and removal of the west end of the existing concrete settling basin structure; construction of a new automatically cleaned, vertical, wedgewire fish/debris screen structure approximately 100 feet long by 30 feet wide by 22 feet deep; and construction of a fish bypass that returns juvenile fish migrating downstream to a point below the dam in the Green River. The fish/debris screen surface area will be approximately 80 feet long and 13 feet high (1,040 square feet) and will be designed to meet the Washington State and federal screening criteria. Construction of the fish/debris screen structure will require removal of the existing north bank retaining wall. Chapter 5, Habitat Conservation Measures (HCM), includes additional discussion on the modified fish screening and downstream passage facilities.

The existing Headworks dam is currently impassable to upstream migrating fish. However, the proposed fish/debris screen bypass structure at the Headworks will incorporate provisions to allow future upstream fish passage. Instream work downstream of the dam will include filling and excavating to create a level spillway apron and excavating channels for fish attraction purposes. The existing Headworks will be modified by adding an adult fish ladder leading to a trap-and-holding facility (see Chapter 5 for further discussion of adult fish passage at the Headworks).

Approximately 700 feet of existing 7-foot-diameter concrete pipe between the existing settling basin and the upstream portal of Tunnel No. 2 will be taken out of service and replaced with a new 8-foot-diameter steel pipe. The pipe will include a bypass section for use during construction or maintenance of the fish/debris screen structure.

4.2.3 North Fork Well Field

Tacoma also operates a well field in the North Fork Green River, above HHD. The well field, developed in 1977, consists of seven wells, which can be used to withdraw water from an unconfined aquifer at depths ranging from 65 to 103 feet. Water withdrawn from the North Fork well field is used instead of water withdrawn at Tacoma's Headworks under its FDWRC. Water from the well field is pumped into a pipeline that flows into a 10-million-gallon reservoir located near the Headworks facility. Operation of the well pumps is automatically controlled by signals transmitted via microwave from the operations control building at the Headworks.

The well field is used to replace surface water withdrawn from the Green River when turbidity levels approach 5 nephelometric turbidity units (NTUs). Substantial pumping of the well field is typically associated with high turbidity in the Green River, which is associated with periods of high runoff and increased stream flows. High levels of turbidity could also occur as the result of mass-wasting events in upper watershed tributaries or along the shoreline of the Howard Hanson Reservoir; however, landslides and other mass-wasting events are typically associated with periods of extended rainfall that saturate the soils.

In general, pumping from the North Fork well field occurs during the winter and spring when turbidity and runoff are highest. Over a 5-year period in the 1960s, periods of high turbidity (>5 NTUs) in the Green River, during which withdrawal from wells would be required, averaged 85 days per year. Periods when well withdrawals would have been required have been identified during September (Noble 1969); however, those September turbidity events occurred when flows in the North Fork and mainstem Green River were higher than average. Table 4-6 summarizes average daily flows and well demand by month based on an analysis of turbidity levels at Tacoma's Headworks in the 1960s.

The USGS operated a stage recorder at RM 2.3 on the North Fork between 1965 and 1982, and measured an average annual flow of 87 cfs at that location (Gage #12-1057.1 North Fork Green River near Lemolo). The gage was located in a reach where surface flow infiltrates into the aquifer, thus the North Fork Green River below the gage has frequently been dry when surface flow at the gage was as much as 11 cfs. Even when the North Fork Green River has been observed to be dry downstream of the Lemolo gage site, instream flows of up to 37 cfs have been measured in the reach downstream of the well field where underflow emerges (Noble 1969).

Table 4-6. Summary of average daily flow in the North Fork Green River and expected well demand from the North Fork well field by month.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Daily Flow (cfs)[1]	147	124	92	117	121	73	26	12	24	38	96	169
Days of well use (avg.)[2]	15.2	10	6.2	8.8	11	5.4	0	0	2.6	2.4	10.2	13
Days of well use (range)	4-25	0-28	0-18	0-23	0-20	0-20	0	0	0-13	0-4	7-13	7-19

1 Mean average daily flow at USGS gage 12105710 North Fork Green River near Lemolo, WA for the period July 1965 – September 1982.

2 Average number of days that well use would be required over a 5-year period in the 1960s, based on the number of days when turbidity exceeded 5 NTUs measured at the Headworks (Noble 1969).

The well field aquifer is fed by water that infiltrates from the North Fork Green River where it enters the broad valley of the ancestral Green River at approximately RM 3.0 until the point where the stream intersects the water table near the well field. The recharge rate is directly related to river stage (Robinson 1974). The mean discharge of underflow is estimated to be 60 cfs (Noble 1969), and may reach as much as 150 cfs during the winter months (Robinson 1970).

The well field yield is limited to the quantity available from aquifer underflow plus depletion from aquifer storage (Noble and Balmer 1978). The aquifer is small, and recharges quickly during wet periods. However, the infiltration rate is less than the aquifer tranmissivity rate, and the wells are able to fully intercept the underflow (Noble and Balmer 1978). The small amount of aquifer storage and lack of recharge limits the North Fork well field as a source of water during dry periods when flows in the North Fork are low. Operation and testing of the wells indicates that the well field can sustain approximately 60 mgd (93 cfs) under very wet conditions where recharge of the aquifer occurs at a high rate during the pumping period, and probably sustain 24 mgd (37 cfs) continuously under all except the driest conditions.

Investigations of the lower North Fork Green River have shown that the majority of flow within the reach downstream of the North Fork well field is supplied by emerging groundwater during the late summer and early fall (Noble 1969). As surface flows decline, the proportion of flow provided by underflow increases, and in extreme cases may maintain flow within the lower North Fork channel even when the upstream channel is dry. Instream flows supplied wholly or partly by groundwater outflows provide temperature refugia for salmonid fishes during summer and late fall, low flow periods.

Runoff, aquifer recharge and groundwater upwelling influence surface flow in the North Fork channel. In addition, rising pool levels from the Howard Hanson Reservoir occasionally inundate the North Fork channel. Howard Hanson Dam is operated as a flood control facility and provides up to 106,000 ac-ft of storage at elevation 1,206 feet (see Chapter 4.3.1.1). In comparison, the North Fork channel in the vicinity of the well field ranges from elevation 1,225 feet to 1,178 feet. The highest pool level attained to date was 1,183 feet in 1996. During the flood control season, stored floodwater causes the pool level to rise and inundate the lower North Fork channel. The channel remains inundated for several days as the reservoir is drawn down in preparation for the next flood control event.

Water is also stored behind HHD during the summer to provide for downstream low flow augmentation. The summer conservation pool is 1,141 feet and inundates the lower 1.2

miles of the North Fork channel. The reservoir has been occasionally surcharged for 1 to 2 weeks during early June to 1,147 feet to facilitate debris removal by the USACE. Increasing the reservoir pool level from 1,141 feet to 1,147 feet inundates an additional 357 linear feet of the North Fork channel (Wunderlich and Toal 1992). The City of Tacoma and the USACE are proposing to store 5,000 ac-ft of water during drought years to provide additional water for downstream low flow augmentation. The 5,000 ac-ft of additional water would extend the duration of the 1,147 feet reservoir pool level several weeks beyond that required for debris removal. The reservoir pool level drops as water is released for downstream low flow augmentation, but with the storage of the 5,000 ac-ft of additional water, the North Fork channel at elevation 1,147 feet would remain inundated an average of 17 days each year between late May and mid-June (HDR 1996).

4.2.4 Burlington Northern Santa Fe Railroad

The Burlington Northern Sante Fe Railroad parallels the upper Green River for much of its length. The line was built by the Northern Pacific Railroad in 1886-1887 (USACE 1998). The rail line proceeds out of Auburn and follows the river in an easterly direction, gaining elevation to the top of Stampede Pass at about the 3,700-foot elevation and then proceeds down the east side of the Cascade range along the Yakima River to Cle Elum. In 1983 the line became inactive. Thirteen years later, as a result of a local increase in container traffic at the ports of Seattle and Tacoma, Burlington Northern Sante Fe (the former Northern Pacific Railroad) spent over 130 million dollars to reactivate and upgrade the line. This upgrade included expanding the rail bed by placing additional rock in the Green River, and improvements of the tunnel and snow shed at the pass. The line was reopened in 1997, and it is anticipated that as many as eight trainloads of cars will be routed through the Stampede Pass line on a daily basis when it reaches full operation.

In many places along the upper Green River, the rail line is adjacent to the Green River channel and separates the main channel from much of its natural floodplain. Disruption of river bed migration and associated reduced recruitment of wood and sediment, loss of access to side channels and tributaries, and localized impacts from instream filling with rock and ballast for the rail bed have affected the physical and biotic environment in these reaches.

4.2.5 Levee System

The lower Green River from Mueller Park downstream (RM 32.9) is almost entirely leveed or riveted, all built before 1970 (Fuerstenberg et al. 1996). Levees have also been constructed in the middle Green River between Flaming Geyser State Park and Auburn, mostly between 1936 and 1964. This levee system is largely maintained by the USACE or local governments and protects farmland, commercial, residential, and industrial areas throughout the lower Green and Duwamish river valleys from flooding. The levee system, along with channelization and dredging, has essentially disconnected the lower Green River from its natural floodplain.

4.3 Operational Setting

Flow of the lower and middle Green River is primarily controlled by the operation of HHD and the Headworks. The operation of HHD is primarily for flood control, but other uses for water stored in the reservoir include low flow augmentation for fish, and under the AWS project, storage and release of water for Municipal and Industrial (M&I) use for the City of Tacoma. Water from the FDWRC is diverted at the Headworks into P1; water from the SDWR will be diverted at the Headworks into P5.

4.3.1 Operation of HHD

Howard Hanson Dam is currently operated under congressional legislation to provide flood control and low flow augmentation. The USACE operates the project for flood control and maintains full storage capacity during the flood season, generally November through February. Outside of this window, the dam is used to provide low flow augmentation of 110 cfs to benefit fish. The operation of the dam has evolved substantially since it went into operation in 1962. Through proposed legislation for the AWS project, Phase I of the project will provide storage for M&I water supply and include various measures for ecosystem restoration. This discussion of the operational framework for HHD assumes that AWS project Phase I is in place.

4.3.1.1 Flood Control

The HHD reservoir (inundation pool) extends approximately 3.5 miles eastward from the dam along the main river channel and 1.5 miles northerly up the main tributary of the North Fork of the Green River at elevation 1,141 feet (USACE 1998). The reservoir has historically been maintained at minimum level (about elevation 1,070 feet) from the end of October to the end of March to provide flood control storage space. The reservoir provides 106,000 ac-ft of flood control storage at elevation 1,206 feet. Prior to the AWS project, the reservoir began filling in April to a maximum pool elevation of 1,141 feet. At this conservation pool level, the reservoir impounded 25,400 ac-ft and covered 732 acres. Under the AWS project Phase I, the reservoir will begin to fill on 15 February to a maximum pool elevation of 1,167 feet to provide summer and early fall low flow augmentation and M&I water supply. At full conservation pool level, the summer/fall reservoir will impound a total of 50,400 ac-ft (25,400 ac-ft under previous operation and under AWS project Phase I 20,000 ac-ft for municipal water supply and 5,000 ac-ft for low flow augmentation).

Flows are regulated manually by adjusting gate controls at the dam with direction from the USACE's Water Management Section. The reservoir is kept as low as possible (essentially empty) during the flood season so that runoff from the watershed above HHD can be impounded as needed. The highest pool elevation attained to date was 1,183 feet in 1996, and as yet it has not been necessary to use the spillway. The reservoir is drawn down, in normal years, to an elevation around 1,070 feet by 1 November to provide flood storage capacity in the reservoir. During the winter months, flow is regulated to a maximum of 12,000 cfs at Auburn during flood events.

Normal river flows pass through the outlet tunnel in the dam's left abutment. When the river flow reaches flood stage, projected at 12,000 cfs at Auburn, discharge from the dam is reduced and water is impounded in the reservoir. As river flows return to normal following a flood, the water impounded in the reservoir is released at a rate that ensures safe discharge within channel capacity in the downstream area and minimizes damage to levees from sloughing during evacuation of storage. Flood control operations are conducted within the parameters established by the project's congressional authorization, so there is little flexibility to operate for other purposes during the flood season.

Large floating or sunken debris usually passes through the outlet tunnel and downstream, although it may lodge against the intake structure trashrack. This debris is removed periodically from the trashrack. Floating debris is collected during periods of high water by three stationary booms located in the reservoir just upstream of the dam. The debris collected at the stationary booms is removed when reservoir conditions permit and is towed by barge to temporary holding areas. Subsequently, when conditions are appropriate, the reservoir is raised 3 to 5 feet above the normal full conservation pool to facilitate movement of debris to the upper holding areas. Salvageable material is removed and the rest is sawed and piled by bulldozers for burning. As part of the AWS project, some of the large woody debris (LWD) will be transported below the Headworks for relocation by mainstem flows (see Chapter 5).

4.3.1.2 Low Flow Augmentation and Water Supply

The management of HHD is a continually evolving process within the constraints of its congressionally authorized purposes. Aside from flood control operation, HHD has available a range of operational choices during the late spring, summer, and early fall. Since the completion of the project in 1962 the population of the Green River valley and the entire Puget Sound region has increased substantially. Land use in the lower valley has shifted from primarily rural and agricultural to a mix dominated by urban and industrial uses. The role of tribal governments, state, and local agencies in the management of Green River and its resources has changed significantly. The USACE has undergone a general shift from a rigid operational procedure to a more adaptive management approach and is currently involved with other agencies in resource management activities.

Flood control is clearly the first priority of the operation and management of HHD during the winter flood season and is largely inflexible. Water management is more complex after the end of the flooding season. During the spring, the project gradually switches from its primary role (flood storage) to its secondary role (conservation storage). The shift from flood control to summer conservation storage is made in the February through March time frame when conditions warrant it. Water storage in February and March is contingent upon the maintenance of statistically significant flood control volume. In general, the risk of flooding is low during drought conditions when the need for storage is greatest. Water control strategy each year begins with the spring snowmelt. When operations switch from flood to conservation storage, the amount of water released from HHD can be reduced below the level of inflows, allowing the project to refill.

Since increases in storage under the AWS project have not been implemented as of 1998, operation of the dam to meet AWS project objectives has not actually occurred. However, for purposes of describing the operational framework of the dam in this HCP, it is assumed that storage under the AWS project Phase I will determine the refill schedule during the 15 February to 30 June period.

The current springtime operating strategy of HHD reflects the authorized project purposes of flood control and water storage for low flow augmentation. The USACE has also responded to flow management requests from recreational groups and local communities. In some instances, complying with such requests may have affected downstream fisheries resources. Under the AWS project, earlier refill and the adaptive management strategy will give fishery resource agencies and tribes much greater opportunity and responsibility for managing flows in the Green River.

Under Phase I of the AWS project, refill timing and release rates will be based on target instream flows. These rates will be adjusted yearly in response to weather conditions, snowpack, the amount of forecasted precipitation, and biological information and data. The proposed refill rules are designed to meet project objectives for protecting instream resources, meeting existing conservation storage requirements, and providing reliability for storing additional water for low flow augmentation and municipal water supply. Rules providing for recreational, community, and other non-fishery resource needs were not included in the description of the proposed storage and release strategy. Non-fishery resource needs are not a designated downstream delivery objective; however, where those non-fishery resource needs do not conflict with fishery objectives, the USACE will attempt to satisfy multiple uses.

Prior to implementation of the AWS project, the conservation storage level of the reservoir had a maximum pool elevation of 1,141 feet to provide summer and early fall flow augmentation. The 1,141-foot pool level impounds 25,400 ac-ft with a surface area of 732 acres. This storage volume has a 98 percent reliability for maintaining a minimum instream flow of 110 cfs at Palmer, below Tacoma's water supply intake. This storage volume and minimum flows are barely sufficient to provide for instream passage of adult salmon during low flow years and are insufficient to keep steelhead eggs watered. The Muckleshoot Indian Tribe/Tacoma Public Utilities Agreement (MIT/TPU Agreement) stipulates a higher instream flow requirement that conditions Tacoma's water withdrawals under its SDWR (see Chapter 4.3.2).

The AWS project provides for optional storage of up to an additional 5,000 ac-ft of water for flow augmentation under an adaptive management approach. Under the AWS project Phase I, up to an additional 5,000 ac-ft can be stored every year and used for low flow augmentation. The storage provides enough water for maintenance of minimum instream flows of 250 cfs at Auburn; under the adaptive management process, the AWS project water can be used to meet other fishery resource needs, such as the protection of steelhead redds.

Under the AWS project, a springtime flow management strategy was developed involving the use of dedicated and non-dedicated blocks of storage. This strategy provides for an increased rate of storage early in the refill season to provide a large volume of non-dedicated storage. This non-dedicated block of water would be managed in response to input from fisheries resource agencies and tribes to benefit fisheries resources. This strategy was developed to meet project objectives for protecting instream resources, meeting existing conservation storage requirements, and providing reliability for storing additional water for M&I and low flow augmentation. The springtime flow storage and release strategy will be managed under an adaptive management process but tentative refill rules include:

- maximum refill rates during the spring reservoir refill period to protect outmigrating smolts;
- target base flows throughout the refill period, 15 February to 30 June, which are much higher than state minimum flow levels;
- gradual declines in baseflows as the summer progresses using available water to protect incubating steelhead eggs; and
- maintenance of natural freshets or creation of artificial freshets in April and May to speed outmigrating juvenile fish downstream.

4.3.2 Operation of the Headworks

In 1913, the City of Tacoma began diverting waters from the Green River at the Headworks for municipal and industrial use. Present withdrawal from the Green River is 72 mgd or 113 cfs based on water claims dating from 1906 and 1908. In 1986, Ecology acknowledged Tacoma's need for water by granting an additional 65 mgd (or 100 cfs) water right for the Second Supply Project (SSP). This additional water right is subject to Ecology instream flow requirements in effect at the time the water right was issued. Tacoma's additional water right permit is subject to a condition that diversion under the permit must cease when river flow falls below the minimum instream flows set by the state. However, these instream flow requirements were increased under a separate MIT/TPU Agreement.

The MIT/TPU Agreement developed new and higher minimum flows (at Auburn) than the Ecology requirements. For any particular year, instream flows are set by the summer month conditions, beginning on 1 July. The summer month flow conditions for the period 15 July to 15 September as stated in the Agreement are: "For Wet years, the minimum continuous instream flow shall be 350 cfs. For Wet to Average years, the minimum continuous instream flow shall be 300 cfs. For Average to Dry years, the minimum continuous instream flow shall be 250 cfs. For Drought years, the minimum continuous instream flow shall range from 250 to 225 cfs, depending on the severity of the drought." During the remainder of the year, Tacoma must meet minimum flows of 400 cfs at the Palmer gage before diverting water under the SDWR. See Chapter 5 for further discussion of instream flows in the Green River.

4.3.3 North Fork Well Field

Tacoma also operates a well field in the North Fork Green River, above HHD. This well field has a 111 cfs capacity and is used to replace a portion of the surface water withdrawn from the Green River during periods of high turbidity (>5 NTU). These turbidity effects are normally the result of rapid snowmelts and heavy rainfall and, as a result, occur in the spring and late fall months when water demands of the system are lowest and runoff is highest.

Operation of the well pumps is automatically controlled remotely by signals transmitted via microwave from the operations control building. As the blending valves in the water control building open or close, the reservoir water level changes and the wells are sequentially turned on and off.

4.3.4 Recreation

The Green River, particularly the middle reach, is a regional recreational resource of particular value. Several park locations allow direct access to the river for activities such as fishing, floating, canoeing, kayaking, and hiking. The Green River Gorge is roughly 12 miles long, 500 to 1,000 feet wide, and up to 300 feet deep. The Gorge has areas with waterfalls and springs. There is intense public interest to enhance whitewater recreational opportunities on the Green River. In recent years, the USACE has taken these needs into consideration to the extent possible when making water management decisions.

The upper Green River is basically undeveloped and closed to recreation within the City of Tacoma’s watershed (TPU 1993). Some recreational hunting is permitted annually.

4.4 Biological Setting

4.4.1 Fisheries

The historical fisheries habitat within the Green River basin is presumed to have been excellent for anadromous salmon and trout, resident trout, and other coldwater native species (USACE 1996). Over 30 species of fish historically or currently inhabit the Green River, including up to nine anadromous salmonid species. Currently chinook, coho, chum, pink and sockeye salmon, steelhead and coastal cutthroat trout may be found at various times of the year in portions of the Green River. Native char (bull trout and/or Dolly Varden) have been occasionally observed to enter the lower Green/Duwamish

River. Native resident salmonids include rainbow and cutthroat trout and mountain whitefish. Other native fish species are also present, including lamprey, minnows, sculpins, and suckers. Natural spawning anadromous fish have been recognized as a critical link in the aquatic food webs of the Pacific Northwest aquatic ecosystem. They are considered a “keystone” species upon which producers and consumers from the bottom to the top of the food chain depend.

Rearing in the ocean, adult anadromous salmon return to streams with ocean nutrients, enriching the food web from primary producers to top carnivores. At the top of the food web, at least 22 species of wildlife, including black bear, mink, river otter, and bald eagle, feed on salmon carcasses (Cederholm et al. 1989). At the base of the food web, salmon carcasses provide a major amount of nitrogen to streamside vegetation, and large amounts of carbon and nitrogen to aquatic insects and other macroinvertebrates (Bilby et al. 1996). Some researchers suggest that a minimum escapement level for natural spawners may be needed to maintain the integrity of the aquatic food chain.

In addition to their importance to genetic diversity and biological cycles, local salmon and steelhead harvests in the Green/Duwamish basin provide for commercial, sport, subsistence, and cultural uses to people. In particular, Muckleshoot and Suquamish Tribal people have treaty fishing rights to Green River fish, which are important to their economic and cultural sustenance.

In response to the declining status of these valuable species, the U.S. Fish and Wildlife Service (USFWS) listed bull trout (64 FR 58910) and National Marine Fisheries Service (NMFS) listed Puget Sound chinook salmon as threatened (63 FR 11482) requiring protection under the ESA. These proposed and listed stocks include any populations of these species that may reside in the Green River.

The Green/Duwamish river basin lies within the southernmost portion of the North Cascades ecoregion in the Puget Sound basin (USACE 1996). This ecoregion (an area with distinct climate, wildlife, and plant populations) is an important producer of fish and wildlife resources. Anadromous fish species historically had access to the upper basin above the Headworks. However, anadromous fish access to the upper Green River is now blocked by HHD at RM 64.5 (completed in 1962) and the Headworks at RM 61.0 (completed in 1912).

The middle Green River basin includes the 13-mile-long Green River Gorge. The middle Green River basin and lower Green/Duwamish basin lie within the Puget Lowland ecoregion, which is characterized by open hills and flat lacustrine and glacial deposits.

This region once contained extensive wetlands; however, the lower portion of the basin was historically developed for agricultural use. Much of the forested areas was cleared for pastureland, and riparian zones were restricted by levees. Much of the lower basin has since been developed as urban areas and includes the cities of Auburn and Kent (USACE 1996). The Duwamish River historically consisted of extensive saltwater and brackish marshes.

The lower Green/Duwamish rivers support some salmonid spawning in the upper portions and the entire reach was extensively used by juvenile salmonids (Grette and Salo 1986). Tidewater fish that likely used the estuary of the Duwamish River include smelt (*Osmeridae*), sole (*Pleuronectidae*), sanddab (*Bothidae*), goby (*Gobiidae*), sculpin (*Cottidae*), Pacific sandlance (*Ammodytes hexaperterus*), and tube-snout (*Aulorhynchus flavidus*) (Grette and Salo 1986).

4.4.1.1 Distribution

A total of 11 anadromous fish species are covered by this HCP (see Chapter 2). Several of these species also exhibit resident freshwater phases. These species were selected to be discussed in detail because of their status as fishes of primary concern, USFS-sensitive species, or species proposed for listing under the ESA. The anadromous salmonids include chinook, chum, pink, coho, and sockeye salmon, steelhead, coastal cutthroat, bull trout, and Dolly Varden. Resident salmonids proposed for coverage under the ITP include rainbow, cutthroat trout, bull trout, and Dolly Varden. Other anadromous species proposed for coverage under the ITP are Pacific and river lamprey (*Lampetra tridentatus, L. ayresi*). Additional information on the life history types and stock status for select Green River fish species are discussed in Appendix A, Life History of Fish and Wildlife Species Addressed in the Habitat Conservation Plan.

4.4.1.2 Chinook Salmon *(Oncorhynchus tshawytscha)*

Chinook salmon are differentiated into two juvenile behavioral forms, ocean-type and stream-type, based on their pattern of freshwater rearing. Juvenile ocean-type chinook salmon migrate to the marine environment during the first year of life, generally within 3 to 4 months of emergence (Lister and Genoe 1970). Juvenile stream-type chinook salmon rear in fresh water for a year or more before outmigrating to the ocean. Differences between these life history patterns are accompanied by differences in morphological and genetic attributes (Myers et al. 1998). Chinook salmon classification is further divided by the timing of upstream migration (e.g., spring or fall/summer runs).

The principal race of chinook salmon present in the Green River is summer/fall ocean-type chinook. Adult summer/fall chinook migrate upstream in the Green River from late June to mid-November. Spawning takes place from September through mid-November. The juveniles may migrate to the ocean in the first 3 months of life. Ocean-type chinook tend to depend heavily on estuaries for juvenile rearing to achieve a larger size before moving off-shore. Chinook juveniles occur in the Duwamish estuary from early April through late July (Meyer et al. 1980).

The Green River summer/fall chinook are part of the Puget Sound Evolutionarily Significant Unit (ESU). Overall, abundance of chinook salmon in this ESU has declined substantially, and both long- and short-term abundance are predominantly downward. These factors have led to this ESU as listed as threatened under the ESA (63 FR 11482). Chinook salmon within the Duwamish/Green River basin originated from both native and hatchery fish (i.e., are of "mixed origin"). However, the hatchery stock of chinook salmon is currently believed to have descended from the wild run (Grette and Salo 1986). Escapement in the mainstem Green River averaged 7,600 from 1987 through 1992 with a trend toward increasing escapement (WDFW et al. 1994). In its review of the Puget Sound chinook ESU, NMFS classified the Green River stock as healthy based on high levels of escapement (Myers et al. 1998).

4.4.1.3 Bull Trout *(Salvelinus confluentus)* **and Dolly Varden** *(Salvelinus malma)*

Bull trout and Dolly Varden are the two native char species present in western Washington. Bull trout are primarily an inland resident species, though anadromous populations may be present in some coastal drainages (WDFW 1997). Dolly Varden are primarily found within coastal drainages, and include both anadromous and resident life-history forms. A single native char was observed in Soos Creek in 1956, although there is no supporting documentation for this sighting (Beak 1996). A single native char was also observed at the mouth of the Duwamish River in the spring of 1994 (Warner 1998).

Bull trout in the Coastal-Puget Sound distinct population segment (DPS) were listed as a threatened species by the USFWS on 1 November 1999 (64 FR 58910). Dolly Varden were not listed as part of this action. However, both bull trout and Dolly Varden are present in the Coastal-Puget Sound DPS, and have been found to coexist in a number of streams in this region (64 FR 58910). Bull trout and Dolly Varden are very difficult to distinguish based upon physical features, and have similar life history traits and habitat requirements (WDFW 1998; 64 FR 58910). Because these two species are closely related and have similar biological characteristics, the Washington Department of Fish and Wildlife (WDFW) manages bull trout and Dolly Varden together as "native char"

(WDFW 1998). Section 4(e) of the ESA provides for the listing of a non-threatened species if it closely resembles a listed species, and if the listing of this species provides a greater level of protection to the listed species. The USFWS indicated in January 2001 that Dolly Varden are being considered for listing as threatened due to their similarity of appearance to bull trout (66 FR 1628). Consequently, Tacoma included both bull trout and Dolly Varden as species to be covered by the HCP and under the ITP.

Native char (bull trout and Dolly Varden) spawn during the fall (September through November) in western Washington (WDFW 1998). Spawning occurs in areas possessing cold water temperatures, with spawning typically commencing when water temperatures drop below 9ºC (48ºF) (WDW 1992). Incubation of eggs occurs through the winter months, with emergence occurring during the early spring (WDW 1992). Juveniles require cold water temperatures for rearing (less than 16ºC [61ºF]), and are closely associated with coarse substrates and LWD (64 FR 58910). Juveniles generally remain in streams for 2 to 3 years before migrating to larger rivers (fluvial forms), lakes (adfluvial forms), or the ocean (anadromous forms). For the remainder of this document, reference to bull trout is considered to include both bull trout and Dolly Varden.

4.4.1.4 Coho Salmon (Oncorhynchus kisutch)

Coho salmon of the Green River system are divided into two stocks, Soos and Newaukum creeks, by geographic separation and differences in spawning timing. This designation is tentative due to the lack of biological characteristics (WDFW et al. 1994). Both stocks are of mixed origin and contain both native and non-native coho. Currently, approximately 3 million yearling coho are released annually from hatcheries on Soos and Crisp creeks. The Newaukum Creek stock is considered depressed, and the Soos Creek stock is currently healthy (WDFW et al. 1994). Green River coho have been placed into the Puget Sound/Strait of Georgia ESU, and are warranted for protection under ESA (Weitkamp et al. 1995).

The Green River coho are typical of Puget Sound stocks with regard to their life histories; 18 months in fresh water followed by 18 months in salt water (or up to 3 years) (Grette and Salo 1986). Adult coho return to the Green River and migrate upstream from early August through late January. Spawning occurs from mid-November through late January (Caldwell 1994). All accessible reaches are used for spawning, with mainstem spawning heaviest in the braided channel reaches near Burns Creek, in the gorge, and below the Headworks. Major spawning tributaries include Newaukum, Big Soos, Crisp, Burns, Springbrook, and Hill creeks (Grette and Salo 1986).

***4.4.1.5 Sockeye Salmon** (Oncorhynchus nerka)*

Although sockeye salmon are usually associated with lakes where juveniles rear, they will spawn in rivers without lake-rearing habitat present. The Green River is included in this suspected riverine-rearing distribution. Although the origin of these stocks is unknown, between 1925 and 1931 at least 392,050 sockeye salmon fry derived from the Green River, Quinault Lake, and unspecified Alaska stocks were released into the Green River from the Green River State Hatchery (WDFG undated *in* Gustafson et al. 1997). Peak counts of sockeye spawners in the Green River ranged from 1 to 16 fish during 14 years of surveys that occurred between 1954 and 1990. These fish were observed from mid-September to mid-November (Gustafson et al. 1997). Green River sockeye are classified as a riverine-spawning sockeye salmon under other population units by NMFS. Currently there is insufficient information regarding riverine-spawning sockeye to reach any conclusions regarding their status (Gustafson et al. 1997).

Sockeye salmon enter Puget Sound rivers from mid-June through August. Spawning takes place in late September to late December and occasionally into January. Peak emergence for similar river systems occurs from early March to mid-May. Due to lack of nursery-lake habitat, juvenile sockeye in the Green River rear in side channels, sloughs, or travel to the lower estuary to rear (Gustafson et al. 1997).

***4.4.1.6 Chum Salmon** (Oncorhynchus keta)*

Two chum salmon stocks are recognized in the Green River system (WDFW et al. 1994). The Crisp (Keta) Creek fall chum stock originated from releases of Quilcene and Hood Canal stocks at the Keta Creek Hatchery in the early 1980s, and is considered healthy. The Duwamish/Green stock may be a remnant native stock and its status is unknown. The origin of this stock is also unknown, but it is likely that hatchery plants have affected the gene pool (WDFW et al. 1994). Green River chum salmon are included in the Puget Sound/Strait of Georgia ESU. Current levels of abundance for this ESU are at or near historical levels and, therefore, do not warrant protection under ESA at this time (Johnson et al. 1997).

Chum salmon spawn most commonly in the lower reaches of rivers in November and December. Juvenile chum salmon, like ocean-type chinook, have a long period of estuarine residence, which is the most critical phase of their life history and often determines the size of subsequent adult returns.

4.4.1.7 *Pink Salmon* *(Oncorhynchus gorbuscha)*

Pink salmon are uncommon in the Green River. The status report for Pacific Northwest pink salmon stocks was recently released, with the result that neither of the two ESUs are warranted for protection at this time. Prior to the 1930s, odd-year pink salmon were present in the Green River (Grette and Salo 1986). Stray pink salmon are observed on occasion in the Green River, but these incidents do not imply a run is present (Grette and Salo 1986). Washington and Southern British Columbia pink salmon stocks, divided into even- and odd-year ESUs, are not warranted for protection under ESA at this time (Hard et al. 1996).

The pink salmon juveniles migrate quickly to the sea upon emergence and grow rapidly. After a year and a half in the ocean, the maturing fish return to spawn and die (Heard 1991). This 2-year life cycle is unique among Pacific salmon species.

4.4.1.8 *Steelhead* *(Oncorhynchus mykiss)*

The Green River system supports both summer and winter stocks of steelhead (WDFW et al. 1994). These stocks are differentiated by timing of adult return, but share common juvenile behavior patterns. Winter steelhead return to the Green River from November through early June, and summer adults return from April through November (Caldwell 1994). Protection under the ESA is ruled to be unnecessary at this time; however, if numbers decline, a review may become necessary.

The Green River summer steelhead stock is of non-native hatchery origin (WDFW et al. 1994). Currently, about 70,000 summer steelhead smolts are released into the Green River system annually. The stock is managed to provide a recreational fishery, and the stock status is healthy. The Green River also supports winter steelhead. In addition to the naturally reproducing run of native stock, approximately 100,000 hatchery-origin smolts from the Chambers Creek stock are planted annually, but are not believed to interbreed with the native stock due to differences in spawning timing.

4.4.1.9 *Coastal Cutthroat Trout* *(Oncorhynchus clarki clarki)*

A modest coastal cutthroat (anadromous form of cutthroat trout) population is present in the Green River; however, little is known about their status (Grette and Salo 1986). Puget Sound coastal cutthroat trout populations have been relatively stable over the last 10 to 15 years and are not warranted for listing under ESA (64 FR 16397).

Coastal cutthroat have the most variable life history of the indigenous anadromous salmonids (Grette and Salo 1986). Coastal cutthroat trout exhibit early life history characteristics similar to coho and steelhead. Juveniles rear in fresh water for more than 1 year, generally from 2 to 9 years (Wydoski and Whitney 1979). The seaward migration of smolts occurs in April and May and coincides with steelhead smolt emigration (Grette and Salo 1986). Adult upstream migration in the Green River occurs from July through early February (Caldwell 1994) with the peak occurring in October and November (Grette and Salo 1986). Spawning occurs in small streams from March through early May.

4.4.1.10 Pacific and River Lamprey (Lampetra tridentatus, L. ayresi)

The Pacific and river lamprey can be found in coastal streams from California to Alaska (Morrow 1976). Little information exists regarding their status in the Green River; however, numerous Pacific and a few river lamprey were observed during side-channel surveys in the middle Green River conducted by R2 Resource Consultants, Inc. in 1998. Little other information exists on the occurrence of lamprey in the Green River. Pacific and river lamprey have freshwater habitat requirements similar to some of the Pacific salmon; therefore, they have encountered similar habitat problems. Though absolute historical population sizes of the lamprey are not known, it is clear that the fish, once a significant tribal subsistence food, have shown severe population decline.

The USFWS has not initiated a status review of Pacific lamprey or river lamprey in the Pacific Northwest. Plans to do so are not in the foreseeable future, unless USFWS is petitioned to list these fishes under the ESA (Weitkamp 1998).

4.4.2 Plant Communities

4.4.2.1 Terrestrial Plant Communities

Upper Basin

The upper Green River basin is within the Western Hemlock Forest Zone (Franklin and Dyrness 1987). The Western Hemlock Forest Zone is characterized by climax western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) forests, and sub-climax Douglas-fir (*Pseudotsuga menziesii*) forests. Although western hemlock is the potential climax species in this zone, Douglas-fir forests cover large areas of the landscape. Douglas-fir-dominated forests develop following disturbance, such as fire and clearcut logging practices, and can persist for several centuries. Hardwood forests are commonly restricted to moist, early successional sites, where red alder (*Alnus rubra*) often dominates and big-leaf maple (*Acer macrophyllum*) is common. Topography, aspect, geology, soil, and available groundwater all influence plant community patterns at the local level, particularly for understory species. Common understory species include sword fern (*Polystichum munitum*) in moist sites, salal (*Gaultheria shallon*) in dry sites, and Oregon grape (*Berberis nervosa*) in sites with intermediate moisture status. Vine maple (*Acer circinatum*) is a common shrub in the middle understory.

Disturbance has had a major impact on forest patterns in the upper Green River basin due primarily to extensive timber harvest and past wild fires. Timber harvest activities have resulted in the predominance of second-growth, even-aged coniferous stands. There is also a large area of hardwood dominated by red alder with an understory of western hemlock and western red cedar present. The majority of the stands are 30 to 90 years old and, until about 30 years ago, regenerated naturally. More recently harvested areas have been planted with Douglas-fir. Deciduous forests comprised of red alder, big-leaf maple, and black cottonwood (*Populus trichocarpa*) occur on wetter slopes. The distribution of age classes of coniferous and hardwood-dominated stands in lands managed by Tacoma Water are shown in Table 4-7.

Table 4-7. Distribution of forest by age class on City of Tacoma upper Green River watershed lands.

Age Class	Conifer (acres)	Hardwood (acres)	Total (acres)
1-20 yrs	2,261	150	2,411
30-100 yrs	6,168	2,756	8,924
110-170 yrs	280	0	280
180+ yrs	30	0	30
Total Forest Land	8,739	2,906	11,645
Non-Forest Land			3,243
TOTAL			14,888

Source: City of Tacoma GIS Database, Dick Ryan 1998.

Middle Basin

The middle Green River basin also occurs within the Western Hemlock Forest Zone. The forested habitats of the middle basin are similar in composition to the forested habitats in the upper basin, with even less late-successional forest. Existing forested areas in the middle basin are dominated by second-growth Douglas-fir. Further downstream, cover types characterized by pasture and cropland become more common.

Lower Basin

Most of the lower Green River basin below Auburn is within low-lying valley bottom and has little remaining natural vegetation. Existing cover types are mostly pasture, cropland, and urbanized areas. Prior to alteration by Euroamericans, these valley bottomlands were largely wetland as described in the next section.

4.4.2.2 Riparian and Wetland Plant Communities

Upper Basin

Forested riparian areas along streams in the upper Green River basin are typically dominated by red alder and/or black cottonwood. The majority of the shoreline around the HHD reservoir is unsuitable for riparian or wetland communities due to steep slopes and fluctuating water levels (USACE 1998). The result is a lacustrine environment primarily bordered by upland coniferous and deciduous forest. The presence of an unvegetated shoreline of varying width when the water level is drawn down is a common occurrence along reservoirs with fluctuating water levels. Riparian and wetland vegetation around the reservoir is primarily limited to a few locations where low gradient topography occurs adjacent to the reservoir and along the tributary streams that flow into the reservoir. Wetland types identified in the vicinity of the HHD include forested swamp, shrub swamp, emergent marsh, moss, mudflat, and open water.

Forested swamp occurs along the banks and gravel bars of the HHD reservoir and upstream along the mainstem of the Green River just below the upland deciduous forest. These receive water both from high river flows and from small streams that enter backwater sloughs. Some of the small streams originate from hillside springs and thus provide a year-round source of cool surface water. Black cottonwood and red alder are the dominant overstory species. Willow (*Salix* spp.), red-osier dogwood (*Cornus stolonifera*), salmonberry (*Rubus spectabilis*), water parsley (*Oenanthe sarmentosa*), and coltsfoot (*Petasites frigidus*) dominate the shrub and herbaceous layers.

Shrub swamp is located in small patches adjacent to, and slightly above, the emergent marsh wetlands. These are almost entirely associated with summer high reservoir levels. The shrub swamps consist almost entirely of dense willow thickets.

Emergent marsh is the most common wetland community in the vicinity of the reservoir, occurring most often below the filled pool elevation of 1,141 feet. These areas are dominated by woolgrass (*Scirpus cyperinus*), soft rush (*Juncus effusus*), creeping bentgrass (*Agrostis alba*), and creeping buttercup (*Ranunculus repens*), depending on the elevation. Elk graze many of these areas regularly and the vegetation remains cropped as a result. A relatively large area of emergent marsh occurs at the McDonald farm site. Implementation of the Section 1135 Fish and Wildlife Restoration Project will increase the conservation pool level from 1,141 to 1,147 feet above, resulting in a decrease in the amount of emergent marsh below 1,141 feet.

Moss-dominated wetlands occur below the elevation of the emergent marsh. These areas are typically inundated from about June through August. Patches of creeping bentgrass and creeping buttercup are occasionally present. Unvegetated mudflats occupy lower elevations around the perimeter of the reservoir. These areas are exposed up to 6 months during the lowest reservoir pool levels.

Middle Basin

Other than a narrow riparian zone, few wetlands occur in the narrow floodplain of the Green River between HHD and the lower end of the Green River Gorge. Wetlands in this reach are primarily restricted to a few relatively small flat areas adjacent to the river and are mostly dominated by shrubs and cottonwood/alder forest. Because of the predominantly steep surrounding slopes, development has not encroached on these wetland areas to the extent it has farther downstream in the floodplain.

In the vicinity of the middle Green River below the gorge, the floodplain is wider and contains a mixture of emergent, shrub, and forested wetlands. Riparian deciduous forest dominated by cottonwood and red alder occurs in patches on the floodplain, most of which likely pre-date the operation of HHD when flood control was initiated. For example, a major flood in November 1959 prior to flood control corresponds closely to the age of many forested terraces along the present river. Riparian deciduous forest typically becomes established on new surfaces created by deposition of sediment during flood events. The mosaic of successional stages of riparian deciduous forest reflects the previous flood history of the river. Because the reduction in the magnitude and frequency of flood flows following the construction of the HHD has altered the disturbance regime of the river, the initiation of new stands of these riparian forests has likely been reduced.

Lower Basin

Prior to settlement by Euroamericans, the floodplain of the lower Green River was characterized by extensive wetlands. The low-lying topography, fine-textured soils, and frequent flooding resulted in dense vegetation consisting of shrubs, sedges, or grasses in lower areas and thickets of maple, cottonwood, ash (*Fraxinus latifolia*), and alder on slightly higher ground (USACE 1995). Patches of Douglas-fir, western red cedar, and Sitka spruce (*Picea sitchensis*) occurred in somewhat drier areas. These plant communities have been virtually eliminated in the lower Green River basin as a result of drainage, diking and channelization of the river, agricultural development, and urbanization (see Chapter 4.1.2). Where open space occurs, pasture and cropland are the most common cover types. Small patches of remnant or disturbed wetlands also occur.

4.4.3 Wildlife

4.4.3.1 Gray Wolf *(Canis lupus)*

Within Washington, the gray wolf is listed as endangered at both the federal and state levels. Gray wolves were thought to be extirpated from Washington by 1920, but some may be reestablishing their former range via immigrants from Canada and Idaho. Gray wolves are habitat generalists occurring in open tundra and forest and may be found wherever populations of ungulates exist. Wolves avoid areas of human activity, and wolf populations have been found to decrease when road densities exceed 0.93 mile per square mile (see Appendix for additional life history information and references). Gray wolves often maintain very large home ranges. For example, home ranges were 40 to 47 square miles on Vancouver Island and 93 to 248 square miles in northern British Columbia. Although the species is considered rare, a Class 2 sighting (reliable but unconfirmed) of a gray wolf was reported in the upper basin of the Green River (USFS 1998). It is extremely unlikely to occur in the lower and middle basin areas.

4.4.3.2 Peregrine Falcon *(Falco peregrinus)*

The peregrine falcon was recently delisted at the federal level, but remains listed as an endangered species at the state level. The population has rebounded over the past 25 years, following a dramatic decline due primarily to environmental contamination with DDT and other toxins. Peregrine falcons typically nest on sheer cliffs, canyon walls, and rocky outcrops ranging in height from 75 to 2,000 feet, but occasionally peregrines will nest in snags, old eagle nests, pinnacles, sand dunes, talus slopes, cutbanks, buildings, and bridges. Nest sites usually have a panoramic view of open country, often overlook water, and are always associated with an abundance of waterfowl, shorebirds, or passerine prey. In the Pacific Northwest, nests are always close to major water sources (with a maximum distance of 3,300 feet), but adults will hunt up to 17 miles away from nest sites. In winter, intertidal flats, estuaries, and inland wetland habitats are important hunting areas for the peregrine. Although the species is considered rare, at least four individuals have been sighted in the upper Green River basin (USFS 1996). No nests are known to occur on or near the lands covered by this HCP. It is not likely to inhabit the lower or middle basin areas of the Green River.

4.4.3.3 Bald Eagle (Haliaeetus leucocephalus)

The bald eagle is a federal threatened species in the 48 conterminous states and a state threatened species in Washington. In the 1950s, bald eagle populations began a precipitous nationwide decline due to eggshell thinning and other reproductive failures induced by chemical contamination of the environment with DDT, polychlorinated biphenyls, and Dieldrin. Since the ban of DDT in 1972, and reduction of other environmental toxins, bald eagle numbers have rebounded in Washington and throughout much of the United States and Canada. In the Pacific Northwest, bald eagles exhibit a close association with freshwater, estuarine, and marine ecosystems that provide abundant fish and waterfowl populations. The nesting habitat of bald eagles is characterized by large dominant trees in stands of old-growth conifers, or old-aged second-growth coniferous stands. Bald eagle nests are most often built along rivers, large lakes, and reservoirs in a large Douglas-fir, Sitka spruce, or black cottonwood (>30 inches diameter at breast height [dbh]). Nest trees usually have prominent topographic locations and unobstructed views of surrounding waters; other large trees near nest sites are often present to serve as alternate nests and perches. Bald eagles frequently remain in their nesting territories throughout the winter in Washington, or they move relatively short distances to seasonal food supplies where they may be joined by eagles that nest in Canada. Winter communal roost sites are generally close to feeding areas with low human disturbance levels, although eagles may travel up to 9 miles to feeding areas. Night roost sites are usually established in old-growth stands or mature forest with old-growth components that provide thermal cover and wind protection. Bald eagles will use live conifers, cottonwoods, big-leaf maples, and snags for perches and night roosts. Nesting bald eagles have been reported in the upper and middle Green River basins (Eagle Lake and Lake Sawyer) (USFS 1996, 1998). Nesting is uncommon in the lower section of the Green River basin, due to the scarcity of suitable breeding sites at lower elevations in King County. Bald eagles have been observed every month of the year near the Howard Hanson Reservoir; however, they are most common during the winter months. The large number of waterfowl present during winter are likely an important prey source.

4.4.3.4 Marbled Murrelet *(Brachyramphus marmoratus)*

The marbled murrelet is federally listed as a threatened species in Washington, Oregon, and California, and the state of Washington lists it as a threatened species. A variety of factors has been implicated in its decline, including over-fishing of its prey, entanglement in fishing nets, mortality due to oil spills, and loss of forest nesting habitat. The marbled murrelet is a small seabird that spends most of its life cycle on marine waters, but is the only North American Alcid that nests in trees. Suitable nesting habitat is old-growth coniferous forest or mature coniferous forest with an old-growth component. Murrelets typically require large coniferous trees for nest sites, usually greater than 32 inches in dbh, with large-diameter moss-covered limbs. Nests consist of depressions in moss or duff on large lateral branches located within the live crown of mature or old-growth trees. Average stand age is 522 years (range 180-1,824 years) for nest sites in the Pacific Northwest, but nests have been located in younger (90-120 years old) western hemlock stands with a mistletoe component. Nest sites occur in stands ranging from about 12 to 2,475 acres and often having multi-layered canopies with high canopy cover (mean = 85 percent) immediately over the nest, as well as an open canopy near nest trees. Suitable marbled murrelet nesting habitat has been identified in the upper Green River basin, but surveys have revealed the presence of only one occupied stand. The occupied stand is on USFS land adjacent to the HCP Area. Marbled murrelets are not expected to occupy the HCP Area because of the lack of suitable nesting habitat. Habitat is generally lacking throughout the middle and lower basins as well, and murrelets are unlikely to occur there.

4.4.3.5 Northern Spotted Owl *(Strix occidentalis caurina)*

The northern subspecies of the spotted owl is federally listed as threatened in Washington, Oregon, and California. The state of Washington lists it as an endangered species. Studies throughout the Pacific Northwest have found that northern spotted owls on the west slope of the Cascades typically select old-growth and other late-successional coniferous forest for foraging, roosting, and nesting. The species nests up to 3,200 feet in elevation on the Olympic Peninsula and up to 4,000 feet in the northern part of its range. Large-diameter trees are required to provide cavities for nest sites, since spotted owls on the west slope of the Cascades do not typically use stick nests or other platform nests. On a landscape basis, spotted owls select home ranges that emphasize old-growth within the landscape (44-53 percent average). Reproduction declines sharply with less than 40 percent old-growth forest, and areas with less than 20 percent old-growth forest rarely support nesting owls. Due to the intensive level of surveying in the Green River basin, it is believed that most spotted owls have been located and a reasonably good understanding of territory interactions has been established. Currently, there are 16 spotted owl activity centers that are within 1.8 miles of the Upper HCP Area. These represent 15 pairs of spotted owls (10 with confirmed reproduction) and one single spotted owl of unknown status. Nine of these lie within 0.7 mile of the Upper HCP Area and one is within the HCP Area. Although the spotted owl inhabits the upper basin, it is unlikely to occur in the middle basin or lower Green River basins due to the lack of suitable habitat.

4.4.3.6 Grizzly Bear (*Ursus arctos*)

Within Washington, the grizzly bear is federally listed as threatened and state listed as endangered. The grizzly bear is a habitat generalist, but is primarily restricted to high alpine wilderness areas comprised of semi-open country. Grizzly bears avoid areas of human use, including the presence of roads and timber cutting. The grizzly bear is a free-ranging animal that utilizes a large home range, with males having larger home ranges (200-500 square miles) than females (50-300 square miles). The grizzly bear is an opportunistic omnivore; however, 80 to 90 percent of its diet is green vegetation, wild fruits, berries, nuts, and bulbs or roots. The majority of the meat in its diet comes from carrion. The grizzly bear begins searching for a place to den in early fall. It may travel extensively to find a suitable location, generally on a remote mountain slope where snow, which provides insulation, will last until late spring. Dens are excavated, often under the root systems of large trees. Although the species is considered rare, it is possible that it may infrequently inhabit the upper basin, but not the lower and middle basin areas of the Green River. No confirmed grizzly bear sightings have occurred in the watershed, with the nearest reported sighting at least 15 miles away, north of I-90 and east of Lake Cle Elum (USFS 1998).

4.4.3.7 Oregon Spotted Frog (*Rana pretiosa*)

The Oregon spotted frog is a federal candidate for listing and a state endangered species. The reason for its decline is not known, but degradation of wetlands and introduction of the bullfrog (*Rana catesbeiana*) are suspected. The Oregon spotted frog is highly aquatic, nearly always found in marshes or on the edges of lakes, ponds, and slow streams with non-woody wetland plant communities including sedges, rushes, and grasses. Adults usually feed in water or within 2 feet of the shoreline. Spotted frog wetlands are usually surrounded by early successional habitats up to the closed sapling-pole stage and are not specifically associated with mature forested areas. One unconfirmed adult was reported during surveys in the upper Green River basin (USFS 1996), but this location is closer to the known range and habitat of the more abundant Columbia spotted frog (*Rana luteiventris*). Given the rarity of *R. pretiosa* in Washington, lack of historic records in eastern King County, and the species' low elevational preference, presence on the upper Green River basin is very unlikely. It also is unlikely to be found in the lower and middle basins because of recent extirpations throughout its range.

4.4.3.8 Canada Lynx *(Lynx canadensis)*

The Canada lynx is listed by the state of Washington and the USFWS as threatened. Factors contributing to the listing of the species were human alteration of forests, low numbers as a result of past over-exploitation, expansion of the range of competitors (bobcats and coyotes), and elevated levels of human access into lynx habitat. The Canada lynx requires a matrix of two important habitat types. For thermal and security cover and for denning it uses mature, closed-canopy, boreal forest that contains a high density of large logs and stumps and is near hunting habitat. For hunting it uses early successional forest with high prey densities. Additionally, lynx avoid large open spaces and tend not to cross openings greater than 330 feet. The abundance of Canada lynx is correlated with the population cycle of the snowshoe hare *(Lepus americanus*), its primary prey. One male was reported in the upper Green River basin (USFS 1996), but it is extremely unlikely to occur in the lower and middle basin areas.

4.4.3.9 Cascades Frog *(Rana cascadae)*

The Cascades frog is currently classified as a federal species of concern. The species might be sensitive to habitat fragmentation, drought, disease, fish introductions, and UV radiation. The Cascades frog is a montane species that rarely occurs at elevations below 2,000 feet, and in Washington it has been recorded up to 6,200 feet. Cascades frogs are most commonly found at lakes, ponds, swamps, marshes, sphagnum bogs, and fens, but also inhabit pools adjacent to streams in alpine meadows and forests. After breeding, adults may travel away from water, well into terrestrial upland habitats. Macrohabitat studies have found significant correlations for open wetlands, sapling conifers (6-26 years old), recent clearcuts (0-5 years old), and mature conifers (>45 years old), suggesting that all successional stages are important, except for the stem exclusion stage (pole conifers) and alder/hardwood stands. The Cascades frog is locally abundant in high elevation areas (2,000-6,200 feet) in the upper Green River basin above the Headworks, but is not expected to inhabit the lower and middle basins.

4.4.3.10 Cascade Torrent Salamander *(Rhyacotriton cascadae)*

The Cascade torrent salamander is classified a federal species of concern and a state candidate species. Torrent salamanders are locally vulnerable to clearcut logging because of associated watershed disturbances such as siltation and sedimentation, and temperature increases due to canopy removal. These salamanders are almost always found in or adjacent to cold, clear, swift mountain streams, but seeps and permanently wet talus are also inhabited. Their eggs are deposited in water and the larva are completely aquatic for 3 to 5 years before metamorphosing into terrestrial adults. Adults are fully terrestrial, air-breathing salamanders, but seldom wander more than 3 feet from water. Streams inhabited by torrent salamanders are usually located in forested areas, primarily in mature and old-growth conifer or mixed forest, but quantitative habitat data are still lacking for this one of four *Rhyacotriton* species. The Cascade torrent salamander is unlikely to occur in the HCP Area because of its rarity and lack of historical range within the Green River basin. Although the species could potentially inhabit the upper basin, it is highly unlikely in the lower and middle basin areas of the Green River due to the lack of cold, headwater streams at lower elevations.

4.4.3.11 Van Dyke's Salamander *(Plethodon vandykei)*

The Van Dyke's salamander is a federal species of concern and a state candidate for listing in Washington because of its rarity and very limited distribution. Van Dyke's salamanders are typically found in the splash zones of small streams (Washington Department of Natural Resources [WDNR] Types 3 and 4), waterfalls, and seeps; however, these salamanders may also be locally abundant on steep talus slopes up to 3,600 feet in elevation. They emerge at night or during rainfall to forage on the forest floor and along stream banks. Macrohabitat studies have shown significant preferences for closed-canopy forest types: alder/hardwoods, pole conifers (27-44 years old), and mature conifers (>45 years old). A single incidental sighting at Twin Camp Creek (USFS 1996) suggests a population exists in the upper Green River basin in the HCP Area, but it is not very likely in the lower and middle basin areas of the Green River due to a scarcity of unmanaged riparian forest zones left along lowland stream and creeks.

4.4.3.12 Larch Mountain Salamander *(Plethodon larselli)*

The Larch Mountain salamander is probably one of the rarest amphibians in Oregon and Washington. It is classified as a federal species of concern and state sensitive species because of its rarity, its unique habitat associations (talus), and extremely small geographic range. This upland salamander species is fully terrestrial and usually inhabits steep talus slopes (30-50 degrees) kept moist by a covering of mosses and a dense overstory of coniferous trees, although it also occurs in lava tubes, caves, and in old-growth forest stands without talus. The Larch Mountain salamander has recently been documented as a resident of the upper Green River basin (USFS 1997, 1998), but may also occur at lower elevations in the middle Green River basin (below the Headworks) if suitable talus habitat is available. It is unlikely to occur in the lower basin because old-growth forest and steep talus slopes are virtually absent in this areas.

4.4.3.13 Tailed Frog *(Ascaphus truei)*

The tailed frog is currently classified as a federal species of concern. Tailed frogs are locally vulnerable to clearcut logging because of associated watershed disturbances such as siltation and sedimentation, and temperature increases due to canopy removal. The tailed frog ranges from nearly sea level up to 5,250 feet in elevation. Tailed frogs require cold, fast-flowing permanent streams (WDNR Types 3 and 4) within forested areas, but do not inhabit ponds and lakes. The aquatic larvae (tadpoles) may take from 1 to 6 years to metamorphose while they remain in the stream. At night, adult tailed frogs emerge from cover and forage in adjacent upland forests, wandering up to 1,300 feet from water. Streams supporting large populations of tailed frogs usually occur in mature and old coniferous forests, but macrohabitat studies on an industrial forest have found significant correlation between tailed frog occurrence and both pole conifers (27-44 years old) and mature conifers (>45 years old), but not for alder/hardwood stands. In a California study, tailed frogs were present in a variety of stands more than 30 years old, but absent or very rare in clearcut stands. In an Oregon study, tailed frog abundance was correlated with the presence of forest buffers (>100 feet) along streams. Tailed frogs have been reported in the upper basin of the Green River, but the species is not very likely to occur in the lower and middle basin areas due to the lack of cold, headwater streams at these lower elevations.

4.4.3.14 Northwestern Pond Turtle *(Clemmys marmorata)*

The Northwestern pond turtle is listed as an endangered species by the state of Washington and is a federal species of concern. Threats to this declining species include habitat alteration, drought, predation (on juveniles by exotic fish and bullfrogs), local disease outbreaks, and loss of connectivity between populations due to habitat fragmentation. The northwestern pond turtle inhabits marshes, ponds, sloughs, brackish waters, and slow sections of streams with gentle and unshaded banks, rocky or muddy bottoms, and emergent aquatic vegetation. Females leave the water to nest up to 1,640 feet from shoreline in adjacent open, grassy areas with soft soil and good sun exposure, but most nests are dug within 300 feet of water. Hibernating pond turtles dig burrows along undercut banks, in soft bottom mud of ponds, or in uplands up to 1,640 feet from water. Pond turtle waters are generally surrounded by early successional stages (grass-forb, shrub, open sapling-pole) and are not usually associated with mature forests. This species is extremely unlikely to occur in the upper Green River basin above the Headworks because of a lack of historical records in the Washington Cascades and limited tolerance to high elevations (>1,000 feet) in Washington. The species could be present in lowland habitat of the lower and middle Green River basins. One individual was captured in the Ravensdale area in 1992 and added to the Woodland Park Zoo captive breeding program (Plum Creek 1996).

4.4.3.15 Northern Goshawk *(Accipiter gentilis)*

The northern goshawk is classified as a state candidate species and federal species of concern. In the Pacific Northwest region, nesting goshawks primarily inhabit large tracts of mature and old-growth coniferous forest, but will sometimes nest in younger closed-canopy forests (≥40 years old). Selected stands provide dense canopy cover, clear flight space below the canopy, and large trees to provide support for the large stick nests. Goshawk home range size averages about 6,000 acres, including a nest site of about 30 acres, the post-fledging family area of about 420 acres, and the foraging area of about 5,400 acres. Topographically, a preference has been discovered for nesting on lower, gentle slopes, and only rarely on slopes greater than 40 percent. Goshawks usually avoid nesting on southern slopes. Recent studies have indicated that goshawks use clearcuts less than expected by chance and appear to select foraging sites based on preferred habitat structure, rather than localities of prey abundance. Aside from a concern about habitat loss, excessive forest fragmentation has been linked with increases in potential competitors and predators, such as the red-tailed hawk and great horned owl. Goshawks have been documented in at least five different locations in the upper Green River basin, but are unlikely residents for the middle basin, and extremely unlikely for the lower basin because of increasing urbanization and habitat fragmentation. Outside of nesting territories, occasional wintering goshawks could appear in all areas of the Green River basin for variable periods of time, but are less likely to take up winter residency in urbanized areas or in young regenerating forests (<40 years old).

4.4.3.16 Olive-sided Flycatcher *(Contopus cooperi)*

The olive-sided flycatcher is currently considered a federal species of concern. Olive-sided flycatchers are generally found in open mature stands of conifers, or along the edges of clearings created by burns, wind throw, wetlands, and clearcutting where high perches in tall trees and snags are available. Nests are usually built in conifers from 7 to 72 feet above ground, but occasionally in deciduous trees. Territory size is about 25 acres. In California, over half (52 percent) were on edges, and were positively correlated with the length of edge and stand insularity, and negatively correlated with distance to edge. In California, higher densities of olive-sided flycatchers were observed in sapling (0-20 years old) and mature forest (>100 years old) than in pole/sawtimber (20-80 years old). Another study along the California/Oregon border found a positive correlation with conifers and a negative correlation with hardwoods. The species is known to inhabit the upper basin of the Green River, and is moderately likely to inhabit the lower and middle basin areas.

4.4.3.17 Vaux's Swift *(Chaetura vauxi)*

The Vaux's swift is a state candidate for listing in Washington. It is declining in population throughout its range, probably due to a reduced availability of large, decadent trees and snags. The primary habitat requirement of the Vaux's swift is the presence of large-diameter hollow trees (living or dead), which are used for breeding and roosting. Nest trees are usually large, live trees with broken tops or woodpecker entrance holes. Nest trees range from 18 to 38 inches in dbh and from 50 to 122 feet in height. Large communal roosts are often established by non-breeding adults, and later by breeding pairs. These communal roost sites are established in large hollow chimney snags, ranging from 39 to 53 inches dbh and 53 to 73 tall. In the Washington Cascades, swifts were more abundant in old-growth forest (≥ 250 years old) than in either young (42-75 years old) or mature (105-165 years old) forest. In Oregon, swifts were observed in 41 percent of the old-growth stands surveyed, but only 8 percent of the logged stands surveyed. The Vaux's swift breeds throughout the Washington Cascades and is documented extensively in King County, including at least 49 individuals reported in the upper Green River basin (USFS 1996). There is a reasonable possibility that it inhabits the lower and middle basin areas of the Green River as well.

4.4.3.18 California Wolverine *(Gulo gulo luteus)*

The California wolverine is a federal species of concern and a state monitor species. The wolverine is most common in alpine and subalpine habitats, but may occur in all forest zones within its range. In British Columbia, habitat is conifer-dominated forests, alpine tundra, and freshwater emergent wetlands. Wolverine home ranges vary in size from 21 to 350 square miles, suggesting a need for large wilderness areas. Natal dens have been found in holes dug under fallen trees, in cavities, rock crevices, thickets, abandoned beaver lodges, old bear dens, under the root wads of fallen trees, and in old creek beds.

The wolverine is an opportunistic omnivore in summer, but principally a scavenger in winter. Its summer diet is diverse; berries, small mammals, sciurids, and insect larvae are eaten because of their increased availability. Ungulate carrion is an important part of the wolverine's diet throughout the year; however, in winter they can take live prey slowed by deep snow. There is a 1983 record of an individual observed in the upper Green River basin (USFS 1996), but the species is extremely unlikely to occur in the lower and middle basin areas of the Green River.

4.4.3.19 Pacific Fisher *(Martes pennanti pacifica)*

The Pacific fisher is a federal species of concern and has been listed by the state of Washington as endangered. On the westside of the Cascades, fishers show a preference for contiguous closed-canopy late-successional coniferous forests at mid-elevations. These forest types usually have an abundance of logs and snags that provide habitat for prey and denning opportunities for fishers in the form of cavities. Possibly to reduce infanticide by male fishers, female fishers appear to select for pileated woodpecker cavities as den sites, the size of which allow only the female to enter. Additionally, second-growth forests with sufficient cover are sometimes used, particularly as hunting habitat. Fishers also show a preference for utilizing riparian corridors, especially for travel and rest sites, and avoiding areas of low canopy closure and areas of high snow accumulation. They also appear to avoid highly fragmented forests and clearcuts. There is a 1983 record of an individual observed in the upper Green River basin, but they are not expected to inhabit the lower and middle basin areas.

4.4.3.20 Common Loon *(Gavia immer)*

The common loon is a candidate for listing by the state of Washington. Apparent population reductions in Washington may be a result of disturbance to nesting loons caused by recreational use of lakes and long-term habitat loss from development along lakeshores. Loons require large wooded lakes with substantial fish populations for nesting. Nests are constructed on the ground on islands or mainland within 5 feet of the water's edge, but are vulnerable to disturbance and predation. Man-made artificial islands have been used successfully by nesting loons in areas where there is a lack of natural nesting habitat. Nesting loons inhabit two large waterbodies in the upper Green River basin (Eagle Lake and Howard Hanson Reservoir). Nesting is not expected in the lower and middle basins of the Green River, given the complete lack of known breeding sites at these lower elevations in King County.

4.4.3.21 Pileated Woodpecker *(Dryocopus pileatus)*

The pileated woodpecker is a state candidate species in Washington. Its numbers have been limited by forest practices that have resulted in the loss of large-diameter snags and decadent trees. The pileated woodpecker typically inhabits large tracts of late-successional forest because it requires large-diameter snags and decadent live trees in which to nest, roost, and forage. In Oregon, all nest and roost trees were located in stands of at least 70 years in age. Logs are also an important foraging substrate for the pileated woodpecker because they provide habitat for forest-dwelling ants. Home ranges are very large, averaging 1,181 acres in one Oregon study. The species inhabits the upper basin of the Green River, and is likely present in the lower and middle basin areas as well.

4.5 Factors Contributing to, or Reversing, the Decline of Fish Populations and Habitat

There have been extensive changes to the Green River watershed and ecosystem since Euroamerican settlement began more than a century ago. Land and water use activities such as logging, urbanization, agriculture, municipal and industrial water use, and flood control have all influenced, in various ways, the processes regulating the flow of water, sediment, energy, and nutrients throughout the basin. These processes govern the underlying production potential of the system and directly influence fish and their food. Direct manipulation of fishery resources, including the establishment and operation of hatcheries, and commercial, sport, and Tribal fishing have influenced population sizes directly. As a consequence, many features of the Green River's fisheries habitat and production potential have been influenced, compromised, reduced, or lost. This section reviews the changes, summarizes how they have influenced fish and their environment, and identifies what is being done to reverse some of the losses. In so doing, the framework is then set for understanding the context of the effects of Tacoma's water withdrawals and associated conservation and monitoring activities.

Unless noted explicitly, primary sources of information for this section include Williams et al. (1975), Dunne and Dietrich (1978), Salo and McComas (1978), Fuerstenberg et al. (1996), USACE (1996), and USACE (1998).

4.5.1 Physical Backdrop

Salmonid habitat and production in the Green River are controlled according to basin-scale characteristics of sediment sources, transport, and deposition, prevailing climate and hydrology, and nutrient supply. In the upper Green River basin, the steep, bedrock-and boulder-dominated headwater streams are generally nutrient-poor. Nutrients and food energy likely originate primarily from decomposition of organic material input from the surrounding forests. Coarse sediments enter the stream system by means of periodic mass wasting and rock fall and collect in the lower gradient reaches of the upper valley area, where alluvial deposits are created and reworked. Fine sediment production is low relative to other nearby, glacially fed rivers. Peak stream flows occur during the winter and spring months as rainfall and snow melt runoff. The upper/middle basin is elongate and does not constitute a large runoff source area for the lower basin.

Migratory anadromous and resident salmonid populations were once found throughout the upper system, including several species of Pacific salmon, steelhead/rainbow, and coastal/resident cutthroat trout (Beak Consultants 1994; WDFW 1997). Returning adult anadromous salmon, trout, and lamprey provided input of nitrogen, phosphorus, and other important elements from the ocean to the stream system, in support of the production of future generations. Trees in the riparian zone would fall into the headwater tributaries and mainstem, thereby providing biologic and geomorphic functions such as creating pool habitat, and retaining gravel and organic material. The basin was also likely a source of large organic debris to downstream reaches.

The upper half of the middle Green River basin flows through a steep gorge with a channel bed of bedrock, boulders, and the occasional small patch of gravel. The gorge parent material is relatively erodable sandstone and mudstone, and thus was not an important historical source of gravel for spawning habitat found farther downstream. Hence, the primary fluvial geomorphic function of the gorge was as a sediment transport reach between the upstream source and downstream depositional/alluvial areas. Salmonid spawning habitat was available in limited quantities, and the reach served primarily as a passage corridor for anadromous salmonids and provided rearing/holding habitat for juvenile and adult anadromous and resident fish alike. The lower reach of the middle Green River basin, below RM 45.6, represents a gradient transition zone between sediment transport and deposition. Much of the lower reach was braided and the stream meandered freely across the floodplain. The White River joined the Green River between RM 34.0 and RM 35.0 and contributed roughly 75 percent of the total sediment load to the lower basin. Sediment also originated from local landslides of glacially compacted valley floor material.

Riparian wetlands bordered the channel along most of its length, and episodic floods would cause the river to overflow its banks onto the floodplain. Adjacent wetlands and valley soils retained water during precipitation events and high flows, and subsequently supplemented the river’s streamflow during summer and early fall low flow periods.

Trees would fall into the stream and provide habitat structure. Spawning habitat was available throughout most of the lower reach of the middle basin. Side channels were also present throughout much of the river in lower gradient reaches, providing rearing habitat for juvenile salmonids. Tributaries, both small and large, provided habitat for salmonids and other fish species.

What is today the lower Green River (previously the combined flows of the Green and White rivers) meandered freely through the extensive, low gradient Duwamish Bay deposits that dominate the lower basin topography. The stream channel was quite sinuous. The White River, a glacier-fed system, supplied large quantities of sediment and water. The Black River historically passed the combined flow of Lake Washington and the Cedar River into the lower river at RM 11.0. Flooding was frequent throughout the lower basin. Below the Black River, the river flowed through a system of tidally influenced marshes and swamplands. The south end of Elliott Bay was characterized by broad, intertidal flats and shallows. The freshwater portions of the lower and middle basins, up to the gorge, were bordered by extensive riparian vegetation and wetlands. During low flow periods, the zone of freshwater-saltwater mixing was likely closer to the mouth of the Duwamish River than occurs now because of the combined flow of the Green, White, and Black rivers. Fish habitat provided by tidal marshes, side channels, and the estuary were important osmotic staging areas for juvenile anadromous salmonids as they prepared for their transition to life in the Puget Sound and the Pacific Ocean. Productivity in the Duwamish estuary was likely high because of detrital/organic inputs from upstream, inorganic fine sediment contributions from the White River, suitable physical conditions for primary production within the estuary and mudflats, and local wildlife organic contributions.

4.5.2 Anthropogenic Influences

Euroamerican settlement has been associated with substantial changes to the Green River basin over the last 150 years or so. Many physical changes to the hydrology, sediment supply and transport characteristics, floodplains, and stream channels have occurred, as have other direct and indirect impacts to fish and their habitat. The changes are summarized by category below, in no particular order of importance.

4.5.2.1 White/Black/Cedar River Diversions; Lowering of Lake Washington

Significant changes to the hydrology of the lower Green River basin have occurred in response to flood control measures. In particular, two major tributaries were rerouted to other drainages. The White River, which contributed more than 50 percent of the total flow to the lower Green River, was diverted naturally to the Puyallup River in 1906 by a log jam. A permanent diversion structure was subsequently constructed and completed in 1911 that forced the flows of the White River to join with the lower Puyallup River. The Black River, which enters at RM 11.0, was reduced to a small fraction of its former flow in 1916 by construction of the Ship Canal/Ballard Locks and associated lowering of the water level in Lake Washington, along with diversion of the Cedar River into the lake to provide flows for the locks.

The combined diversions of the White and Black rivers reduced summer flows to roughly 30 percent or less of their historical magnitude within the lower Green River basin. Sediment supply to the lower basin was also reduced sharply. The diversions enabled salt water from the estuary to move farther upstream than before, to roughly RM 10.0 under low summer flows and high tides; a salt wedge is usually found up to RM 7.0 (Dawson and Tilley 1972). Migration routes of anadromous species were influenced dramatically in the White and Cedar rivers and in the other Lake Washington tributaries as the returning fish searched for the water of their natal streams. The Green River salmonid gene pool was isolated from the White and Cedar/Lake Washington stocks.

4.5.2.2 Consumptive Water Use

The City of Tacoma began diverting water from the Green River in 1913 with the completion of the Headworks at RM 61.0, at a rate of up to 113 cfs (72 mgd). Fish passage facilities were not provided, and anadromous fish consequently could not access habitat in the upper basin. In some years, the amount of water needed for diversion during the summer and early fall could exceed the amount originating naturally upstream of the Headworks. Tacoma's FDWRC, which provides for water withdrawals of up to 113 cfs, is not constrained by Washington State minimum instream flow requirements because its claim predates when Ecology issued rules for instream flow requirements. In recent years, Tacoma has attempted to work cooperatively to minimize impacts of water withdrawals on fisheries and other instream resources; however, Tacoma diverted water from the mainstem Green River under the FDWRC for more than 50 years without flow augmentation. The HHD was completed by the USACE in 1962 to provide flood control to the Green River valley and to provide 24,200 ac-ft of water storage for summer low flow augmentation.

Tacoma's SDWR was originally limited only by state of Washington-imposed minimum instream flows at the USGS gage at Palmer. Additional constraints on the use of the SDWR and constraints on the FDWRC were developed as part of the 1995 MIT/TPU Agreement. The Agreement settles Muckleshoot claims against Tacoma arising out of

Tacoma's municipal water supply operations on the Green River including the FDWRC and SDWR, but not Tacoma's involvement in the AWS project.

There are more than 6,000 water rights and claims on file with Ecology for ground and surface water within the Green River basin, with a large number located within the Big Soos and Newaukum subbasins. Although some groundwater is pumped from deep aquifers, other groundwater comes from shallow water tables that are connected directly to streams, and may be over-appropriated. Water rights and claims have been made by local municipalities for municipal, industrial, and agricultural water supply; sewage (including the Renton Plant in the lower Green River); and small-scale domestic uses (Culhane et al. 1995).

4.5.2.3 Howard Hanson Dam

Howard Hanson Dam was completed by the USACE at RM 64.5 in 1962 for flood control purposes, with King County as the local sponsor. The facility was designed to provide flood protection up to the 500-year event and limit flood flows downstream to 12,000 cfs at Auburn; flood control operations are subject to congressional mandate. The reservoir is kept as low as possible during the flood season and is essentially a run-of-the-river facility until the river reaches flood stage, at which time flows in excess of the 12,000 cfs limit are impounded and later released. The original authorization of HHD also provided for storage of 24,200 ac-ft of water for summer low flow augmentation. During the winter, the HHD reservoir is held empty between storm events. In late spring, inflow is reduced and the reservoir allowed to partially fill to provide a summer conservation pool for low flow augmentation. As a result, winter and spring flood flows below the dam have been reduced over historic conditions. Summer flows increased as a benefit of the original construction of the HHD project. In the past, spring refill operations dramatically reduced flows in the middle and lower river for several weeks between April and June, the timing depending on hydrologic conditions in the mountains and USACE operating procedures. These spring refill operations impacted downstream fisheries resources and created conflicts between storage and release mandates.

The dam has interrupted the flow of gravel and cobbles from the upper to the middle and lower basins and curtailed channel-forming flows, effectively rendering the channel geomorphically inactive throughout most of its length below the dam. Between June and October, water releases influence water temperatures up to 6 miles downstream of the dam. Outflow is colder than inflow in early summer, and then becomes warmer than inflow water throughout the remainder of the summer.

Together, the Headworks and HHD have effectively blocked access of anadromous fish to the upper basin. The anadromous runs are thought to have been an important source of selected trace elements and nutrients to the ecosystem of the upper Green River. The dams also interrupted upstream-downstream migrations of resident salmonids and other fish species. Although limited trap-and-haul operations have been instituted, studies of downstream migrant survival through the HHD facility have documented low survival of fish from the upper Green River basin due to poor passage conditions at the dam during refill operations.

4.5.2.4 Logging

Logging is associated with direct and indirect impacts to the Green River aquatic ecosystem, including: increased fine turbidity and sediment loading; altered hydrology; removal of riparian wood that provides shade, leaf litter, bank stability, and LWD to the stream; and destruction of tributary habitat by construction and operation of splash dams. Important sources of sediments induced by logging activities include roads and landslides. Clearcutting of large areas has influenced flood flows within the upper valley by means of increased areas of land susceptible to rain-on-snow events. Initial clearing by settlers was associated with limited logging primarily within the lower and middle Green River. Large-scale logging began circa 1880-1910 in the lower and middle Green River basin and rapidly moved upstream into the upper basin between 1910 and 1930. Logging has extended to the highest portions of the upper basin in recent years. Private lands were logged extensively in the 1960s and 1970s. Most old-growth timber has been logged, with isolated patches remaining in the most inaccessible portions of the upper basin; more than 80 percent of the upper basin forest contains trees that are less than 100 years old. Forest practices prior to the 1970s did not consider riparian zone protection or Best Management Practices (Watson and Toth 1995). Essentially all of the middle basin has been harvested at least once, including areas within the riparian vegetation zones.

Land ownership in the upper Green River basin alternates in the characteristic square-mile checkerboard pattern found elsewhere in Washington, where alternating squares are owned by the USFS or private timber companies. Plans are underway regarding a land exchange between the USFS and the Plum Creek Timber Company. The USFS proposes to exchange 11,845 acres of public land draining mostly below Sunday Creek (RM 86.2) for several thousand acres of headwater land along the Cascade crest owned by Plum Creek. Plum Creek and Weyerhaeuser plan to continue to harvest within the upper basin. Future timber harvest on land owned by Plum Creek, Weyerhaeuser, the City of Tacoma, the WDNR, and other private landowners will be subject to more stringent forest practice regulations than were observed in the past.

4.5.2.5 Agriculture

Agricultural-related changes occurred well before the effects of urbanization. Conversion of the floodplain to agricultural land has resulted in disconnection of side-channel habitat, destabilization of stream banks by cattle, runoff of fertilizer, pesticides, and fecal coliform bacteria into the river, and preclusion of riparian succession. The first documented land clearing was in 1851; livestock were introduced shortly thereafter. Initially crop production was for local consumption, but eventually as more land was cleared, production was increased for commercial sales outside of the area. Much of the early flood control activities was designed to increase the agricultural use of the Green River floodplain, both for crops and livestock.

4.5.2.6 Urbanization

Urbanization involves conversion of land and wetlands into residential, commercial, and industrial uses. Primary effects of urbanization on river ecosystems, in addition to the related water and land uses described in previous and successive paragraphs, include: water quality degradation through sewage discharge and septic tank leakage, spills of pollutants, runoff over contaminated and fertilized surfaces, groundwater contamination and subsequent non-point source inflow to the stream channel, and point source discharge; increased peak flows and reduced summer flows in association with increased impervious area and reduced floodplain storage; increased fishing pressure as the population expands; filling of wetlands and drainage channels for development; and removal of riparian vegetation and increased summer water temperatures. Pollutants associated with urbanization that influence water quality include heavy metals, petrochemicals and related byproducts, herbicides and pesticides, other organic compounds, and nutrients. Pollutants are concentrated in estuary sediments and impact organisms living in or on that medium.

The lower Green River basin has undergone extensive urbanization, while the middle basin is currently in the process of conversion from agricultural to urban land use. The upper watershed has not experienced urbanization. The City of Seattle was sufficiently large by the early 1900s to have influenced the lower Green/Duwamish River channel structurally (see Chapter 4.5.2.8). Water quality impacts from the city occurred primarily within the estuarine area. Growth continued gradually throughout the region, but in the 1970s growth in the region accelerated greatly, with a significant amount of the lower Green River basin becoming developed. Over 97 percent of the lower Green/Duwamish estuary has been filled and developed. Industry is the primary land use downstream of the Black River confluence at RM 11.0.

4.5.2.7 Roads and Railroads

The first road in King County was built in the lower Green River basin in 1854; railroad construction began circa 1867, primarily in support of logging activities. Since then, the construction of roads and railroads has resulted in channelization of portions of the lower and middle and upper Green River. Channelization is associated with loss of habitat structure, increased flow velocities, and narrowing of the active floodplain. Water quality has been influenced by spills and runoff of hydrocarbon, other organic compounds, and metal pollutants from road surfaces. Some side tributaries throughout the system have had accessibility blocked to spawning fish by installation of impassable culverts. The railroad line in the upper Green River basin was inactivated in 1983, although the Burlington Northern Santa Fe recently upgraded and reactivated the line in 1996 to help alleviate congestion on other mainlines. As many as eight train loads of cars per day are expected to use the upgraded line.

4.5.2.8 Diking, Leveeing, Draining, Dredging, Channel Clearing, and Filling

The lower and middle Green River basin channels have undergone extensive physical transformation to provide for navigation, flood control, and land development. The result has been straightening and confinement of the river to a single channel without riparian vegetation (important for both habitat and water quality) and instream habitat structure.

Removal of woody debris from the stream channel was first performed in the mid-1850s to facilitate navigation. Drainage of wetland areas began in the lower and middle Green River basins circa 1858 to provide land for agriculture and settling. As the region’s population grew, floodplain pumping was initiated; the Black River pumping station was installed in 1971 to pump stormwater from the floodplain into the Green River mainstem.

As part of the dredging and filling activities, the lower Green/Duwamish river delta was straightened and channelized. The majority of the estuary was filled by the mid-1940s. The East Duwamish Waterway was dredged initially in 1895, and the material used for Harbor Island fill. Dredging was completed in both the East and West Waterways in 1917, with the material used to fill intertidal flat areas of the Duwamish River. Extensive filling of the intertidal area also occurred during the hydraulic sluicing of Beacon Hill. Dredging of the lower river continues, where the depth of the channel is maintained at approximately 12 feet.

Large scale levees were built beginning in the early 1900s to help prevent the floodplains of the lower Green River from flooding. Periodic levee construction and maintenance activities continue to the present, both to protect higher density population areas and specific residential areas. Bank protection measures have resulted in restricting or preventing active channel meandering and migration across the floodplain. A recent survey of the middle Green River below Flaming Geyser State Park determined that levees and streambank revetments on one or both banks accounted for between 10 and 30 percent of the length of three contiguous reaches above about RM 38.0, and between 60 and 80 percent of the length of three contiguous reaches running between RM 25.0 and RM 38.0 (Perkins 1993).

4.5.2.9 Hatchery and Supplementation Practices

Hatchery and supplementation practices, often referred to as artificial propagation, have historically been used as partial or complete mitigation for urbanization, hydropower, municipal and agricultural water supply, highway construction or other projects that affect stream habitats. Artificial propagation has also been used to sustain or increase available numbers of fish for recreational and commercial harvest. Under the ESA, artificial propagation is a potential recovery mechanism for some stocks of Pacific salmon (Hard et al. 1992). For instance, artificial propagation appears to have reversed the decline in abundance of spring-run chinook salmon in the White River in western Washington (WDFW et al. 1996). However, artificial propagation appears to entail risks as well as opportunities for recovery of Pacific salmon populations. Steward and Bjornn (1990) noted that interactions between hatchery fish and natural fish may result in greater competition for food, habitat, or mates; an increase in predation or harvest pressure on natural fish; potential transmission of disease and deleterious genetic interaction between populations. In its status review of chinook salmon, the NMFS noted that hatchery production may mask trends in natural populations and hinder the determination of whether runs are self-sustaining (Myers et al. 1998).

There are several hatchery facilities located and operating within the Green River system, and another is planned as part of the MIT/TPU Agreement. The state of Washington opened the Green River Hatchery on Soos Creek in 1902; it produced chinook and coho salmon primarily, and chum salmon secondarily. The majority of fish reared at the hatchery have been released within the Green River drainage, although the stock has been used to supplement stocks in other basins, including the Stillaguamish, Snohomish, Lake Washington, Nisqually, and many coastal systems. The Keta Creek hatchery, located on Crisp Creek, was opened originally by the state in 1969 and later expanded and operated by the MIT circa 1981. The facility has produced chinook, coho, and chum salmon, and steelhead trout. A state steelhead trout rearing pond facility is located near Palmer. A pond complex has also been operated for chinook salmon supplementation at Icy Creek, located within the Green River Gorge. Past donor stock for fall or spring chinook released within the Duwamish River system has included fish originating from hatcheries located in British Columbia and on the Deschutes River, Hoh River, Skagit River, Skykomish River, Sol Duc River, Cowlitz River, Issaquah Creek, and other locations (NMFS 1998). Chinook and coho salmon, and steelhead trout juveniles have been planted periodically upstream of HHD since 1982. Adult steelhead have been released to spawn upstream of HHD since 1992.

4.5.2.10 Fishing Harvest

Salmon originating from the Green River are caught in both the United States and Canada sport and commercial saltwater fisheries. Hatchery production facilitates a higher harvest rate than wild-spawning populations are able to sustain. Sport angling and Tribal gill net fisheries for chinook and coho salmon and steelhead trout have been active within the densely populated Elliott Bay area, near the mouth of the Duwamish River. Sport and Tribal fisheries also have caught large numbers of returning adult salmon within the Duwamish/Green River. Fishing harvest rates for salmon populations in the Green/Duwamish River peaked in the 1980s. The MIT and WDFW have recently curtailed fishing to promote increased escapement. As a result of curtailment in local fisheries, harvest outside of Washington State (e.g., Canada) may exceed in-state catches.

4.5.3 Current Processes Affecting Fish Habitat and Populations

Under natural conditions, aquatic ecosystems in the Pacific Northwest, including the Green River, are dynamic in both space and time. The behavior of fluvial systems in the Pacific Northwest ecoregion is driven by four components:

1) climate, which varies over time and causes floods and associated erosional events to be punctuated in time;
2) a complex topography that causes the supply of sediment and wood to streams to vary spatially;
3) a branching channel network that juxtaposes different sediment transport regimes and promotes the convergence of sediment pulses in larger rivers; and
4) basin history, which affects the timing, volume, and location of wood and sediment supplies (Benda et al. 1997).

The result is a mosaic of conditions within a basin at any time as a result of disturbances. Natural ecosystems have a large capacity to absorb change without being dramatically altered (Reeves et al. 1995). In the context of these naturally variable ecosystems, disturbances may be described as “pulse” or "press" disturbances. Pulse disturbances alter conditions but allow the ecosystem to recover and remain within its normal bounds. Press disturbances force an ecosystem to a different set of conditions, preventing or delaying recovery beyond the normal time frame (Yount and Niemi 1990; Bender et al. 1984).

Natural disturbances can be either “pulse” or “press” disturbances; the eruption of Mount St. Helen’s is an example of a natural “press” disturbance; periodic floods or wildfires are “pulse” disturbances. However, many anthropogenic disturbances, such as flood control or urbanization, are considered “press” disturbances (Yount and Niemi 1990). The following text describes current human activities governing the variability of important ecosystem processes including sediment transport, flooding, woody debris recruitment and low flows in the Green River.

The partitioning of the Green River into the lower, middle, and upper basins reflects divisions of the system by both natural processes and human influences. Prior to construction of the Headworks and HHD, the upper Green River basin was distinguished from below by natural geologic features (i.e., the gorge). With the exception of the impounded reservoir area, physical features of fish habitat in the upper Green River basin have been influenced primarily by timber harvest and transportation activities. However, the artificial geographic division imposed by water withdrawal and flood management facilities is approximately coincidental with the geologic division and thus is useful in the context of evaluating Tacoma activities. The biggest influence on fisheries in the upper basin by the Headworks and dam has been the disconnection of the upper basin from the middle/lower Green River and the ocean: hence the significance of the provision of fish migration.

The division between the middle and lower Green River basins (Highway 18/Big Soos Creek) approximates the division between the lower gradient, depositional reaches in the lower basin and the intermediate gradient reaches upstream. The geographic division also roughly separates highly urbanized reaches downstream and lesser-developed reaches upstream. The middle basin includes the physically (and biologically) distinct canyon reach and a transition reach that is still adjusting to changes in flow and sediment supply caused by the construction of the Headworks, HHD, and diversion of the White River. The fisheries in the lower basin have been influenced most by urban development, although construction of the Headworks and HHD has also affected fisheries in the lower basin. Fisheries in the middle basin, however, have been influenced most directly by the construction of HHD and Tacoma water withdrawals. Specific aspects of fish habitat in the Green River system that have been influenced most adversely are summarized below.

4.5.3.1 Sediment Transport

Coarse, gravel-size sediment is transported downstream only during moderate to high flows, and is stored within the channel bed and banks during intervening low flow periods. Construction of the Headworks and diversion of water by Tacoma did not seriously impair gravel movement from source areas in the headwaters to downstream alluvial reaches, since the Headworks facility has a small storage capacity and because Tacoma's withdrawal is small relative to the size of flows required to initiate coarse sediment transport. The construction of HHD, however, substantially reduced the supply of gravel to the middle Green River basin, because coarse material drops out behind HHD during high flows, and free-flowing low flows are inadequate to resume transport. Construction of HHD may be considered a press disturbance in terms of its effect on sediment transport.

Since gravels from the headwaters are trapped behind HHD, and there are few sources of resistant coarse sediment in the middle Green River, the availability of spawning habitat has been reduced downstream of the dam. Gravel stored in the channel downstream of HHD continues to move downstream during high flows, but since 1964 no sediment has been transported from upstream reaches to replenish it. In addition, the volume of sediment transported downstream each year may actually have increased, because flow regulation by HHD has increased the frequency of moderate flows (approximately 3,500 to 9,000 cfs) that are capable of mobilizing gravel in some reaches (Dunne and Dietrich 1978). Bank revetment construction may have also helped accelerate the loss of spawning gravel by straightening and confining the channel, thereby further increasing its sediment transport capacity. There is evidence that the effects of HHD and levee construction on gravel storage in the middle Green River extend downstream to Newaukum Creek (RM 41.2), which is now the most significant source of sediment to the middle Green River (Perkins 1993).

4.5.3.2 Floodplain Maintenance and Side Channel Connectivity

Rivers construct and maintain channels such that small and moderate-sized discharges (less than or equal to flows with a 2-year recurrence interval) are contained within the channel, while larger discharges that occur less frequently exceed the channel capacity and overflow onto the floodplain (Leopold 1994). In low gradient, unconfined channels such as the middle Green River, the channel migrates back and forth across its floodplain in a sinuous pattern in response to differential patterns of bank erosion and sediment deposition. Channel migration may occur as a result of slow, steady erosion of the outside of a meander bend accompanied by an approximately equivalent amount of deposition on the inside of the meander bend, or it may occur as a sudden, unexpected shift (avulsion) into an old channel or area that is lower in elevation than the existing channel. As a result of these processes, natural low gradient alluvial channels typically develop a complex consisting of a network of single thread low flow channel containing numerous gravel bars, side channels that transmit water only during moderate to high flows and may support successional vegetation of varying ages, and abandoned oxbow lakes, sloughs or wetlands distributed across the floodplain. Such off-channel habitats may historically have been an important component of juvenile rearing habitat within the middle and lower Green River basins, providing rearing habitat and refuge from high flows.

Large floods are also important sources of recharge to shallow alluvial aquifers that are an integral component of floodplain ecosystems (Naiman et al. 1992). During floods, water is stored in sloughs and side channels, or seeps into floodplain soils, recharging groundwater storage. This stored groundwater slowly drains back to the channel, providing a source of cool inflow during the summer (Naiman et al. 1992).

The quantity and quality of off-channel habitat is currently limited in both the middle and lower Green River due to flood control operation at HHD, Tacoma's regular diversion of water, and channelization and flood control measures. Floods larger than the former 2-year return interval event have been prevented since the construction of HHD, and this has effectively been a press disturbance precluding the occurrence of large, channel-altering flows responsible for creating new side channels and recharging the floodplain aquifer. Tacoma's diversion does not significantly affect the size or frequency of extreme high flows, but reduces side-channel connectivity, especially during the spring and summer. Since the reduced flows are generally in the range of low flows experienced without HHD and Tacoma's FDWRC withdrawal, the change in springtime side-channel connectivity is considered a pulse disturbance. Channelization and construction of levees, revetments and roads has disconnected many formerly accessible side channels. The quality and connectivity of side-channel habitats in the middle Green River may also have diminished because of changes in the Green River sediment transport regime described above, which may promote channel incision and disconnection of side channels from the mainstem at low flows. Rearing habitat quantity and quality is particularly limited in the lower Green River due to extensive urbanization, channelization, and flood control measures.

As a partial consequence of the loss of side-channel habitat, tributary habitat has become much more important to anadromous salmonids than historically. Development and associated changes in the hydrologic and sediment transport regimes in the Big Soos and Newaukum creek drainages in particular have had, and will continue to have, a significant influence on present salmonid rearing success.

4.5.3.3 Woody Debris Transport

Woody debris is an important component of salmonid habitat because it provides habitat space (pools) and structure (cover), provides habitat and food for aquatic invertebrates, helps retain local deposits of spawning gravel in reaches where the sediment transport capacity exceeds the rate of supply, contributes to bank stability, and can be integral to channel migration processes in alluvial reaches. Removal of in-channel LWD has occurred throughout much of the Green River basin as a result of timber harvest practices prior to 1975, flood control, and clearing by private individuals to facilitate recreational boating.

Recruitment of new wood to the river throughout the basin has been reduced by management actions as well as human-induced changes in fluvial processes. Timber harvest in the riparian zone reduced the source of future LWD in the upper watershed. Land clearing for agriculture and development has had a similar affect on future LWD recruitment in the middle and lower Green River. Clearing and harvest of the riparian zone generally reduce bank stability, which then must be achieved artificially by constructing levees or revetments. Establishment of woody vegetation on reinforced banks is often prevented because of flood control concerns, thereby removing shade and reducing inputs of organic detrital matter. Construction of HHD physically blocked the downstream transport of wood originating in the headwaters. Flood control operations at HHD, which prevent large channel-altering flows, in combination with channelization and construction of levees and revetments, has reduced the rate of channel migration in the middle Green River, effectively stopping the movement of the channel into wooded areas that would provide material to the channel. Together, alterations in woody debris recruitment and transport represent a press disturbance in the Green River basin.

Tacoma's water withdrawal has had little effect on LWD recruitment and redistribution since wood, like sediment, is recruited and transported by high flows. Tacoma's withdrawal represents only a small fraction of the volume of high flows, and may often be constrained during those events because of turbidity concerns.

4.5.3.4 Droughts

Anadromous fish migrating upstream must pass through the lower and middle portions of the Green River. Some species, such as chinook salmon, begin this upstream migration in the early fall, when flows are often naturally lowest, particularly in drought years before fall rains arrive. Low flows in the Green River basin are naturally sustained by the slow release of water stored in the banks and alluvial aquifers connected to the river. Under natural conditions, sustained low flows of as low as 172 cfs may have occurred in the middle Green River during late September (Chapter 4.1.4.1).

A number of factors have influenced summer low flows in the middle Green River. Historically, there may have been plenty of water in the lower Green River, but diversion of the White and Black rivers is estimated to have reduced summer low flows in the lower Green River by as much as 50 percent (Dunne and Dietrich 1978). Apparent declines in summer stream flows also have been identified in the Soos and Newaukum creek basins, and are attributed primarily to groundwater withdrawals and reduced groundwater recharge as a result of increased urbanization (Culhane et al. 1995). Tacoma's diversion of 113 cfs, in combination with reduced inflows from the Soos and Newaukum creek basins, has extended the duration and reduced the magnitude of annual low flows.

Prior to mainstem flow augmentation, summer water demands frequently exceeded availability, and flows in the lower basin were at times so low that early arriving chinook salmon attempting to migrate upstream were instead trapped lower in the river where water temperatures and water quality can be adverse in the late summer. Low summer flows may also influence juvenile steelhead and coho survival in both the mainstem and tributaries, because of elevated water temperatures, poor water quality, and reduced rearing habitat. Augmentation of summer low flows using water stored in the Howard Hanson Reservoir has partially offset these reductions in the middle Green River.

An analysis of Green River flows using the Indicator of Hydrologic Alteration (Richter et al. 1996) suggests that while the number of low flow events (defined as discreet flow events less than the 75 percent exceedance flow) has not changed substantially, the average duration has increased by 10 days with both Tacoma's FDWRC and HHD operations (Burkey 1999). Average daily flows at the Palmer USGS gage in July through September for the period 1964 through 1996 were lower than flows predicted without FDWRC withdrawals and HHD, despite low flow augmentation by HHD (Burkey 1999). The median 7-day low flow for the analysis period was 12 percent less than the predicted 7-day low flow without HHD and Tacoma's FDWRC diversion, and the median date of the annual minimum flow generally occurred 2 to 3 weeks earlier than it would have without the projects (Burkey 1999).

4.5.3.5 Estuarine Maintenance

Estuarine habitat is the component of fish habitat that has been the most severely compromised in the Green River system. Practically all of the original intertidal flats, wetlands, and swamps in the lower basin have been drained and lost to development, resulting in a severe loss of physical habitat space and biological productivity. Transport of the fine sediments responsible for forming and maintaining estuarine habitat has not been significantly influenced by construction of HHD and Tacoma's diversion, since the majority of this material may remain in suspension during even moderate flows. In fact, forest harvest activities in the upper watershed, and development in the middle and lower watershed may actually have increased the fine sediment load of the Green River. However, fine material is systematically dredged from the Duwamish waterway to maintain the navigation corridor, and fine sediments in the bed of the present estuary and Elliott Bay are contaminated with toxic compounds carried in on fine sediment originating in urban and industrial areas.

The natural ability of the estuarine system to counter water quality problems has been lost as a result of development and changes in flow. The extent of the saltwater influence has moved upstream to roughly the confluence with the Black River because of the diversion of the White and Cedar rivers. The loss of up to 50 percent of summer low flows has also resulted in increased temperatures and a reduced ability to dilute pollutants. The loss of habitat and food production, coupled with poor water quality, has likely reduced survival of anadromous salmonids and other species that rely on estuarine habitat for at least part of their life history (Blomberg et al. 1988).

4.5.3.6 Effects of Changes in the Flow and Sediment Regimes on Water Quality

In general, water quality problems that potentially contribute to the decline of salmonids in the Green River increase in severity as the water flows downstream. In the upper watershed, the primary vector affecting water quality and fish production is increased turbidity and fine-sediment loading associated with timber harvests. Water quality in the middle and lower watershed is influenced by a number of land and water uses and is degraded in the form of:

- increased summer water temperatures due to removal of riparian vegetation, diversion of the White and Black rivers, and release of warmer water later in the summer from HHD storage. Water temperatures exceeding the state standard have been recorded frequently enough to warrant registering middle and lower segments of the Green River on the state's 303(d) lists; and

- reduced DO due to elevated water temperatures and increased biochemical and chemical oxygen demand associated with high nutrient and pollutant inputs (DO levels that fail to comply with the state standard have also been recorded in the middle and lower watershed during sustained low flow periods; however, these failures have not been recorded frequently enough to warrant placement on the state's 303[d] list).

Furthermore, disconnection of the floodplains by reduced flooding, plus the physical removal of wetlands (particularly in the lower basin) has reduced the natural capacity of the system to store and treat water entering and flowing through the river system. In addition to fisheries impacts, poor water quality has also influenced the aquatic macroinvertebrate community in the lower and middle basins.

In the 1980s, water quality and sediment monitoring identified pollution in the Duwamish River and Elliott Bay (Duwamish River and Elliott Bay Water Quality Assessment Team [WQAT] 1999). The pollution originated from a number of point and nonpoint sources. Recent improvements in wastewater and stormwater treatment facilities and processes (e.g., secondary treatment of wastewater, rerouting treatment plant effluent from the river to Puget Sound, sediment cleanup and capping of contaminated areas, and other measures [WQAT 1999]) have had a noticeable effect on improving water quality in the Duwamish River and Elliott Bay. Using water quality data collected weekly in 1996 and 1997 from 21 stations throughout the Duwamish Estuary, the Water Quality Assessment Team concluded that there are currently minimal risks to aquatic life from chemicals in the water column. In particular, the Water Quality Assessment Team found no risks to juvenile salmon from direct exposure to chemicals in the Duwamish River or Elliott Bay (WQAT 1999).

4.5.4 Restoration Activities (parties other than Tacoma)

There are a large number of groups and institutions involved in a wide range of active, planned, or conceptual restoration projects that are intended to reverse the losses in habitat quantity and quality that have occurred in the Green River system within the last 100 years. King County plays a leading role, both in identifying needs and in facilitating projects. A recent Regional Needs Assessment (King County 1995) identified several categories of impacts that can be addressed directly by the County within the Green River system, including: providing drainage, conveyance, and treatment of surface water; flood hazard reduction; improved water quality; and protecting and restoring fish habitat. Successful implementation of restoration programs is considered by the county to be contingent on effective collaboration between institutions and on securing adequate funding. In addition, King County, in conjunction with other local governments, businesses, Indian Tribes, environmental groups, and state agencies is working to develop a science-based salmon conservation plan for Water Resource Inventory Area (WRIA) 9, which includes the Green River. Tacoma has been and will continue to participate in the WRIA planning process.

Sixteen projects were recommended for implementation by King County in 1998-1999 (Table 4-8). A number of other projects are currently under evaluation for potential future implementation (Table 4-9). The majority of King County-related work is slated for the lower and middle Green River basins. These projects address a range of habitats and riverine functions important to a variety of salmonid life stages.

Currently, there are seven projects by King County, the USACE, and other parties targeted for estuarine areas. These areas are critically important rearing and acclimation habitat for juvenile salmonids prior to outmigration to the ocean. The projects include creation of intertidal benches in areas of steep, narrow shorelines, and creating and enhancing wetland areas. Although limited in area relative to the extensive estuarine area once present in the Duwamish estuary, these restoration projects represent a substantial increase in intertidal habitat suitable for salmonids, compared to present conditions.

In an attempt to restore functions of the lower and middle river important to several salmonid life stages, projects are directed toward reconnecting the river and its floodplain, improving passage to tributaries, restoring tributary habitat, enhancing mainstem channel and riparian conditions, and replacing and restoring side-channel habitat. In most cases, these projects are small in scale, but cumulatively they address many of the factors limiting salmonid production in the Green River system. By focusing on critical riverine ecosystem processes and life history requirements, restoration projects can have effects that contribute to population recovery throughout the basin.

Constraints due to flood control and urban infrastructure limit opportunities for restoration in the lower and middle basin, but there are over 20 sites each in the lower and middle basins now proposed for restoration. Lower and middle basin tributaries in which restoration is proposed include Big Spring Creek, Black River, Longfellow Creek, Springbrook Creek, Mill Creek, Mullen Slough, Puget Creek, Riverton Creek, Fostoria Creek, Garrison Creek, Gillium Creek, Jenkins Creek, Auburn Creek, and Newaukum Creek. Projects in tributaries emphasize land acquisition, channel/riparian enhancement, and removal of passage barriers to improve and increase available habitat for fish. Projects in the mainstem Green River emphasize reconnection to floodplain and side channels, which will provide more rearing habitat, and improvements in riparian conditions, which will help reduce water temperatures for both juvenile and migrating adult fish during the summer months.

In addition to Tacoma, the USFS is a primary proponent for restoration projects in the upper Green River basin. The USFS has identified a number of candidate restoration opportunities (Table 4-10). Proposed and active restoration projects targeted for the upper Green River system include side-channel reconnection, habitat enhancement, fish passage, and sediment control.

These projects address both watershed level processes, as well as stream habitat improvements. Upgrading and decommissioning of forest roads should substantially reduce ongoing fine sediment input to streams that result from previous forest management practices. This watershed-level restoration action removes the source of degradation, making instream restoration more effective. Instream placement of LWD is also proposed to reduce impacts from past and ongoing sediment input in the upper basin. Habitat enhancement measures include restoration of side-channel areas and improvement of juvenile rearing habitat. Replacement of culverts to improve passage in several is also proposed.

Tacoma's habitat and species protection commitments identified in Chapter 5 and evaluated in Chapter 7 are similar to, or complement other King County and USACE programs. Together, efforts by City of Tacoma, King County, USACE, USFS, and local governments represent a basin-wide, landscape-scale approach to increasing the populations of salmonid stocks within the Green River basin. Although a return to pristine, natural conditions in the basin is not feasible, or likely possible, these restoration efforts are an ambitious attempt to restore many elements of the Green River ecosystem that will provide important benefits to fish.

Table 4-8. King County Green/Duwamish Early Action Habitat Projects: recommended priority capital projects for 1998-1999.

Project Name	Project Description	Groups Involved	Basin[1]
Big Spring Creek	Relocate >1,000 feet of a coldwater tributary to Newaukum Creek, away from a county roadway. Place wood debris and vegetate the streambanks for a riparian buffer.	King County Trout Unlimited Mid-Sound Fisheries Enhancement Group	MT
Black River Marsh	Construct backwater channel near confluence of Black and Green rivers. Restore riparian area.	King County Elliott Bay/Duwamish Restoration Panel	LT
Duwamish Waterway Park	Estuary restoration of Seattle park site.	U.S. Army Corps of Engineers King County People for Puget Sound	E
Hammakami Levee Removal	Remove remaining portions of Hammakami Levee to restore river connection to channel/wetland habitat.	King County	MG
Loans Levee Setback	Set levee back behind existing side channels and restore/relocate mouth of Burns Creek.	King County Elliott Bay/Duwamish Restoration Panel	MG
Longfellow Creek	Acquisition and restoration at key parcels along Longfellow Creek, removal of passage barriers, streambed enhancement, and streambank reforestation.	City of Seattle King County	LT
Mainstem Green River Levee Habitat Enhancement	Improve habitat functioning of Green River levee system through installation of habitat/flow diversion logs, replanting with native vegetation, etc.	King County	LG
Metzler/O'Grady LWD	Install LWD in the existing, connected side channels in Metzler and O'Grady county parks.	U.S. Army Corps of Engineers King County	MG

Table 4-8. King County Green/Duwamish Early Action Habitat Projects: recommended priority capital projects for 1998-1999.

Project Name	Project Description	Groups Involved	Basin[1]
Mill Creek Corridor	Stream channel enhancements along 1.15 miles of middle/upper Mill Creek in Auburn (adjacent to the racetrack mitigation site).	King County City of Auburn City of Kent U.S. Army Corps of Engineers	LT
Mullen Slough Nursery	Restore stream habitat and riparian area along lower Mullen Slough; develop native plant nursery.	City of Kent King Country Elliott Bay/Duwamish Restoration Panel	LT
O'Grady Reconnection	Reconnect small tributary to Green River, build pool and weir fishway to improve passage.	King County	MT
Porter Levee (Slaughterhouse)	Set existing levee back behind intact side channel, to restore river/floodplain interconnections and fish access to side-channel slough system.	U.S. Army Corps of Engineers King County Trout Unlimited Elliott Bay/Duwamish Restoration Panel Muckleshoot Indian Tribe Mid-Sound Fisheries Enhancement Group	MG
Puget Creek Estuary	Acquisition of key parcels in Puget Creek's headwater wetland, and erosion control in steep ravine reaches within Puget Park.	U.S. Army Corps of Engineers Port of Seattle	LT
Riverton Side Channel	Create channel linking lower Riverton Creek with detention pond, creating a side channel.	City of Tukwila King County Muckleshoot Indian Tribe	LT
Upper Watershed Culvert	Remove or retrofit the first of numerous culverts that are barriers to fish passage along tributaries in the upper watershed.	Tacoma Water King County	UT
Volunteer Revegetation Program	Provide funds and a program for volunteers to replant high priority riparian areas along the Green River and its tributaries.	King County	MG

(1) L = lower, M = middle, U = upper basin; G = Green River mainstem, T = tributary, E = estuary

Table 4-9. Selected Candidate Ecosystem Restoration Study projects under evaluation for feasibility by King County, the U.S. Army Corps of Engineers, and local watershed jurisdictions.

Project Name	Project Description	Basin[1]
Bass Lake Acquisition	Purchase 26 acres including and adjacent to high quality lake and wetland system	MT
Coho Rearing Pond	Beaded ponds in middle Green River system.	MG
College Side Channel	Excavate entrance to existing side channel one-half mile downstream of Highway 18; enhance through addition of LWD.	LG
Elliott Bay Nearshore	Estuary restoration within Elliott Bay.	E
Flaming Geyser Acquisition	Purchase and preserve 40-acre parcel just downstream of Flaming Geyser State Park.	MG
Fostoria Creek	Divert storm flows and reconstruct 2,100 feet of instream and riparian habitat.	LT
Garrison Creek (1)	Restoration of a 1,200-foot-long reach of Garrison Creek and a degraded 80-acre wetland/upland parcel owned by the City of Kent.	LT
Garrison Creek (2)	Acquire and restore a 20-acre wetland site along Garrison Creek; install stream and wetland enhancement and interpretive features.	LT
Geodeke Acquisition	Excavation of two-stage channel with dendrites, installation of LWD, and riparian plantings along 0.4 miles of Mill Creek.	LT
Gilbrough Slough	Side channel creation.	MG
Gilliam Creek	Retrofit flap gate and install fish ladder to provide improved fish access into Gillian Creek at the mouth. Install pump station to bypass flows.	LT
Gravel Replacement	Place gravel into the middle Green River to compensate for the sediment loss due to construction of HHD.	MG

Table 4-9. Selected Candidate Ecosystem Restoration Study projects under evaluation for feasibility by King County, the U.S. Army Corps of Engineers, and local watershed jurisdictions.

Project Name	Project Description	Basin[1]
Hamm Creek (mouth)	Excavate intertidal bench along Duwamish River and daylight Hamm Creek, expanding intertidal habitat, and creating and enhancing freshwater wetlands.	E
Horath/Kaech Levee Removal	Remove levee, thereby reconnecting isolated side-channel habitat.	MG
Horseshead Bend Side Channel	Excavate side channel through unimproved county parkland.	LG
Jenkins Creek Acquisition	Acquire 3.5-acre riparian/wetland site along Jenkins Creek.	MT
Kanaskat North and South	Restore fish access to two 4,500-linear-foot side-channel habitats via excavation, flow diversion, and addition of woody debris.	MG
KENCO	Estuary restoration on Duwamish industrial site.	E
Lower Mill Creek	Excavation of two-stage channel with dendrites, installation of LWD, and riparian plantings along lower 2.3 miles of lower Mill Creek.	LT
Lower Springbrook Creek	Installation of LWD within, and planting of native vegetation along, a 4,500-foot reach of Springbrook Creek.	MT
Mahler Park	Enhancement of habitat within a 30-acre wetland site in a city park. Installation of interpretive facilities.	MT
Mainstem Natural	LWD placement in mainstem.	MG
Mill Creek Acquisition	Acquisition and restoration of 40 acres of riparian land in the Kent Valley.	LT
NE Auburn Creek	Remove dysfunctional flap gate; replace with slide gate located approximately 2,000 feet farther upstream along tributary. Reconstruct channel, add LWD, replant riparian area.	LT

Table 4-9. Selected Candidate Ecosystem Restoration Study projects under evaluation for feasibility by King County, the U.S. Army Corps of Engineers, and local watershed jurisdictions.

Project Name	Project Description	Basin[1]
Newaukum Creek Conservation Easement	Purchase of conservation easement.	MT
Northwind Weir	One-acre estuary restoration project on Duwamish industrial site, with two additional upland acres restored.	E
O'Grady "10" Acquisition	Acquire 10 acres of high quality habitat adjacent to O'Grady Park.	MG
O'Grady Connector	Acquire 85 acres of high quality riparian habitat adjacent to O'Grady Park.	MG
Pautzki Levee Removal	Remove levee, improving connection between Green River and isolated wetland.	MG
Road Restoration	Abandonment and restoration of forest roads in the North Fork, Tacoma Creek, and Pioneer Creek drainages above HHD.	UT
Seaboard Lumber	Regrade the property, creating more intertidal and upland habitat in the estuary.	E
Site 1, Duwamish	Construct an intertidal slough perpendicular to the Duwamish along a 1,000-foot-long undeveloped parcel. Construct mudflats, emergent marsh, and riparian forested buffer zones.	E
Sunning Hills Wetland	Acquire 2-acre wetland site near Mill Creek in Auburn.	LT
Train Wreck	Bioengineering retrofit of recently installed riprap erosion protection along upper Green River.	UG
Tukwila Pond	Enhance water quality and habitat value of Tukwila Pond through a combination of measures: flow diversion, regrading of pond bottom, elimination of phosphorus source, and replantings.	LT

Table 4-9. Selected Candidate Ecosystem Restoration Study projects under evaluation for feasibility by King County, the U.S. Army Corps of Engineers, and local watershed jurisdictions.

Project Name	Project Description	Basin[1]
Turley Levee Setback	Set levee back behind existing side channels and restore connections to Green River.	MG
Upper Springbrook Creek Acquisition	Acquire and enhance 900 feet of stream reach immediately below the headwaters of Springbrook Creek.	LT
Valley Drive-In Side Channel	Excavate side channel through unimproved county parkland.	LG

(1) L = lower, M = middle, U = upper basin; G = Green River mainstem, T = tributary, E = estuary

Table 4-10. Candidate restoration projects identified for USFS lands in the Green River Watershed Analysis (USFS 1996).

Project Name	Project Description	Project Purpose
Maintenance or Restoration of Side Channels	Identify potential and current side-channel habitat through aerial photography review, existing stream surveys and field reconnaissance for maintenance and restoration.	Improve current and restore lost side-channel habitat. The area between RMs 77 and 84 should be the first priority for improvements because it provides some of the major refuge within the analysis area.
Placement of Instream LWD Structures	Introduce LWD structures in stream reach where pool rearing or spawning habitat is currently limiting fish production.	Increase fish production by increasing habitat that may be limiting.
Assessment and Potential Replacement of Culverts	Review some streams that may be incorrectly categorized as non-fish-bearing stream to determine if culverts are migration barriers.	Replace culverts that are acting as fish migration barriers.
Sunday and East Creek Fish Habitat Improvements	Improve juvenile-rearing habitat on Sunday and East creeks.	Juvenile-rearing habitat improvement for coho salmon.
Road Decommissioning	Decommission 11.2 miles of roads identified through the Access and Travel Management Process or roads located within a landslide mapping unit.	Restore roads no longer needed for management, for control and prevention of road-related runoff and sediment production, improvement of riparian vegetation conditions and restoration of instream habitat complexity.
Road Upgrades	Upgrading Roads 5403/5405, 5400, and 5210.	Improve the road drainage and/or reduce sediment production.
Revegetation of Decommissioned Roads	Revegetate approximately 30 miles of road to meet minimum Forest Plan standards for vegetative cover.	Improve vegetation on decommissioned roads to meet minimum Forest Plan standards for vegetative cover.

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Habitat Reaches Impacted by Fine or Coarse Sediment Deposits	Decrease sediment depositions resulting from mass failures and debris torrents using LWD to produce scouring and pool habitat, and riparian plantings to stabilize banks and provide future shade and LWD recruitment.	Restore habitat that has been degraded by sediment deposits resulting from mass failures or debris torrents.
Riparian Vegetation	Determine which areas would benefit from silvicultural treatments using aerial photography, silvicultural records, and data from stream surveys.	Improve water temperatures, LWD, pool and/or gravel frequencies, and bank stability where it may be seriously limiting fish populations.

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5. Habitat Conservation Measures to be Implemented Under the HCP

The Green River has been and will continue to be the main source of water for the City of Tacoma. The Green River likewise represents a regionally important ecosystem that supports economically, culturally, and recreationally significant populations of anadromous and resident salmonids (see Chapter 4). This chapter describes specific habitat conservation measures that Tacoma Water (Tacoma) is financially committed (either solely or in combination with others) to implement as part of this Habitat Conservation Plan (HCP).

Although Tacoma is concerned about ensuring certainty in meeting existing and future demands for water, Tacoma has long recognized that potential conflicts exist between meeting such demands and the needs of the ecosystem of the Green River basin. As a result, Tacoma has taken an active part in identifying impacts related to its operations and activities, and developing measures to avoid, minimize, or otherwise mitigate for such impacts. These measures have been developed through many years of active discussions with Tribal, federal, state, county, and private interest group representatives, and meetings and discussions with individuals comprising scientific advisory groups formed to address technical environmental issues. Because Howard Hanson Dam (HHD) is a major influence on the structure and function of the Green River ecosystem, and HHD operations affect Tacoma's water withdrawals, many of the measures were generally developed in close collaboration with the U.S. Army Corps of Engineers (USACE).

An important backdrop to this list of conservation measures is understanding that, since the 1980s, Tacoma has been actively working with the Muckleshoot Indian Tribe (MIT) to remedy past fish and wildlife damages related to the construction and operation of the Tacoma Water Supply Intake at River Mile (RM) 61.0 (Headworks) diversion. The 1995 Muckleshoot Indian Tribe/Tacoma Public Utility[1] Mitigation Agreement (MIT/TPU Agreement) is a substantial commitment by Tacoma directed toward the implementation of a suite of measures that were considered by both parties to compensate for all impacts to the fishery resources associated with Tacoma's operations in the Green River, including the First Diversion Water Right Claim (FDWRC) and the Second Diversion

[1] Tacoma Public Utility, Water Division is now known as Tacoma Water (Tacoma). Since the agreement is a well-recognized document, it will continue to be referenced as the MIT/TPU Agreement.

Water Right (SDWR). The effects of the joint USACE and Tacoma HHD Additional Water Storage (AWS) project were not addressed by the MIT/TPU Agreement.

In addition to fish and wildlife habitat enhancement measures, Tacoma has committed to: 1) construct a fish ladder and adult collection and trap-and-haul facility to provide passage to adult fish around the Headworks and HHD; 2) higher minimum flows (greater than Washington State instream flow requirements); and 3) provision for either a fish restoration facility designed to rear salmonids using "naturalized" procedures (see HCM 2-05), or comparable funding of other measures targeted toward fisheries enhancement in the Green/Duwamish river system. These measures directly benefit the species for which Incidental Take Permit (ITP) coverage is being sought. Tacoma has also committed to contribute funds for activities conducted by other parties (e.g., MIT, USACE[2]), for the benefit of fish and wildlife resources in the Green River.

Tacoma's habitat conservation measures and stewardship actions are listed in Table 5-1. Because a number of the measures has been jointly sponsored by Tacoma and other parties, the measures can be divided into three types, depending on their focus and where and how benefits are directed:

1) implementation of measures designed to offset or compensate for impacts resulting from a Tacoma water withdrawal action (e.g., withdrawal of water under SDWR) – designated Type 1 measures;
2) contribution of funds and/or implementation of measures designed to offset or compensate for impacts resulting from a non-Tacoma action (e.g., financial support of gravel nourishment measures to offset effects of HHD flood control) – designated Type 2 measures; and
3) implementation of mitigation/restoration measures in the Green River watershed designed to offset impacts of Tacoma non-water withdrawal activities (e.g., forestry operations in the upper watershed) – designated Type 3 measures.

[2] The cost-share arrangement referenced in this document between Tacoma and the USACE is subject to changes in the Water Resource Development Act or other Congressional funding initiatives that may adjust the cost-share formula between the parties.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 1-01	FDWRC Instream Flow Commitment	Guaranteed continuous flow maintained at Auburn, WA gage (stipulated in the MIT/TPU Agreement)	Type 1	N.A.
HCM 1-02	Seasonal Restrictions on SDWR	Minimum flow restrictions on SDWR withdrawals at Auburn and Palmer, WA gages (stipulated in the MIT/TPU Agreement)	Type 1	N.A.
HCM 1-03	Tacoma Headworks Upstream Fish Passage Facility	Construction/operation of upstream fish passage facility at Headworks	Type 1	N.A.
HCM 1-04	Tacoma Headworks Downstream Fish Bypass Facility	Installation of screen and fish bypass facility at Headworks	Type 1	N.A.
HCM 1-05	Tacoma Headworks Large Woody Debris (LWD)/Rootwad Placement	Installation of LWD, rootwads and boulders to enhance rearing capacity in Headworks inundation pool	Type 1	N.A.
HCM 2-01	HHD Downstream Fish Passage Facility	Construction/operation of downstream fish passage facility at HHD	Type 2	Mitigation and Restoration FP-A8
HCM 2-02	HHD Non-Dedicated Storage and Flow Management Strategy	Provide opportunity to manage springtime water storage and release at HHD to minimize impacts to salmonids	Type 2	N.A.
HCM 2-03	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures	Rehabilitate fish and wildlife habitat in the reservoir inundation zone, riparian areas upstream and downstream of HHD	Type 2	Mitigation and Restoration MS-02, 04, 08 TR-01, 04, 05, 09 VF-05
HCM 2-04	Standing Timber Retention	Retention of 166 acres of deciduous, 48 acres mixed, and 15 acres of conifer forest in the HHD pool inundation zone	Type 2	N.A.
HCM 2-05	Juvenile Salmonid Transport and Release	Transport and release of juvenile salmonids above HHD if determined to be beneficial	Type 2	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 2-06	Low Flow Augmentation	Option to provide an additional 5,000 acre-feet (ac-ft) of water for low flow augmentation	Type 2	USACE 1135
HCM 2-07	Side Channel Reconnection Signani Slough	Reconnect and rehabilitate 3.4 acres of off-channel habitat in Signani Slough (RM 60)	Type 2	Restoration VF-04
HCM 2-08	Downstream Woody Debris Management Program	Introduce woody debris into Green River downstream of Headworks	Type 2	Restoration MS-09
HCM 2-09	Mainstem Gravel Nourishment	Provide up to 3,900 yd^3 gravel into Green River downstream of Headworks	Type 2	Restoration LMS-01, 02, 03, 04
HCM 2-10	Headwater Stream Rehabilitation	Creation of off-channel habitat, installation of LWD/rootwads in Green River, N F Green River, and eight tributaries	Type 2	Restoration MS-03 TR-06, 07
HCM 2-11	Snowpack and Precipitation Monitoring	Install up to three snow pillows in the upper Green River basin	Type 2	N.A.
HCM 3-01 — UPLAND FOREST MANAGEMENT MEASURES				
HCM 3-01A	Forest Management Zones	Management of Tacoma lands within the HCP according to natural, conservation, or commercial designations	Type 3	N.A.
HCM 3-01B	Natural Zone	No timber harvesting except to modify fish or wildlife habitat or remove danger trees with 150 feet of roads	Type 3	N.A.
HCM 3-01C	Conservation Zone	No even-aged harvesting in conifer-dominated stands and no harvesting of any kind (except danger tree removal within 150 feet of roads and fish and wildlife habitat modifications) in conifer-dominated stands older than 100 years	Type 3	N.A.
HCM 3-01D	Commercial Zone	Coniferous forests will be managed on an even-aged rotation of 70 years	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-01E	Hardwood Conversion	Stands in the conservation and commercial zones dominated by hardwood on sites capable of producing conifers may be converted to conifers by clearcutting	Type 3	N.A.
HCM 3-01F	Salvage Harvesting	Salvage timber harvesting only in forested areas of the Commercial Zone and stands in the Conservation Zone under 100 years old affected by wind-throw, insect infestation, disease, flood or fire according to set prescriptions	Type 3	N.A.
HCM 3-01G	Snags, Green Recruitment Trees and Logs	Tacoma will retain all safe snags and at least four green recruitment trees and four logs per acre, where available	Type 3	N.A.
HCM 3-01H	Harvest Unit Size	Even-aged harvest units will not exceed 40 acres in size, uneven aged harvest units and salvage harvest units will not exceed 120 acres in size	Type 3	N.A.
HCM 3-01I	Even-aged Harvest Unit Adjacency Rule	Even-aged harvesting will occur when the surrounding forest land is fully stocked with trees a minimum of 5 years old and 5 feet high	Type 3	N.A.
HCM 3-01J	Harvest Restrictions on Sites with Low Productivity	Timber harvesting will occur only on lands with a Douglas-fir 50-year site index of 80 or greater	Type 3	N.A.
HCM 3-01K	Contractor, Logger, and Employee Awareness	Contractor, loggers, and forestry workers operating in the Upper HCP Area will be required to comply with relevant HCP measures	Type 3	N.A.
HCM 3-01L	Logging Slash Disposal	Slash will not be burned in the Natural Zone unless burning is part of habitat modification; slash disposal in the other zones will meet specific requirements	Type 3	N.A.
HCM 3-01M	Reforestation	All even-aged stands will be replanted with 300-400 suitable trees per acre by the first spring following harvest	Type 3	N.A.
HCM 3-01N	Harvest on Unstable Slopes	Tacoma will identify potentially unstable landforms and apply general prescriptions developed by watershed analysis or site-specific prescriptions developed by a slope stability specialist	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-02 — RIPARIAN MANAGEMENT MEASURES				
HCM 3-02A	No-Harvest Riparian Buffers	Tacoma will retain no-harvest buffers along all streams and wetlands in the Upper HCP Area	Type 3	N.A.
HCM 3-02B	Partial-Harvest Riparian Buffers	Tacoma will retain partial-harvest riparian buffers outside no-harvest buffers on Type 3 and Type 5 streams	Type 3	N.A.
HCM 3-03 — ROAD CONSTRUCTION AND MAINTENANCE MEASURES				
HCM 3-03A	Watershed Analysis	Tacoma will participate in all Watershed Analyses performed according to the WFPB within the HCP area	Type 3	N.A.
HCM 3-03B	Road Maintenance	Tacoma will participate in the development of a Road Sediment Reduction Plan describing the priorities and schedule for road maintenance, improvement and abandonment activities that will be implemented to reduce road sediment inputs	Type 3	N.A.
HCM 3-03C	Road Construction	Tacoma will implement all draft and final mass-wasting prescriptions specific to new road construction in WAUs where watershed analyses are approved or pending; in WAUs where assessments have not been completed within 2 years following issuance of the ITP, Tacoma will complete a slope stability analysis and develop site-specific prescriptions for road construction	Type 3	N.A.
HCM 3-03D	Roads on Side Slopes Greater Than 60 Percent	Tacoma will use full bench construction with no side-casting of excavated materials on side slopes greater than 60 percent	Type 3	N.A.
HCM 3-03E	Erosion Control	Tacoma will place mulch and/or grass seed on all road cuts and fills with slopes over 40 percent or near water crossings as well as in areas of severe erosion/slumping danger or above and below roads	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-03F	Stream Crossings	When constructing roads through riparian areas, Tacoma will minimize right-of-way clearing, cross streams at right angles, minimize stream disturbances and side-casting of excavated materials, and provide for upstream and downstream passage in fish-bearing streams	Type 3	N.A.
HCM 3-03G	Road Closures	Tacoma will maintain a locked gate to restrict road use except where the USFS requires roads to be open	Type 3	N.A.
HCM 3-03H	Roadside Vegetation	Tacoma will maintain low-growing vegetation along roads to stabilize soils and minimize erosion	Type 3	N.A.
HCM 3-03I	Road Abandonment	Tacoma will abandon roads in the HCP Area that are no longer needed for watershed management, forestry operations, or HCP implementation according to a specified schedule	Type 3	N.A.
HCM 3-03J	Culvert Improvements	Tacoma will inventory all roads in the HCP Area and identify all culverts that block fish passage within 1 year of issuance of ITP, plans to eliminate blockages will be made within 2 years, and all blockages will be eliminated within 5 years of issuance of an ITP	Type 3	N.A.
HCM 3-04 — SPECIES SPECIFIC MANAGEMENT MEASURES				
HCM 3-04A	Grizzly Bear Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, or use helicopters to harvest timber or conduct silvicultural activities within 1 mile of any known active grizzly bear den from 1 October through 31 May and will contact the USFWS prior to any similar activities within 3 miles of a known den at other times of the year	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04B	Grizzly Bear Sightings	Tacoma will suspend all management activities under its control in the Upper HCP Area within 1 mile of confirmed grizzly bear sightings for 21 days unless activities are necessary for the operation of the water supply project	Type 3	N.A.
HCM 3-04C	Grizzly Bears and Roads	Tacoma will not construct roads across non-forested blueberry and black huckleberry fields, meadows, avalanche chutes, or wetlands in the Upper HCP Area	Type 3	N.A.
HCM 3-04D	Grizzly Bear Visual Screening	Tacoma will retain visual screens along preferred grizzly bear habitat or along roads within 1 mile of said habitat if a grizzly bear is documented in the Green River watershed	Type 3	N.A.
HCM 3-04E	Grizzly Bears and Trash	Tacoma will take measures to prevent the dumping of trash that may attract grizzly bears in the upper watershed	Type 3	N.A.
HCM 3-04F	Grizzly Bears and Firearms	Tacoma will prohibit firearms within vehicles of contractors working for Tacoma in the Upper HCP Area (except in special cases)	Type 3	N.A.
HCM 3-04G	Gray Wolf Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or use helicopters to harvest timber or conduct silvicultural activities within 1.0 mile of any known active gray wolf den from 15 March through 15 July and within 0.25 mile of any known active gray wolf “first” rendezvous sites from 15 May through 15 July	Type 3	N.A.
HCM 3-04H	Pacific Fisher Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile of any known active Pacific fisher den from 1 February through 31 July	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04I	California Wolverine Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile of any known active wolverine den from 1 October through 31 May	Type 3	N.A.
HCM 3-04J	Canada Lynx Den Site and Denning Habitat Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile of any known active Canada lynx den or potential lynx denning habitat from 1 May through 31 July	Type 3	N.A.
HCM 3-04K	Seasonal Protection of Peregrine Falcon Nests	Tacoma will not fell timber, yard timber, construct roads or use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile, or blast within 1.0 mile, of any known active peregrine falcon nest from 1 March through 31 July	Type 3	N.A.
HCM 3-04L	Long-Term Protection of Peregrine Falcon Nest Sites	Tacoma will not fell timber or alter habitat within 100 feet of any known peregrine falcon nest site or potential nest cliff greater than 75 feet in height in the Upper HCP Area; Tacoma will retain large potential perch trees within 660 feet of known peregrine nests	Type 3	N.A.
HCM 3-04M	Seasonal Protection of Bald Eagle Nests and Communal Winter Night Roosts	Tacoma will not fell timber, yard timber, construct roads, or alter habitat within 0.25 to 0.5 mile, use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile, or blast within 1.0 mile of any known active bald eagle nest from 1 January through 31 August or active communal winter night roost at sensitive times of day from 15 November through 15 March	Type 3	N.A.
HCM 3-04N	Long-Term Protection of Bald Eagle Nests and Communal Winter Night Roosts	Tacoma will not fell timber or otherwise alter habitat within 400 feet of any known bald eagle nest or communal winter night roost in the Upper HCP Area	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04O	Seasonal Protection of Northern Spotted Owl Nests	Tacoma will not fell timber, construct roads or use helicopters to harvest timber or conduct silvicultural activities within 0.25 mile, or blast within 1.0 mile, of the activity center of any known northern spotted owl pair from 1 March through 30 June	Type 3	N.A.
HCM 3-04P	Year-Round Protection of Northern Spotted Owl Nests	Tacoma will not fell timber or otherwise alter habitat within 660 feet of the activity center of any known northern spotted owl pair or resident single in the Upper HCP Area	Type 3	N.A.
HCM 3-04Q	Seasonal Protection of Northern Goshawk Nests	Tacoma will not fell timber, yard timber or construct roads within 0.25 mile, use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile, or blast within 1.0 mile, of any known active northern goshawk nest from 1 March through 31 August	Type 3	N.A.
HCM 3-04R	Year-Round Protection of Northern Goshawk Nests	Tacoma will not fell timber or otherwise alter habitat within 660 feet of any known active northern goshawk nest in the Upper HCP Area	Type 3	N.A.
HCM 3-04S	Pileated Woodpecker Nest, Roost, and Foraging Trees	Tacoma will give preference to leaving green recruitment trees with visible signs of pileated woodpecker nesting, roosting, and/or foraging when selecting snags and trees to meet other HCMs	Type 3	N.A.
HCM 3-04T	Vaux's Swift Nest and Roost Trees	Tacoma will give preference to leaving green recruitment trees with visible signs of current Vaux's swift nesting and/or roosting and those with the potential for future use when selecting snags and trees to meet other HCMs	Type 3	N.A.
HCM 3-04U	Larch Mountain Salamander Habitat Protection	Tacoma will survey potential Larch Mountain salamander habitat prior to activities that might substantially reduce forest canopy and/or result in substantial disturbance to the substrate; areas found to be occupied will be protected	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04V	Sightings of Covered Species	Tacoma will notify the USFWS in a timely manner of any reported sightings of a spotted owl, marbled murrelet, grizzly bear, gray wolf, Pacific fisher, California wolverine, or Canada lynx in the Upper HCP Area	Type 3	N.A.
HCM 3-04W	Seasonal Protection of Occupied Marbled Murrelet Nesting Habitat	Tacoma will not fell timber, yard timber, or construct roads within 0.25 mile, use helicopters to harvest timber or conduct silvicultural activities within 0.5 mile, or blast within 1.0 mile of suitable marbled murrelet nesting habitat where "occupancy" has been determined or "presence" has been observed but occupancy is undetermined from 1 April through 15 September	Type 3	N.A.
HCM 3-04X	Site-Specific Protection for Northwestern Pond Turtles	Tacoma, the WDFW, and the Services will cooperatively develop site-specific protection plans for Northwestern pond turtles if the turtles are found to occur on or near the covered lands and it is determined the covered activities have the potential to impact the turtles	Type 3	N.A.

[1] Type 1: Protection measures designed to offset impacts of a Tacoma water withdrawal activity.
Type 2: Protection measures designed to offset impacts of a non-Tacoma activity.
Type 3: Protection measures designed to offset impacts of a Tacoma non-water withdrawal activity.

[2] Project numbers refer to mitigation and restoration measures identified in the Draft Environmental Impact Statement (DEIS) for the Additional Water Storage Project (USACE 1998). Note that during further development of the measures, site designations may change from those identified in the DEIS.

- AWSP Howard Hanson Dam – Additional Water Storage Project
- FDWRC First Diversion Water Right Claim
- HCM Habitat Conservation Measure
- HCP Habitat Conservation Plan
- HHD Howard Hanson Dam
- ITP Incidental Take Permit
- LMS Lower Mainstem; refers to AWS projects located in the mainstem Green River below HHD
- LWD Large Woody Debris
- MIT Muckleshoot Indian Tribe
- MS Mainstem; refers to AWS projects located in the mainstem Green River
- N.A. Not Applicable
- SDWR Second Diversion Water Right
- TPU Tacoma Public Utilities
- TR Tributary; refers to AWS projects located in Green River tributaries
- USFS United States Forest Service
- USFWS United States Fish and Wildlife Service
- VF Valley Floor; refers to AWS projects located in the Green River valley floor
- WAU Watershed Administrative Unit
- WFPB Washington Forest Practices Board

1

Many of the conservation measures described in this chapter have been developed to protect or enhance aquatic, wetland, or upland habitats or to address ecosystem functions such as sediment transport. These measures often benefit many of the species for which Tacoma is seeking coverage under the ITP. For example, maintenance of minimum flows in the middle and lower Green River, while designed to benefit various salmon species covered by the ITP, would also directly benefit other fish, wildlife, and riparian plant communities. Other conservation measures were developed to address habitat or management issues specific to a species, such as protecting active dens of grizzly bear, Canada lynx, and gray wolf. Where a species is not addressed by a specific conservation measure, general habitat conservation measures were considered to provide adequate protection.

This chapter describes each of the habitat conservation measures and is presented by the "type" of measure as previously described in this subsection. The order of presentation begins with Type 1 measures and extends through Type 3. The primary description of Tacoma's commitment for each measure is contained within textboxes (text outlined by solid black line) located at the beginning of each subsection. Following the textbox, the objective, rationale for implementation of the measure, and the anticipated ecological benefits are presented for each conservation measure. Costs for implementation of the conservation measures are contained in Chapter 8. Each measure has been given an identification number consisting of the letters HCM (Habitat Conservation Measure) followed by a two-digit number (e.g., HCM – XX).

5.1 Habitat Conservation Measures – Type 1

Type 1 habitat conservation measures are those designed to offset or compensate for impacts resulting from Tacoma water withdrawal activities. For instance, as part of the MIT/TPU Agreement, Tacoma agreed to design, construct, and operate an upstream fish passage facility at its Headworks, the Green River municipal and industrial water supply intake located at RM 61.0. The upstream fish passage facility was one of several measures that were developed as part of the MIT/TPU Agreement that settles Muckleshoot claims against Tacoma, including the FDWRC and the SDWR, arising out of Tacoma's municipal water supply operations on the Green River. Selected excerpts of the 1995 MIT/TPU Agreement are provided in Appendix B.

5.1.1 Habitat Conservation Measure: HCM 1-01 FDWRC Instream Flow Commitment

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-01

MEASURE: FDWRC Instream Flow Commitment

Tacoma will constrain water withdrawals under the FDWRC to provide guaranteed minimum continuous instream flows (during the period 15 July to end of flow augmentation from HHD) at the Auburn, Washington gage (USGS Gage # 12113000) as defined for different summer weather conditions:

Summer Weather Condition	Auburn Instream Flow
Wet Years	350 cfs
Wet to Average Years	300 cfs
Average to Dry Years	250 cfs
Drought Years	250 to 225 cfs, depending on the severity of the drought

Wet, average, dry, and drought weather conditions will be determined by the use of reference zones within Howard Hanson Reservoir that show available storage by date within the 24,200-acre-foot (ac-ft) block of water stored for flow augmentation purposes (Figure 5-1). Tacoma will have the option to lower the flow requirement to 225 cubic feet per second (cfs) at the Auburn gage during drought conditions. At that time, Tacoma may rely on the South Tacoma well field or other groundwater sources to meet its water supply need, and reduce water withdrawals under the FDWRC. Tacoma may also utilize the South Tacoma well field or other groundwater sources if the USACE augments releases from HHD to meet a 225 cfs flow at Auburn during the summer months and if fall precipitation does not occur in sufficient quantities to meet minimum flows at Palmer. Tacoma will reduce its withdrawal to help prevent a premature drawdown of the reservoir by the USACE. However, 30 days prior to any reduction, Tacoma will convene a drought coordination meeting with the MIT, local, state and federal resource agencies, and USACE to discuss alternatives and seek to institute “consensus derived” water use restrictions. Before lowering the minimum flow in the Green River, Tacoma will institute water use restrictions consistent with an existing water use curtailment plan.

HCM 1-01 (continued on next page)

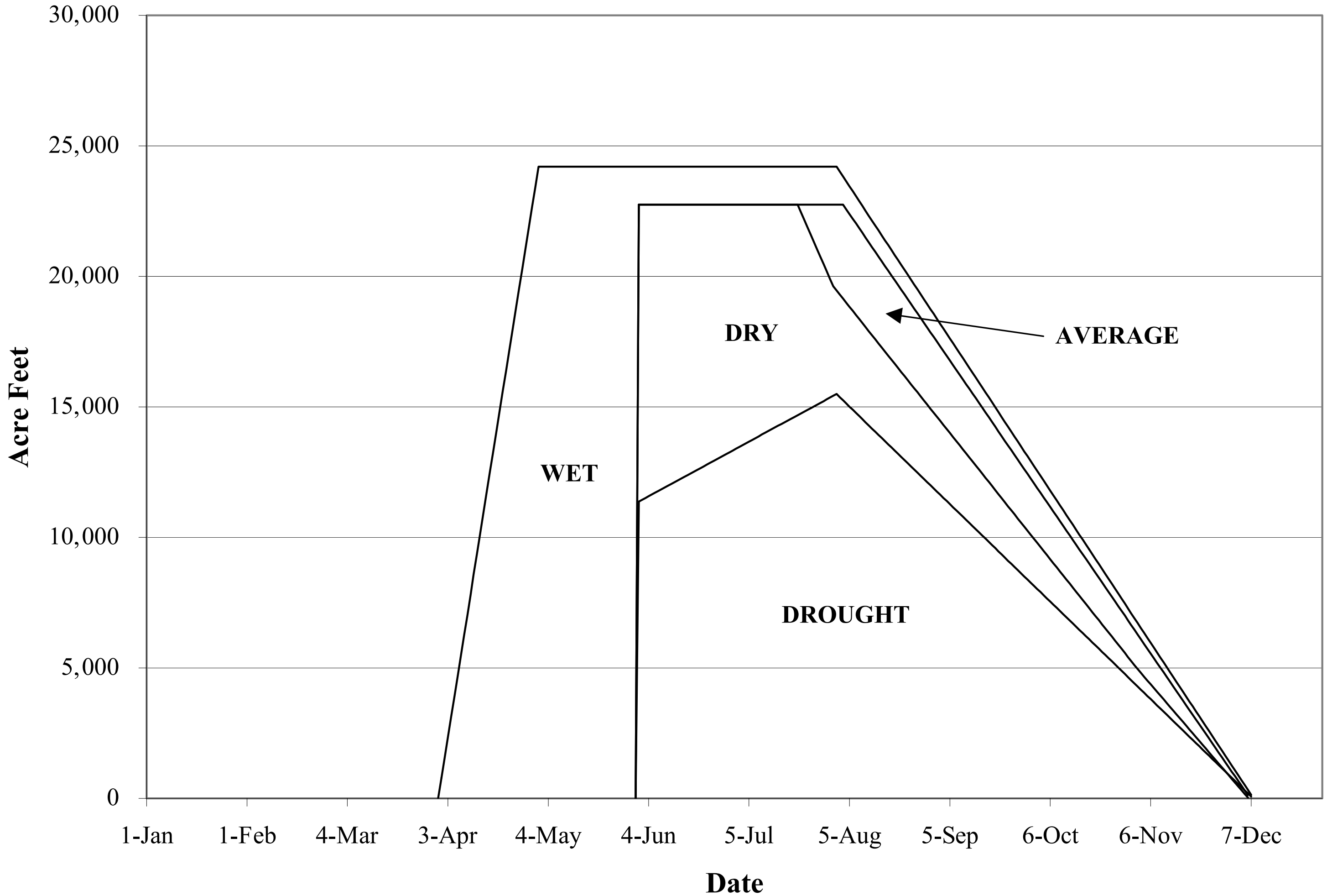

Figure 5-1. Storage reference zones within Howard Hanson Reservoir used to determine minimum flow conditions under yearly wet, average, dry and drought conditions during the period 15 July to 15 September. The storage reference zones pertain to the 24,200-acre-foot block of water stored for flow augmentation purposes.

HCM 1-01 (continued)

During the summer period, the instream flow will be maintained above 225 cfs at the Auburn gage even during drought conditions. These commitments by Tacoma are contingent upon:

- continued dedication of 24,200 ac-ft of water stored in Howard Hanson Reservoir for low flow augmentation to maintain a minimum flow of 110 cfs measured at the U.S. Geological Survey (USGS) Palmer Gage; and
- at least 2,500 ac-ft of the 5,000 ac-ft of storage authorized by the Section 1135 project for flow supplementation being used to support minimum instream flows during drought conditions.

Should resource agency decisions on the use of water stored behind HHD for flow augmentation purposes deviate from these contingencies and thereby limit Tacoma's ability to meet its flow commitment under HCM 1-01, then Tacoma shall be temporarily relieved of its commitment to the extent of the deviation from the contingencies described above.

Tacoma began withdrawing water from the Green River for municipal water supply in 1911 at its Headworks facility at RM 61.0. In 1971, a water right claim of 400 cfs was filed for this diversion (Ecology 1995). Under current conditions, Tacoma withdraws up to 113 cfs under its FDWRC. A water right claim on file with the Washington State Department of Ecology (Ecology) cannot be validated until an adjudication occurs. As part of HCM 1-01, Tacoma will not pursue adjudication of the full 400 cfs, but will cap its FDWRC at 113 cfs.

Tacoma's FDWRC instream flow commitment is to support flow levels measured at the USGS gage at Auburn. This measure will begin to be in effect upon Tacoma's initial exercise of its Second Diversion Water Right. The FDWRC is not constrained by minimum flows prescribed by Ecology for the Green River in the Washington Administrative Code (WAC) 173-509 at either the Palmer or Auburn USGS gages.

North Fork Well Field

In view of potential impacts to instream resources in the North Fork, Tacoma will restrict use of the North Fork well field to periods when the turbidity of Green River surface water supplies approach 5 Nephelometric Turbidity Units (NTUs), unless emergency conditions require use of the North Fork aquifer in lieu of surface water. This restriction will be in effect upon signing of the Incidental Take Permit. This restriction does not apply to occasional pumping of the well field to supply domestic water to Tacoma operations staff living on-site. During the period 1 July through 31 October, should turbidity of the mainstem Green River approach 5 NTUs, Tacoma will begin pumping from the North Fork well field at a rate that maintains a maximum pumping-related stage drop of no greater than 1 inch per hour in the lower North Fork channel at an area of potential salmonid holding refugia to be determined in

HCM 1-01 (continued on next page)

HCM 1-01 (continued)

coordination with the NMFS and USFWS. As the well field is brought on-line, Tacoma will use in-line storage or groundwater supplies in the vicinity of Tacoma (e.g., South Tacoma well field) to meet municipal water demand.

Tacoma will conduct a study to identify the physical effect of the rate of well field pumping on stage changes in the lower North Fork channel in consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) within two years following signing of the ITP. The study must be designed and completed in coordination with the NMFS and USFWS and submitted to the MIT and local, state and other federal resource agencies for review and comment. The results of the study will be used to identify a maximum rate of pumping that maintains a pumping-related stage reduction of no greater than 1 inch per hour in selected adult salmonid refuge area within the lower North Fork channel as determined by the NMFS and USFWS.

Restrictions on the use of the North Fork well field will be subordinate to Tacoma's responsibility to comply with Safe Drinking Water Act Maximum Contaminant Level Limits. In the event that such emergency conditions were to occur, Tacoma agrees to take every effort to avoid actions that would be detrimental to the North Fork Green River's natural resources as the City meets its responsibility to maintain water quality and protect public health. In the event of an emergency, Tacoma will consult with the USFWS and NMFS to determine a course of action that will minimize impacts to North Fork fisheries.

Objective

The objective of this measure is to implement guaranteed continuous instream flows in the Green River below Tacoma's Headworks to protect important fisheries habitats as specified in an agreement between the MIT and Tacoma.

Rationale and Ecosystem Benefits

Instream flows that provide for important fish habitats are fundamental to the long-term protection and propagation of fishery resources in the Green River. Since November 1906, there has been a large decrease in instream flows of the lower Green River. This has resulted from a combination of developments, including but not limited to the diversion (in 1906) of the White River into the Puyallup River (causing a loss of approximately 50 percent of the inflow to the Green/Duwamish estuary), the diversion (in 1912) of the Cedar River into Lake Washington (the Cedar historically flowed into the Black River, which flowed into the Green), and the construction and operation of Tacoma's Headworks diversion near Palmer, Washington (see Chapter 4). Overall, 70 percent of the flows of its former watershed have been diverted out of the Green River basin.

From 1911 to 1947, Tacoma diverted up to 85 cfs of water from the Green River at the Headworks under the FDWRC. Since 1948, Tacoma has diverted up to 113 cfs from the Green River under the FDWRC. The combined effects of these actions often resulted in seasonal depletions in instream flows that were detrimental to existing fish populations. The construction and regulation of HHD and reservoir in 1962 afforded some flow protection to downstream fish habitats by providing storage of water for low flow augmentation to meet a minimum flow target of 110 cfs measured at the USGS gage at Palmer located below Tacoma's Headworks. The instream flow at Palmer may drop below 110 cfs if the inflow to HHD is below 110 cfs and there is insufficient storage to augment flows (e.g., during winter flood control season).

Observation by state and Tribal biologists indicated that flows of 110 cfs at Palmer were barely sufficient to provide for passage of adult salmon in the lower river during low flow years and were sometimes insufficient to keep steelhead eggs watered. In 1988, Ecology completed an instream flow study (using the USFWS Physical Habitat Simulation [PHABSIM] methodology [see Chapter 7]) that identified and recommended much higher instream flows (Caldwell and Hirschey 1989).

The guaranteed flow levels at Auburn specified in this conservation measure were developed as a result of an agreement between MIT and Tacoma. The flows specified in the MIT/TPU Agreement are designed to protect important fishery habitats below Tacoma's Headworks consistent with annual differences in precipitation and flow availability. Because of timing, the ecological benefits of such flows would include improvements in both habitat quantity and quality. With respect to quantity, the flows would provide for a variety of important and seasonally specific life history stage requirements (see Appendix A), including adult salmon holding and spawning habitat, incubation and emergence of steelhead eggs and fry, and upstream passage of adult salmon (see Chapter 7). The flows would also increase the amount of available freshwater habitat in the Green/Duwamish estuary during the summer extreme low flow periods. Benefits related to habitat quality would likely include reductions in water temperatures during the summer months immediately below HHD, increases in or maintenance of dissolved oxygen (DO) levels, and the potential dilution of nutrients and introduced pollutants in the lower Green River. Tacoma's commitment to maintain flows during the period 15 July to the end of flow augmentation from HHD will provide a guaranteed level of resource protection. The end of HHD flow augmentation typically occurs after 15 October but no later than early December. This flow commitment will not provide the full range of flow variability needed to satisfy ecosystem functions. Flow variations, to the extent allowed within the operational constraints of HHD, are provided by other habitat conservation measures.

Tacoma has long encouraged customers to use water efficiently, but increased its focus on conservation during the summer of 1987 when a drought in Puget Sound drastically reduced river flows in the Green River. The late summer drought that year made it difficult for adult chinook salmon to swim upstream to spawn. To facilitate the salmon's upstream migration, Tacoma reduced the amount of water it withdrew from the river and instituted voluntary and mandated water use restrictions. The less water people use, the more water is available for fish in the Green River. Conservation is especially important in the summer when river flows are at their lowest and water use is at its highest. Tacoma continues to invest considerable resources to educate its customers about the importance of conserving water (see Appendix C, Water Conservation Planning).

North Fork Well Field

Tacoma withdraws water from the North Fork well field to replace or supplement surface water withdrawn from the Green River at the RM 61.0 Headworks. When the turbidity of Green River surface water supplies approach 5 NTUs, the North Fork well field provides a source of clean groundwater that allows Tacoma to provide the public with water that meets rigorous federal and state water quality standards. In general, pumping from the North Fork well field occurs during the late fall, winter and spring when turbidity increases as a result of storm events and resultant periods of high streamflow.

Tacoma's use of the North Fork well field may pose the greatest risk to instream resources during the late summer and early fall. If pumping from the well field was to occur without a storm-related rise in streamflow, adult salmonids holding in the lower North Fork channel could be exposed to channel dewatering. Groundwater outflow below the well field maintains cool water temperatures and provides potentially important adult holding and rearing habitat for salmonids. If pumping from the North Fork well field during the late summer interrupts the outflow of groundwater and reduces flow into the channel, fish holding in the lower North Fork could be trapped in isolated pools or be forced to move downstream to the reservoir.

Restricting withdrawals from the North Fork well field to periods when the turbidity of the mainstem Green River approaches 5 NTUs reduces the risk of impact to instream resources in the lower North Fork to those periods when water withdrawals are needed to avoid violation of Primary Drinking Water Standards. Restricting the pumping of water from the North Fork well field to a rate that maintains a pumping-related stage reduction of no greater than 1 inch per hour in the lower North Fork channel during the period 1 July though 31 October helps ensure that fish holding in the lower North Fork channel will have the opportunity to move downstream to the reservoir and potentially avoid becoming stranded by pumping-related stage reductions.

Tacoma occasionally needs to inspect and repair its Headworks facilities to maintain them in good operation condition. To the extent possible, this type of extraordinary maintenance is conducted during the wet season (1 November through 30 June). In addition, the Headworks facilities will be modified during construction of the Second Supply Project. At such times, the surface water diversion needs to be reduced, or shut down completely, for short periods of time, and the North Fork well field brought on-line to replace the surface water diversion. Prior to conducting planned extraordinary maintenance or modification to the Headworks facilities, Tacoma will consult with the NMFS and USFWS to identify a course of action that will minimize impact to North Fork fisheries.

5.1.2 Habitat Conservation Measure: HCM 1-02 Seasonal Restrictions on the Second Diversion Water Right

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-02

MEASURE: Seasonal Restrictions on the Second Diversion Water Right

Before withdrawing water under the SDWR at an instantaneous rate not to exceed 100 cfs, Tacoma will adhere to the following seasonal minimum flows at the Palmer, Washington gage (USGS # 12106700) and Auburn, Washington gage (USGS #12113000):

INSTREAM FLOW BY SEASON REQUIRED FOR SDWR WITHDRAWAL

Season by Dates	Palmer	Auburn
15 July to 15 September	200 cfs	400 cfs
16 September to 14 July	300 cfs	NA

NA – Not applicable – The SDWR is not constrained by minimum instream flows in the Green River measured at the USGS gage at Auburn during the period 16 September to 14 July.

These instream flow conditions are in addition to those specified under HCM 1-01 and specify the flow conditions under which the SDWR can be exercised. Both instream flow conditions must be met before SDWR water can be diverted. Thus, if instream flows at Auburn fall below 400 cfs, even if minimum flows for the Palmer gage are achieved, Tacoma may not withdraw water using its SDWR. Tacoma's exercise of its SDWR will be constrained by the minimum flow requirements identified in this habitat conservation measure or by minimum flows prescribed by Ecology in WAC 173-509, whichever are greater. Tacoma will also work with Ecology to modify minimum flow

HCM 1-02 (continued on next page)

HCM 1-02 (continued)

requirements for the Green River prescribed by Ecology in the WAC to be consistent with the flow commitments identified in this HCP.

Tacoma's ability to divert its SDWR from the Green River is restricted by the City's 1995 agreement with the MIT. That Agreement establishes minimum instream flows at both the Palmer and Auburn gages on the Green River. When flows at either gage are below the minimum flow levels stated above Tacoma, cannot divert water under its SDWR.

Tacoma intends to divert its SDWR to storage behind HHD under the AWS project between 15 February and the point when either 20,000 ac-ft have been stored, or when stream flows reach the thresholds specified above. When Green River flows are below the flow thresholds, and Tacoma cannot divert water under its SDWR, the stored water would be used for municipal supply.

Objective

The objective of this measure is to set controls on the withdrawal of Tacoma's SDWR to further ensure protection of fisheries habitat in the Green River.

Rationale and Ecosystem Benefits

This conservation measure is likewise focused on providing instream flows in the lower Green River that promote a healthy instream ecosystem. The measure is complementary to HCM 1-01 and focuses on seasonal (summer) flow requirements to maintain important fish habitats in the river.

This measure essentially controls when Tacoma will be able to exercise its SDWR. That is, during the summer period (15 July to 15 September) both the Palmer and Auburn instream flow requirements noted above must be met before Tacoma can withdraw water directly from the Green River under its SDWR. Water stored for municipal supply behind HHD under the AWS project can be used at any time since it represents a prior exercise of the SDWR. Operationally, as flows in the lower Green River begin to decrease during the late spring and early summer, Tacoma will begin reducing the amount of water it diverts under the SDWR by the amount necessary to meet the specified instream flow requirements. This reduction in diverted flow would continue until the SDWR becomes non-operational (i.e., no water is being diverted), at which time the instream flow conditions specified in HCM 1-01 would dictate the minimum flows in the lower Green River. When low instream flows in the Green River prevent Tacoma from exercising its SDWR and withdrawing water directly from the river, Tacoma will use water stored behind HHD for municipal use to meet the demands of its water supply customers.

The instream flow values specified in this habitat conservation measure for the USGS gage at Palmer are equal to or higher than those set by Ecology as part of its Instream Resource Protection Program (IRPP) (Chapter 173-509 WAC).

Instream Flow Requirements at the USGS gage at Palmer (USGS #12106700) under the 1995 MIT/TPU Agreement and Ecology's Instream Resource Protection Program.

Season	MIT/TPU	Ecology (WAC 173-509)	
		Normal Year	Critical Year
15 July to 15 September	200 cfs	150 cfs	150 cfs
16 September to 30 September	300 cfs	150 cfs	150 cfs
1 October to 15 October	300 cfs	190 cfs	150 cfs
16 October to 31 October	300 cfs	240 cfs	150 cfs
1 November to 14 July	300 cfs	300 cfs	150 cfs
1 November to 15 November	300 cfs	300 cfs	190 cfs
16 November to 30 November	300 cfs	300 cfs	240 cfs
1 December to 14 July	300 cfs	300 cfs	300 cfs

During the period 15 July to 15 September, as a result of the 1995 MIT/TPU Agreement, Tacoma's exercise of its SDWR will also be constrained by minimum flows measured at the USGS gage at Auburn. During the period 15 July to 15 September, Tacoma will not be able to withdraw water directly from the Green River under its SDWR if instream flows drop below 400 cfs measured at the USGS gage at Auburn. This minimum flow is greater than the 300 cfs instream flow requirement identified in the WAC 173-509 for the USGS gage at Auburn during the period 15 July to 15 September. Tacoma's exercise of its SDWR will be constrained by minimum flow requirements identified in HCM 1-02, or by minimum flows prescribed by Ecology in WAC 173-509 for the USGS gage at Palmer, whichever is greater. Except for the commitment in this HCP to constrain its exercise of the SDWR during the period 15 July to 15 September by a minimum flow of 400 cfs measured at the USGS gage at Auburn, Tacoma's SDWR is not constrained by minimum instream flows identified in WAC 173-509 for the Green River at Auburn.

The flows for the period 15 July to 15 September approximate those identified as providing peak adult chinook holding, and juvenile chinook, coho, and steelhead rearing habitats in the section of river below the Headworks (Caldwell and Hirschey 1989). The flows specified for Auburn (i.e., 400 cfs) for the same time period (15 July to 15 September) likewise protect adult chinook and steelhead holding, and steelhead juvenile habitats. The flows are even greater than those identified as providing peak chinook and coho juvenile habitats (400 cfs versus 220 cfs) (Caldwell and Hirschey 1989). The specified instream flows would protect the habitats in the Green River during the period of time when Tacoma exercises its SDWR. Anticipated benefits include improved, but still only partial, protection of steelhead egg incubation and fry emergence, increased juvenile rearing habitats, increased early summer holding habitats for adults and juvenile fish, and increased attraction flows to facilitate adult returns to the river. As in HCM 1-01, benefits would include those related to water quality improvements, as well as benefits for wildlife and riparian ecosystems.

5.1.3 Habitat Conservation Measure: HCM 1-03 Tacoma Headworks Upstream Fish Passage Facility

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-03

MEASURE: Tacoma Headworks Upstream Fish Passage Facility

Tacoma will modify the existing Headworks facility by increasing the height 6.5 feet and by adding an adult upstream fish passage facility. The facility includes a fish ladder over the Tacoma Headworks combined with a trap-and-haul operation to pass adult fish from the Headworks to above HHD. In addition, the channel downstream of the diversion dam will be reshaped to provide greater fish attraction to the ladder entrance (Merry 1995). An alternative location for the upstream fish passage facility may also be considered. Any alternative location must satisfy the objective of providing anadromous fish access to the Green River above HHD and must be developed in coordination with the MIT, USACE, Washington State Department of Fish and Wildlife (WDFW), and the USFWS and NMFS (known collectively as the Services). Adult fish will be transported using a truck specially outfitted to minimize handling and transport stress. Details and final design of this facility will be developed in close coordination and collaboration with MIT, USFWS, USACE, NMFS, WDFW, and other interested parties. The upstream fish passage facility at Tacoma's Headworks will be operational before Tacoma's initial exercise of its SDWR.

Funding the construction and operation of the upstream fish passage facility is evidence of Tacoma's commitment to long-term measures to help restore anadromous fish production above the USACE's HHD. Once upstream fish passage facilities are completed, the agencies and Tribes with jurisdiction for fisheries management will determine the number and species of fish to be transported into the upper watershed. Determining how many and which species of fish should be considered for reintroduction to the upper watershed is a fish management decision that is beyond the responsibility of Tacoma. The MIT and WDFW are co-managers of Green River fish and wildlife resources and together with the NMFS and USFWS will evaluate fisheries aspects of reintroducing anadromous fish into the upper watershed.

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Tacoma does not believe reintroduction of anadromous fish to the upper watershed poses a risk to drinking water quality and public health at the numbers that have been discussed to date. This would include the introduction of up to 6,500 adult coho and 2,300 adult chinook. This level would be reached over a period of years allowing adequate opportunities to assess water quality on an ongoing basis. Tacoma will monitor the effects of fish passage on drinking water quality as part of its surface water treatment operations (see Chapter 6.1.4). If continued monitoring confirms that reintroduction of adult anadromous fish does not pose a risk to public health, no further action will be taken. If, to adequately protect drinking water quality, it becomes necessary to limit the biomass of adult fish transported into the upper watershed, Tacoma will coordinate with the NMFS, USFWS, and the fisheries managers before instituting measures to decrease fish passage. As part of the coordination effort, Tacoma will select one or more independent experts to evaluate available options. The independent expert will submit a report to the City, fisheries managers, and public health officials with recommendations as to the level of fish passage that can occur without posing a risk to drinking water quality and public health.

Objective

The objective of this measure is to construct and operate facilities for the upstream movement of adult anadromous fish as part of an overall program to provide anadromous fish access to the Green River above HHD.

Rationale and Ecosystem Benefits

Tacoma's Headworks diversion dam was constructed in 1911 at RM 61.0, 3.5 miles downstream of the eventual site of HHD. This facility was the first complete barrier to adult salmon and steelhead in the Green River, and eliminated anadromous fish production in the upper watershed. The completion of HHD in 1962 created a further barrier to upstream passage and served to essentially isolate approximately 220 square miles of watershed area (45 percent of the entire Green River basin). Most of the headwater streams in the upper watershed are unconstrained by levees or dikes. Thus, a portion of the upper watershed contains anadromous fish habitat that could be restored to production using an adult passage/trap-and-haul facility at the Headworks. Since 1992, MIT, Tacoma, WDFW, and Trout Unlimited have cooperatively administered a temporary fish ladder and trap-and-haul program. As a pilot program, between 7 and 133 adult steelhead have been captured at the Headworks fish trap and either released above HHD for natural spawning or used as broodstock to produce fry for outplanting in the upper Green River watershed.

Under this measure, adult fish will be collected at the Tacoma Headworks at RM 61.0 and released at the upstream extent of the HHD reservoir in the vicinity of RM 72.0. Upstream migrating adult salmonids could be released into the reach between the Headworks and HHD if deemed beneficial by MIT and WDFW in coordination with the Services. The facility will include a fish ladder over the Tacoma Headworks combined with a trap-and-haul operation from the Headworks to above HHD. This measure was selected in favor of other passage alternatives for several reasons. Although the fish ladder has the physical capability to allow fish to be released immediately above the Headworks, this would only open up 3.5 miles of the mainstem Green River. This area consists of a high-energy confined channel. Such channels typically route most gravel-sized sediment rapidly through the reach, unless there are stable large woody debris (LWD) or other obstructions present that form hydraulically protected areas (Paustain et al. 1992). Since the majority of primary spawning and rearing habitats are above HHD, a second upstream fish passage facility consisting of either a very long fish ladder or a trap-and-haul facility would also need to be constructed at HHD to achieve similar benefits to this measure.

Construction of a fish ladder at the Tacoma Headworks separate from a trap-and-haul facility at HHD would impose higher stress and increased migration delays to upstream migrants than the preferred measure. Adult fish would need to locate and enter a second fishway leading to a trap-and-sorting facility at HHD. Given the configuration of the river and outlet works at HHD, it is likely that a second upstream fish passage facility would need to be located well downstream of HHD, thus further reducing any benefits of allowing salmonids access to the reach between the Headworks and HHD.

There are serious concerns regarding the applicability of conventional fish ladder technology to HHD. The overall height of the HHD (235 feet) would require a ladder with a length of at least 1 mile. Fish attempting to ascend a ladder of this length and height would be exposed to stress and potential water quality deterioration.

Another limitation to installing a fish ladder at HHD is the large fluctuation in the reservoir level. Since HHD provides a major flood control function, the water level behind the dam can vary by more than 150 feet during times when adult salmon and steelhead are migrating upstream. During times when the water level is low, the fish that ascended the 235-foot-high ladder would then need to be lowered (as much as 150 feet) to the level of the reservoir pool behind the dam. This would require that the adults either be returned in a high velocity slide/chute to the pool level or via some type of mechanical elevator. In either case, the fish would experience additional stress associated with the passage facilities. As an alternative to returning the fish to the lower pool level, the fishway could be extended upstream of the reservoir. However, this would entail extending the fishway approximately 7 miles upstream of the dam, which raises a number of additional concerns about whether effective passage could be achieved (given concerns about water temperature and habitat conditions within the fishway). Tacoma is not aware of any fish ladders constructed to provide adult salmonid passage on dams with the height and range of forebay fluctuation as found at HHD.

The preferred fish passage facility includes a fish ladder over the Tacoma Headworks combined with a trap-and-haul operation from the Headworks to above HHD. Estimated capital costs for the entire facility are $2.53 million. Approximately 63 percent of this $2.53 million is needed for the trapping, sorting, and hauling facilities associated with the transport of adult fish above HHD. Once constructed, operational costs for the Green River fish ladder would be minimal. The preferred measure not only affords passage above the Headworks, but also provides passage around HHD without imposing additional delays and stress to the fish.

Tacoma supports the full utilization of the upper Green River watershed for anadromous fish production, consistent with the continued use of the Green River as a source of drinking water. At this time, the City does not believe reintroduction of anadromous fish to the upper watershed poses a risk to drinking water quality and public health. Most salmon die after spawning, but the carcasses are quickly consumed (Cederholm et al. 1999). In a study of seven streams in the Olympic Peninsula in Washington State, over 90 percent of coho salmon carcasses were not flushed downstream but remained within several hundred yards of the original placement site (Cederholm et al. 1989).

The City of Seattle conducted a risk assessment of potential negative impacts of salmonid passage on safe drinking water as part of its plan to reintroduce adult anadromous salmonids into the upper Cedar River. The City of Seattle determined that while passage of mass-spawning sockeye over the intake would compromise drinking water quality and public health, passage of much less numerous coho, chinook, and steelhead into the Cedar River above the intake was unlikely to present drinking water problems (Manning et al. 1996). There are numerous similarities and several important differences between the two plans to reintroduce salmonids above the respective intakes.

The Cedar River watershed is adjacent to the Green River watershed and both flow westerly into Puget Sound. Plans to reintroduce salmonids into the upper watersheds of both the Cedar and Green rivers have targeted reintroduction of coho, chinook, and steelhead. An estimated 4,500 coho and 1,000 chinook may return to the Cedar River above Landsburg, while an estimated 6,500 coho and 2,300 chinook may return to spawn in the upper Green River watershed. While the upper Green River watershed may have the potential to support higher numbers of coho and chinook than the upper Cedar River, the upper Green River watershed is 1.7 times larger than the Cedar River watershed above Landsburg. Tacoma has allowed the transport of adult steelhead into the upper Green River watershed since 1992.

Seattle's salmonid reintroduction plan for the Cedar River provides a fish ladder to allow adult fish access to the Cedar River immediately upstream of the Landsburg Diversion (City of Seattle 1998). Due to the presence of the USACE's 235-foot-high HHD above Tacoma's Headworks, the Green River salmonid reintroduction plan provides for a trap-and-haul facility to move fish past HHD. The reservoir behind HHD and nearly 3 miles of river between HHD and Tacoma's water intake will allow the natural uptake of nutrients from spawned salmon prior to withdrawal of water for municipal water supply purposes. The reservoir behind HHD and the stream reach between HHD and Tacoma's water intake will also minimize the occurrence of adult salmon immediately upstream of Tacoma's intake. Tacoma will monitor water quality at the Headworks as part of its surface water treatment program to verify safety of the upper Green River as a source of safe drinking water (see Chapter 6).

Construction and operation of a new fish ladder and trap-and-haul facility at the Headworks are instrumental to the restoration of anadromous fish runs into the upper Green River basin, but would represent only a part of the required actions needed to restore anadromy to the upper watershed.

5.1.4 Habitat Conservation Measure: HCM 1-04 Tacoma Headworks Downstream Fish Bypass Facility

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-04

MEASURE: Tacoma Headworks Downstream Fish Bypass Facility

Tacoma will modify the existing Headworks diversion to safely bypass fish downstream below the diversion and to eliminate the potential that fish could enter the Headworks intake. The new Headworks structure will incorporate a non-revolving wedgewire screen with dimensions of approximately 220 feet long, 40 feet wide, and 24 feet deep (see Chapter 4). The intake screen surface will be approximately 120 feet long and 13 feet high (1,300 square feet) (see Chapter 4) and designed to meet state of Washington and NMFS screening criteria (Merry 1995). In addition to the fish screen, the modified facility will consist of a debris/trash rack, fish bypass system, new trashracks, trash raking equipment, stoplogs, and dual slide gates. The downstream

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fish passage facility at Tacoma's Headworks will be operational before Tacoma's initial exercise of its SDWR. The modified intake will be 6.5 feet higher than the old intake to compensate for higher water-surface elevations resulting from the increase in the diversion dam crest. The screen and bypass system will be operated and maintained continuously whenever water is being diverted into the Headworks. Debris that collects on the trash racks will be returned to the river channel downstream of the Headworks. Tacoma will coordinate with the Services and other agencies with jurisdiction during the design and construction of the Headworks rebuild. In coordination with the Services, Tacoma will rebuild the Headworks to minimize the risk of injury to salmonids passing downstream over the Headworks spillway. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to provide downstream fish passage at Tacoma's Headworks as part of an overall program to provide anadromous fish access to the Green River above HHD.

Rationale and Ecosystem Benefits

Two routes are currently available to juvenile fish migrating downstream below Tacoma's existing Headworks. The first and safest is direct passage over the dam spillway, which is currently 17 feet high. Reconstruction of the Headworks will raise the diversion by 6.5 feet. Although fish passing downstream over Tacoma's Headworks are believed to incur little injury or mortality during their transit over the existing spillway, some potential for injury does exist. In general, mortality of juvenile fish passing over dams is a function of the height of the structure, the maximum velocity of water (which is primarily dependent on dam height) and the configuration of the channel immediately downstream of the dam. For small fish (< 100 mm), mortality is near zero, even for falls of approximately 100 feet, provided they land in water. Larger fish (> 300 mm) begin to experience mortality at falls greater than 50 feet (R2 Resource Consultants 1998). Fish mortality is also influenced by the maximum velocity of the flow passing over a dam. Where flows passing over a dam empty into a deep pool or stilling basin, mortality is essentially zero at velocities less than 40 feet per second (fps); however, shallow flow or obstructions such as exposed rocks below the spillway appear to increase the rate of mortality and injury (R2 Resource Consultants 1998).

Although there are no site-specific data on the hydraulic conditions or injury or mortality of fish at the existing Tacoma Headworks diversion dam, information from studies at other projects suggest that the rate of mortality experienced by juvenile fish passing over a 17-foot spillway is probably low. Fish passing through the radial gates at HHD drop 26 feet onto a concrete slab with little apparent injury (Seiler and Neuhauser 1985). However, because the channel configuration downstream of the Headworks diversion dam currently consists of a shallow concrete apron, it must be assumed that there could be some injury or mortality of juvenile and adult salmonids passing downstream over the Tacoma Headworks under its current configuration at some flows.

Reconstruction of the Headworks as part of the Second Supply Project (SSP) will raise the diversion by 6.5 to a total height of 23.5 feet. As part of conservation measures HCM 1-03, Tacoma Headworks Upstream Fish Passage Facility, and HCM 1-04, Tacoma Headworks Downstream Fish Bypass facility, Tacoma will rebuild its Headworks facility and reconfigure the channel below the Headworks to minimize potential injury associated with downstream passage of salmonids over the Headworks spillway.

The second avenue of downstream passage is via the Headworks intake. This intake is 20 feet wide and is located in the right abutment (looking downstream) immediately upstream of the existing diversion dam. Approximately 10 percent of the flow in the Green River during the juvenile chinook outmigration season currently enters Tacoma's Headworks intake (calculated assuming 113 cfs withdrawal at the median daily flow 15 March through 16 June). The existing Headworks intake screens do not meet NMFS screen criteria and juvenile salmonids can potentially be entrained or impinged on the intake and killed. The new fish screen and bypass system would be designed to meet federal and state fish protection criteria. This measure therefore represents an important element in the overall restoration of anadromous fish runs into the upper watershed.

5.1.5 Habitat Conservation Measure: HCM 1-05 Tacoma Headworks Large Woody Debris/Rootwad Placement

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-05

MEASURE: Tacoma Headworks Large Woody Debris/Rootwad Placement

Tacoma will place LWD and rootwads to improve rearing habitat (for juvenile salmon and trout) within two sections of the inundation pool immediately upstream of the modified Headworks diversion dam. This measure is designed to mitigate for the effects of Tacoma's Headworks modifications. The first site is located near an access road bridge; the site will be flooded to a depth of 1 to 6 feet due to the increase in pool elevation. At this site, approximately 10 boulders and 43 pieces of LWD will be placed

HCM 1-05 (continued on next page)

HCM 1-05 (continued)

within the active channel. The second site is located along the eastern shore of the Green River, near the upper end of the inundation zone. At this site, five pieces of LWD will be cabled along the bank, with each piece individually anchored to boulders to allow some movement at high flows.

The LWD will consist of fir, hemlock, cedar, or spruce greater than 20 feet long, with a minimum stem diameter of 12 inches. Rootwads will have at least 3 feet of attached stem that is 18 inches in diameter or greater. No more than 18 and no fewer than six of the debris pieces will be rootwads. Boulders will be placed at the upstream end of the bar at Site 1 to dissipate the energy of high flows sweeping across the bar. In addition, boulders will be incorporated into LWD clusters to provide stability. Boulders will have a minimum diameter of 4 feet and be composed of hard rock.

Structures that are deemed non-functional as a result of high flows will be modified or replaced by Tacoma as needed within the first 5 years following construction (see Chapter 6). Tacoma will also fund one complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary.

Alternative measures will be implemented if any of the above measures are determined to be infeasible, or not cost effective during final design, or if environmentally superior measures can be implemented at comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS. Permits for these projects have already been approved by the USACE; therefore, any changes to the existing project designs that may be requested or approved by the Services will also be subject to approval by the USACE. Measures designed to mitigate for the effects of Tacoma's Headworks modifications will be completed before Tacoma's initial exercise of its SDWR.

Objective

The objective of this measure is to improve rearing habitat for juvenile salmonids in the portion of the Green River immediately upstream of Tacoma's Headworks by increasing cover within the new inundation zone.

Rationale and Ecosystem Benefits

The Headworks diversion dam will be raised 6.5 feet to accommodate the diversion of the SDWR. Raising the Headworks will inundate an additional 1,800 feet of channel, or approximately 7 acres (FishPro 1995). Currently, the density of LWD within the area upstream of the Headworks is considered low (0.29 pieces per channel width) compared to free-flowing river systems. This is likely due, in part, to the location of HHD 3.5 miles upstream (which blocks recruitment of LWD from the upper watershed), as well as past logging practices (CH2M Hill et al. 1996; Fuerstenberg et al. 1996).

Placement of LWD and large boulders in the inundation pool will increase the density of LWD and create additional in-channel rearing habitats. At some time during their rearing periods, all juvenile salmonids prefer areas in the stream where they can find shelter from velocity and predators while remaining close to a food source (Chapman 1966).

Large rivers such as the mainstem Green River easily transport even the largest pieces of LWD. In these channels, wood is characteristically distributed in infrequent jams composed of numerous pieces of wood (Cederholm et al. 1997b; Bisson et al. 1987). Because of the high stream power and confined nature of this reach, LWD would be expected to remain stable only along channel margins, oriented parallel or subparallel to the direction of flow.

Site 1 consists of a low terrace that is approximately 650 feet long and 25 to 100 feet wide. This site will be flooded to a depth of 1 to 6 feet as a result of the pool raise. Approximately 10 large boulders (diameter ∃ 4 feet) will be placed at the upstream end of the bar to help reduce the erosive energy of high velocity flows sweeping over the bar. Because the channel is wide and has a high transport capacity at Site 1, LWD will be placed in groups to form a series of small, stable jams along the channel margin. Grouping LWD will increase the habitat value and habitat-forming function of the relatively small pieces of LWD, in addition to promoting structural stability. Stems will be oriented generally parallel to the flow, with rootwads on the upstream end. Individual pieces of LWD will be cabled to each other and secured to large placed boulders or to stable living conifer trees on the bank. Some movement of the LWD/boulder groups is expected following high flows, as the collections of LWD assume a more natural position. This series of small jams located along the upper channel margin is expected to result in the formation of alcoves and small backwater pools with LWD cover that will provide rearing habitat and refugia for juvenile salmonids at high pool elevations after the diversion dam is raised.

Performance criteria established in the Hydraulic Project Approval (HPA) require that all structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at HHD (see Chapter 6). If the structures fail to meet the stability criteria during the first 5 years, Tacoma will repair or replace them, modifying the design criteria as necessary in consultation with NMFS and USFWS. After the first 5 years, Tacoma will provide funding for one additional replacement of the structures, should they decay, or fail following large floods. Should the structures fail more than once during years 6 through 50 of the HCP, habitat benefits of these structures will be reduced.

Site 2 is located at the upper end of the inundation zone. Channel morphology at the site consists of a run/riffle that has formed just downstream of a bar that projects into the flow. The bar creates a relatively protected site where LWD will provide cover and further reduce velocities. Five pieces of LWD will be placed oriented roughly parallel to the flow with rootwads on the upstream end. Each piece of LWD will be loosely cabled to boulder deadmen placed on the bank, allowing the pieces to rise and fall with the flow, and assume a more natural position along the bank. Large woody debris will be placed such that it remains wet during summer low flows. Adding habitat structure at this site is expected to improve rearing habitat at both high and low flows, and to provide a refuge so that fish are not displaced to the inundation pool during high flows.

Tacoma has also pledged to fund two additional habitat rehabilitation projects in the middle Green River; however, these two projects are not included as specific commitments within the HCP. The first of these projects involves providing fish passage to a right-bank off-channel pond (approximately 2 acres in size) at RM 58.5 that is currently disconnected from the mainstem Green River by an inactive beaver dam. The second project involves the rehabilitation of 31 acres of wetland and riparian floodplain at RM 32.9 (Auburn Narrows) consisting of the creation of 5.5 acres of palustrine forest and scrub-shrub wetland, conversion of 1.7 acres of abandoned pasture/emergent wetland habitat to palustrine forested and scrub-shrub wetland habitat, rehabilitation of 2.2 acres of existing wetland habitat, reestablishment of native riparian forest and shrub habitat on 16.4 acres of floodplain, and reestablishment of 5.3 acres of upland forested and shrub plant habitat as riparian buffer. This project may also include development of side channels or beaded ponds that will serve as off-channel habitat suitable for use by rearing salmonids. Tacoma has not included these projects in the HCP because they are located on lands not owned by the City. These projects are part of a cooperative effort with the USACE and King County, and specific commitments to project objectives and conceptual designs may change prior to implementation. In view of the lack of City control over the land and the uncertainty regarding project objectives, Tacoma has not included them in the HCP. However, Tacoma is still committed to implementing the projects as part of mitigation for the SSP.

Placement of LWD and boulders in the inundation pool will provide shelter and create important juvenile rearing habitats in that segment of the Green River. Rehabilitation of off-channel habitat elsewhere in the Green River will also increase the amount of juvenile rearing habitat. This habitat conservation measure is expected to benefit downstream migrating juvenile salmonids as well as resident fish. Species benefiting from this measure will include steelhead trout, chinook and coho salmon, cutthroat trout, and resident rainbow trout. These habitat rehabilitation projects have been designed to mitigate for the effects of habitat alteration related to modification of the Headworks.

5.2 Habitat Conservation Measures – Type 2

Type 2 habitat conservation measures are those designed to offset or compensate for impacts resulting from activities carried out by parties other than Tacoma but for which Tacoma is providing a portion of the funding. For instance, construction and operation of HHD for Green River flood control has interrupted the transport of gravel-sized and larger sediments. Construction and operation of HHD is a USACE activity; however, as local sponsor of the AWS project, Tacoma is providing funds to place gravels in the middle Green River channel.

5.2.1 Habitat Conservation Measure: HCM 2-01 Howard Hanson Dam Downstream Fish Passage Facility

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-01

MEASURE: Howard Hanson Dam Downstream Fish Passage Facility

As local sponsor of the AWS project, Tacoma will provide funding support to the USACE to design, construct, and operate a fish passage facility at HHD to increase the survival of salmonids migrating downstream from the upper Green River watershed. Tacoma will fund its portion of the HHD downstream fish passage facility following completion of the pre-construction engineering and design (PED) phase of the AWS project. Major components of the fish passage facility include a new tower and wetwell, a floating fish collector, a fish lock, a discharge conduit, and a fish transport pipeline. The design consists of a combination floating modular incline screen, fish bypass, and single lock facility. The facility will collect fish from 6 to 20 feet in the water column at all pool elevations (1,070 to 1,167 feet), and is designed to handle 1,200 cfs while meeting biological screening criteria. Four new buildings are also proposed as part of the fish collection facility. These are an administration building, a maintenance building, a monitoring building, and a generator building. An access bridge will provide vehicle, utility, and personnel access to the new facility.

Objective

The objective of this measure is to provide downstream fish passage at HHD as part of an overall program to provide anadromous fish access to the Green River above HHD.

Rationale and Ecosystem Benefits

The upstream fish passage facility at the Headworks will provide adult anadromous fish access to the upper watershed. A downstream fish passage facility is also needed to safely pass outmigrating fish through the HHD project. Currently, juvenile salmon and steelhead migrating from the upper Green River to lower river rearing areas or migrating to salt water must pass through one of two HHD outlets (the flood control tunnel or a 48-inch-diameter bypass pipe). The flood control tunnel (1,035 feet) is regulated by two large radial gates. At release flows of less than 500 cfs, the bypass pipe is used (1,069 feet). Refill of the project typically occurs between early April through June when the pool is filled from low pool (1,070 feet) to the full conservation pool (1,141 feet; plus 3 to 5 feet for debris removal). Spring refill coincides with the main outmigration period of juvenile salmonids. As the pool fills, the outlets are submerged to depths of 35 to 112 feet. As inflow to the reservoir recedes, outflow from the dam is routed to the bypass pipe (flows less than 500 cfs).

Beginning in 1982, juvenile coho and chinook salmon and steelhead trout have been reintroduced into the upper watershed as a means to assess the ability of the existing configuration and operating plan of HHD to pass juvenile fish. Current annual survival of juvenile salmon and steelhead migrating through HHD outlets is estimated between 5 and 25 percent based on a fish passage model and on-site monitoring data (Dilley and Wunderlich 1992, 1993). The low survival rate is primarily a function of two factors: the spring refill of the reservoir submerging the dam outlets and the low survival of juveniles as they pass through the outlets. Juvenile fish require a near-surface outlet with a high discharge capacity outlet (exact volumes depend on site conditions). Therefore, at a time when fish need high flows and a shallow outlet, the project is reducing outflow (refill) and creating a deeper outlet (from 35 to 112 feet deep). During outmigration fish may not find or be willing to use outlets that are deeply submerged. Fish that are delayed or entrapped beyond a certain time may not migrate to salt water and may not contribute to the returning adult population. Fish that sound (dive) to reach the outlet pipe experience high mortality from impacts at sharp bends or turns within the bypass. Direct mortality in the bypass pipe can range from 1 percent to 100 percent depending on the amount of flow, water temperature, pool elevation, and time of year.

The new downstream fish passage facility is designed to provide much higher success of juvenile outmigration and to accommodate the higher water levels and changes in refill timing under the AWS project Phase I. With the floating fish collector and fish lock compensating for changes in reservoir level, previous problems with early refill of the reservoir on outmigration should be minimized. The fish passage structure (described in Chapter 4.2) has an operating flow range between 400 cfs and 1,200 cfs. The target design flow was approximately 1,200 cfs, which is the 50 percent exceedance flow for April and May during the peak outmigration of salmonid juveniles.

In the majority of years, releases from HHD will improve (decrease) instream temperatures up to 6 miles downstream of the dam. The intake of the proposed downstream fish passage facility will be capable of operating at a range of depths. This flexibility in depth of submergence will allow for improved temperature control during the summer. The meeting of temperature requirements could constrain the use of the fish passage facility in late summer. To address these constraints, daily monitoring of outflow temperatures and fish passage will be required, as will close coordination with resource agency biologists.

Although the strategy for operating HHD to meet downstream flow needs during the conservation storage period will evolve through adaptive management, an experimental flow management strategy has been developed using blocks of dedicated and non-dedicated storage (see next habitat conservation measure). As information and understanding of the relationships between the managed flow regime and the biotic resources of the Green River increases, the operation of the HHD can be refined within the range of legal and institutional requirements to balance needs of various fish species, life stages, and water supply.

This habitat conservation measure is intended to offset impacts of the HHD, a USACE activity that has direct benefits to Tacoma. The proposed downstream fish passage facility will address the effects of increased reservoir storage for water supply and storage for low flow augmentation to benefit fisheries resources. Tacoma will also provide funding to support development and implementation of a research program (see Chapter 6). Funding support for the research program will begin in January of the year of storage of water available to Tacoma under its SDWR.

5.2.2 Habitat Conservation Measure: HCM 2-02 Howard Hanson Dam Non-Dedicated Storage and Flow Management Strategy

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-02

MEASURE: Howard Hanson Dam Non-Dedicated Storage and Flow Management Strategy

As local sponsor of the AWS project, Tacoma will support the USACE in developing an enhanced springtime operating strategy for HHD involving the management of dedicated and non-dedicated blocks of water to benefit fisheries resources. The maximum storage volume behind HHD is 106,000 ac-ft. The full storage volume is required to meet USACE flood control responsibilities in the winter months, but only a portion of the maximum storage volume is needed for flood control in the spring. Under the AWS project, up to 49,200 ac-ft of water will be stored behind HHD during the spring to meet fisheries and municipal and industrial water needs. The HHD springtime reservoir refill strategy will be required to always provide congressionally authorized flood control capacity behind HHD.

The USACE currently stores 24,200 ac-ft of water behind HHD between mid-March and early June for summer low flow augmentation for fisheries purposes. Storage of that block dedicated to low flow augmentation water was authorized during original development of the HHD project. Optional storage of up to 5,000 ac-ft of additional water dedicated to low flow augmentation is provided on an annual basis as part of the AWS project (use of this 5,000 ac-ft of water dedicated to aquatic resource needs is described in measure HCM 2-06). The AWS project also provides for storage of up to 20,000 ac-ft of water dedicated to municipal and industrial water supply use. The 20,000 ac-ft of water represents water available to Tacoma under the SDWR and is stored at a rate of up to 100 cfs per day within flow constraints measured at the USGS Auburn and Palmer gages as described in the MIT/TPU Agreement. Water stored behind HHD will be allocated as dedicated or non-dedicated blocks depending on whether the water is allocated to a specific purpose (e.g., water dedicated to municipal water supply or low flow augmentation) or is available for multiple uses (non-dedicated).

Water that is stored and dedicated for municipal use will be available for use by Tacoma at any time. This stored municipal water represents a prior exercise of Tacoma's SDWR and its subsequent use and is not constrained by additional instream flow requirements. When Tacoma requests that stored municipal water be released from HHD, the USACE will comply with the request provided there is sufficient water remaining within the block of water dedicated to municipal use. When water is released from HHD at the request of Tacoma, the volume of water released for municipal use will be subtracted from the remaining municipal water storage account. Should Tacoma not use the stored water as it is released, whether through malfunction of Tacoma's facilities, excessive turbidity, or increased runoff associated with

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precipitation events, then Tacoma's municipal storage account will be reduced by the volume of stored municipal water released.

The non-dedicated block of water can be managed in a variety of ways: released to meet immediate fishery resource needs; dedicated to low flow augmentation storage requirements; dedicated to municipal and industrial water supply to eliminate subsequent storage requirements; or held in reserve as non-dedicated storage to meet potential instream flow needs later in the spring. The non-dedicated storage volume is eliminated as the blocks of low flow augmentation and municipal water supply storage are filled. Water that is released to the river from the non-dedicated block of storage (excess water or water needed by the USACE for the collection and handling of reservoir woody debris) from HHD is assumed to be fish conservation water. Fish conservation water shall not be diverted from the river by Tacoma.

This non-dedicated block of water will provide resource agencies the opportunity to recommend adjusting the rate of storage and release during the refill season to benefit fisheries resources. Potential flow adjustments to benefit fish could include: 1) limits to the maximum rate of reservoir refill (the difference between the inflow and the outflow) to allow natural flow variations to aid downstream fish movement; 2) target instream baseflows to reduce side-channel dewatering; 3) artificial freshets (short-term high flow releases from HHD) to speed the rate of downstream migrating salmonids; and 4) controlled long-term stage declines to protect steelhead redds. The magnitude, duration, and timing of each of these measures will be evaluated through a research program; changes to the refill and release strategy will be determined through an adaptive management process. Should an alternative process be developed in lieu of the dedicated/non-dedicated storage procedure, it will have benefits comparable to or better than the process it replaces. Information on the volume of water stored behind HHD to meet low flow augmentation and municipal needs will be posted on the Internet or comparable public access database by 15 February of the year of initial storage behind HHD of water available to Tacoma under its SDWR.

During the spring reservoir refill period, inflow to the reservoir may contain turbidity levels unacceptable for public water supply use. There has been a concern expressed by resource agency staff that Tacoma might request the USACE to both release the turbid water and subsequently dramatically curtail reservoir discharge in order to quickly refill the pool with clean water. Tacoma and federal and state resource agencies have developed a course of action and operational safeguards to minimize any potential adverse impacts to fish and wildlife resulting from the collection of a high turbidity pool.

In addition to reliance on the North Fork well field during high turbidity periods, Tacoma will utilize groundwater supplies to avoid the need to draw water from a turbid pool behind HHD. During the pre-construction engineering and design phase of the AWS project, Tacoma and the USACE will evaluate the potential risk of storing highly turbid

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water. If Tacoma is unable to be convinced that turbidity in stored water will settle by late May or early June, Tacoma will not proceed with the AWS project until filtration of the water supply can be achieved or until an alternative source of water supply has been developed to meet early summer municipal water needs. In the event that conditions were to occur that are currently unforeseeable, Tacoma agrees to take every effort to avoid actions that would be detrimental to the Green River's natural resources as the City attempts to meet its obligation to protect public health and safety through the supply of water. Tacoma would impose water use restrictions consistent with drought conditions and would coordinate with resource agencies and the MIT prior to requesting a modification of HHD operations that might adversely impact Green River fisheries. Tacoma would not make such a request unless there was an imminent risk of violating Primary Drinking Water Standards along with the associated health risk of such a violation.

Objective

The objective of this measure is to support the development and implementation of a strategy for the operation of HHD that will provide maximum benefits to fisheries habitat, consistent with flood control and municipal water supply.

Rationale and Ecosystem Benefits

Howard Hanson Dam was originally authorized in 1958 and, since completed in 1962, has been operated by the USACE for flood control and downstream low flow augmentation. The HHD controls runoff from approximately 220 square miles of the Green River watershed and provides 106,000 ac-ft of reserve flood control volume to store watershed runoff. The maximum storage volume behind HHD is reserved for the storage of water during the peak flooding seasons, generally November through early February. Runoff from the upper watershed is impounded during storm events and released in a regulated manner to prevent flows in the Green River at Auburn from exceeding 12,000 cfs. After the impounded flows are released, the reservoir is emptied to provide storage for the next storm event. The full storage volume is required to meet USACE flood control responsibilities in the winter months, but only a portion of the maximum storage volume is needed for flood control in the spring. During the spring of each year, the reservoir is allowed to fill to provide water for low flow augmentation to meet the instream flow target of 110 cfs at Palmer. Since the construction of HHD, the springtime strategy of storing and releasing water has evolved. Additional information was developed on the effects of flow management on instream biological resources leading to changes in the springtime HHD operating regime.

HHD Operations: 1962 - 1983

The original authorization for HHD provided for the storage of 24,200 ac-ft of water at elevation 1,141 feet to be used for low flow augmentation for fisheries purposes. Prior to initiating summer refill, the project was operated in a run-of-river mode (i.e., HHD releases match HHD inflow). Although anadromous fish did not have access to the upper watershed prior to 1982, any fish moving downstream from the upper watershed during run-of-river operations passed quickly and safely through two large radial gates at the base of the dam at elevation 1,035 feet. When the radial gates were closed and the reservoir began filling, fish moving downstream were unable to use the radial gates to pass downstream through the project. A 48-inch outlet pipe, located at elevation 1,069 feet and used for spring and summer flow releases of less than 500 cfs, provided the only available route for fish moving downstream. When the 48-inch outlet pipe became submerged by the rising pool level, fish moving downstream were either unwilling to sound to the outlet entrance and/or unable to find the outlet. Fish that were able to exit through the 48-inch outlet pipe suffered a high rate of mortality due to stresses caused by several 90-degree bends within the 48-inch conduit.

Beginning in 1982, juvenile anadromous salmonids were planted in the upper watershed. Although adult salmon had not been passed upstream of RM 61.0 since Tacoma's Headworks facility was completed in 1913, outplanting of juvenile salmonids was used to take advantage of upstream rearing habitat and to evaluate downstream passage through HHD. The original operational strategy for the HHD project, generally followed from 1962 to 1983, delayed the start of refill until June and thereby provided successful passage of downstream migrants through the radial gates. Once refill was initiated, nearly all inflow was stored and only water required to satisfy the instream flow target of 110 cfs at Palmer was released. Storing the water as quickly as possible minimized the duration, but exacerbated the magnitude of downstream impacts by dramatically cutting flows to the lower river once reservoir refill began. This refill strategy reduced flows from an average of 1,140 cfs at Auburn to a low flow of 234 cfs for an average 12-day period in early June (USACE 1995). This rapid rate of reservoir refill caused significant impacts to downstream fisheries, including the dewatering of steelhead redds throughout the lower river.

HHD Operations: 1984 - 1992

During the period between 1984 and 1992, the HHD operational strategy followed by the USACE generally consisted of initiating refill much earlier than the 1962-to-1983 practices to reduce impacts to steelhead redds, while also delaying refill as late as possible to facilitate downstream passage of juvenile outmigrants. Refill was started as early as 19 April. During refill, all inflow was stored except for releases to provide 200 cfs immediately below the Headworks. Although impacts of this strategy on steelhead redds were less severe than before, this practice was discontinued after 1991 (USACE 1995; HDR Engineering and Beak Consultants 1996).

HHD Operations: 1992 - Present

Beginning in 1992, the USACE operational storage strategy for HHD has involved periodic adjustments to meet a variety of resource needs. Releases from HHD are adjusted to account for changing inflow and weather conditions to provide additional flows to benefit fisheries resources, with consideration for whitewater recreational opportunities and specific community activities (USACE 1995). Adjustments in the timing and rate of spring refill represent a compromise between the passage of juvenile outmigrants through the HHD reservoir and downstream fishery impacts. The refill strategy attempts to provide flows for steelhead spawning and incubation in response to expected weather and runoff conditions. Refill is started as early as mid-March to allow greater flexibility in achieving the full conservation pool at elevation 1,141 feet by early June. A relatively constant rate of refill of approximately 400 cfs is used to provide a more natural flow regime, and refill is initiated early to reduce the impacts of steelhead redd dewatering. This strategy involves frequent communication with members of the Green River Flow Management Committee (GRFMC). This interagency committee was formed in 1987 and consists of representatives from MIT, state, federal, and county resource agencies, and other groups. The USACE considers input from the group as an adaptive management strategy to adjust the refill and release regime based on a short-term planning horizon.

To date, the success of the adaptive management process has been limited by physical and operational project constraints. Storing water earlier in the year would provide added operational flexibility, but refill is constrained by the desire to pass downstream migrating fish through the project. Once the radial gates are closed, the rate of successful passage of downstream migrating juvenile salmonids through the HHD project drops dramatically.

The spring flow management regime is also limited by the need to reach the conservation pool by early June. The USACE manages reservoir refill and release to ensure that the 24,200 ac-ft of storage for low flow augmentation is achieved on a 98 percent reliability. Even if the GRFMC recommends that refill be delayed, the USACE will override its suggestions to ensure the 24,200 ac-ft storage objective is not compromised. For example, during the spring of 1997, the committee recommended reservoir refill be delayed since the upper watershed was thought to contain an unusually high level of snowpack. Reservoir storage fell below the 98 percent refill rule curve and in late May the USACE temporarily reduced project releases to quickly fill the reservoir pool. The short-term increase in refill caused flow in the Green River at Auburn to drop from 3,230 cfs on 19 May to 900 cfs on 27 May, before rebounding to 2,930 on 2 June (Wiggins et al. 1998).

HHD Operations: Increased Storage under the AWS Project

As part of the AWS project, authorized uses of HHD will be expanded to provide ecosystem restoration benefits and municipal water supply. Up to 5,000 ac-ft of additional water would be stored for fisheries benefits and 20,000 ac-ft of water would be stored for municipal and industrial use. Under the SDWR, Tacoma can withdraw up to 100 cfs of water at its Headworks, provided instream flow requirements are satisfied at the Palmer and Auburn USGS gages as described in the MIT/TPU Agreement. Under the AWS project, instead of Tacoma withdrawing water at the Headworks between mid-February and late May, the USACE will store up to 20,000 ac-ft of water for Tacoma's municipal and industrial use. The summer conservation pool will be 1,167 feet and total 50,400 ac-ft of storage, which represents:

Storage Volume	Authorized Purpose
24,200 ac-ft	low flow augmentation (as part of original HHD authorization);
1,200 ac-ft	turbidity pool (non-active storage);
5,000 ac-ft	optional annual storage (AWS project fisheries benefits);
20,000 ac-ft	municipal and industrial use (AWS project municipal benefits);
50,400 ac-ft	total storage under the AWS project.

Integral to the adaptive flow management process associated with the AWS project is the need to forecast seasonal flow conditions and runoff in the Green River. During a spring drought with little snowpack, storage of 50,400 ac-ft of water represents over 35 percent of the total runoff measured at HHD (RM 64.5) between 15 February and 31 May (e.g., 1992 as estimated by the CH2M Hill daily flow model [CH2M Hill 1997]). During a wet spring with high runoff conditions, storage of 50,400 ac-ft represents less than 10 percent of the total runoff measured at HHD (e.g., 1972 as estimated by daily flow model, CH2M Hill 1997). Forecasting flow conditions in the Green River basin requires reliable estimates of the volume of water stored as snow and ice in the upper watershed and the ability to forecast long-term weather patterns. Runoff forecasting is an imprecise science, but the reliability of forecasts will be improved with additional snowpack and precipitation monitoring stations in the upper Green River watershed (see Snowpack and Precipitation Monitoring Conservation Measure). Additional snowpack monitoring and improved runoff forecasting will benefit the reliability and flexibility of spring water storage and release.

During the spring reservoir refill period, inflow to the reservoir may contain turbidity levels unacceptable for public water supply use. There has been a concern expressed by resource agency staff that Tacoma might request the USACE to both release the turbid water and subsequently dramatically curtail reservoir discharge in order to quickly refill the pool with clean water. Tacoma representatives acknowledged this concern during a meeting with federal and state representatives in February 1999. During the meeting, a course of action and operational safeguards was established to avoid adverse impacts to fish and wildlife resulting from collection of a high turbidity pool.

Tacoma believes there is a low likelihood that a turbidity pool behind HHD would cause a long-term public water supply operational problem. Tacoma has been advised by the USACE that turbidity problems that could occur during February, March, and in rare instances April, would clear up by late May or early June. This is a major issue for Tacoma since the continuing operation of its surface water supply as unfiltered depends in large part on its ability to provide the public with water that meets rigorous federal and state water quality standards. Tacoma will insist that additional evaluation of turbidity be conducted during the PED phase of the Howard Hanson AWS project. This additional evaluation will consist of hiring a consulting firm skilled in the evaluation of public water supply turbidity concerns to review the HHD operation and evaluate the nature of turbidity during high flow events on the Green River. If Tacoma is unable to be convinced that turbidity in stored water will settle by late May or early June, it would be forced to delay the AWS project until filtration of the Green River municipal water supply could be accomplished, or until an alternative source of supply to meet early summer municipal water needs has been developed.

Operationally, high turbidity periods on the Green River during the spring and early summer refill period would be accommodated through the use of Tacoma's groundwater sources in lieu of reliance upon Green River surface water. Tacoma currently has 72 million gallons per day (mgd) (113 cfs) of groundwater capacity from the North Fork well field. Unfortunately, this full capacity is not available except for brief periods during the winter. It can never operate for a sustained period at 72 mgd. The only time the well field can produce 72 mgd without a water level decline is during heavy rainstorms. Aquifer storage capacity tails off during the summer and is at its lowest during the late summer and early fall. On the average, the North Fork well field has the following water supply capacities during the months when the Howard Hanson reservoir is being filled and turbidity is a concern:

North Fork well field sustained capacities (mgd) by month during Howard Hanson Reservoir refill operations (Kirner 1999).

	February	March	April	May	June
mgd	48	36	24	24	24
cfs	75	56	37	37	37

In addition to reliance on the North Fork well field during high turbidity periods, Tacoma has groundwater supplies available in the Tacoma area. Tacoma's water rights in the vicinity of the City of Tacoma are approximately 90 mgd (140 cfs). This capacity, coupled with the water available from the North Fork well field, would meet Tacoma's demands for water in the event of a turbidity emergency on the Green River. Tacoma would rely on these two primary sources of groundwater to avoid the need to draw water from a turbid pool behind HHD.

In the event that conditions were to occur that are currently unforeseeable, Tacoma agrees to make every effort to avoid actions that would be detrimental to the Green River's natural resources as the City attempts to meet its obligation to protect public health and safety through the supply of water. Tacoma would impose water use restrictions consistent with drought conditions and would coordinate with resource agencies and the MIT prior to requesting a modification of HHD operations that might adversely impact Green River fisheries. Tacoma would not make such a request unless there was an imminent risk of violating Primary Drinking Water Standards along with the associated health risk of such a violation.

Under the AWS project, reservoir refill could begin as early as mid-February, provided that available storage volumes for flood control are not compromised. The construction and operation of a downstream fish passage facility at HHD would provide for the downstream passage of outmigrating fish while allowing the reservoir to begin filling. The AWS project provides the opportunity to store water while managing downstream flows to benefit fish. However, maximizing those benefits requires a different approach to springtime flow management (described below) than has been used since 1992.

Potential HHD Operational Strategy: Dedicated and Non-Dedicated Storage

To minimize the effects of storing additional water behind HHD during the spring, Tacoma initiated an intense modeling effort using a 32-year record of daily flows to evaluate alternative reservoir refill strategies. This process resulted in a potential flow management plan involving the use of dedicated and non-dedicated blocks of water. The rate of water storage would be accelerated early in the spring before the majority of juvenile salmonids have begun their downstream migration. Storage would be completed by mid- to late May to avoid impacts to steelhead redds. The accelerated rate of water early in the refill season would establish a block of non-dedicated storage. The volume of water in non-dedicated storage would be managed in response to input from the GRFMC.[3] The non-dedicated block of water could be used to meet a variety of fishery needs, including:

- augmenting HHD releases during short-term low flow periods in March, April and May;
- augmenting HHD releases during late May and June to protect steelhead incubation;
- suspending HHD storage during storm events to allow freshets to pass; or
- in the absence of a natural freshet, providing a short-term release of high flows to aid downstream migrating salmonids.

In the course of Tacoma's modeling efforts, an initial AWS project flow management strategy was developed that attempted to balance the needs of fisheries and water storage. This strategy ensured refill of the conservation pool while meeting a variety of fisheries protection standards. If implemented, the effects of this strategy would be monitored (see

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[3] Recommendations on the storage and release of water from HHD will be developed through the USACE's coordination with the GRFMC. The GRFMC consists of representatives of Tribal and natural resource agencies convened by the USACE to recommend adaptations in the water storage and release regime of HHD. Responsibility for operation of HHD lies with the USACE. The USACE, in turn, must comply with project purposes as identified by congressional authorization and must abide by NMFS and USFWS direction through Section 7 consultation under the Endangered Species Act (ESA).
The GRFMC consists of representatives from the:

USACE	U.S. Army Corps of Engineers;
NMFS	National Marine Fisheries Service;
USFWS	U.S. Fish and Wildlife Service;
MIT	Muckleshoot Indian Tribe;
WDFW	Washington State Department of Fish and Wildlife;
Ecology	Washington State Department of Ecology;
King County	King County Department of Natural Resources; and
Tacoma	Tacoma Public Utilities, Tacoma Water.

Representatives from other groups, such as Trout Unlimited and Friends of the Green River, have participated in past meetings of the GRFMC. It is up to the USACE, and ultimately the NMFS and USFWS, to determine the degree of influence of each member of the GRFMC.

Chapter 6) and adjustments implemented under the recommendations of the GRFMC. Fisheries protection standards and potential flow adjustments include: maximum refill rates; target baseflows; and the release of artificial freshets if deemed beneficial by the GRFMC. These potential flow adjustments are further described below:

Maximum Refill Rate. Under Phase I of the AWS project, the 400/300/200 flow management strategy modeled using the 32-year record of daily flows includes a maximum refill rate of:

- **192** cfs per day (5,000 ac-ft maximum) from 15 February through 28 February,
- **400** cfs per day (800 ac-ft per day) in March,
- **300** cfs per day (600 ac-ft per day) in April, and
- **200** cfs per day (400 ac-ft per day) from May through June.

Outmigration studies conducted at HHD in 1984 and 1991 to 1995 show that inflow, outflow, and refill rate all influence successful smolt outmigration (Dilley and Wunderlich 1992, 1993). In general, it is thought that higher flows through the HHD result in faster smolt migration through the project and higher smolt survival. To date, empirical data have been collected that have evaluated smolt travel times occurring with fill rates up to 400 cfs per day. Further studies are needed to more fully determine the overall effects of different refill rates. Such studies should lead to the identification of those rates that maximize passage success of juveniles through the bypass facility. The timing associated with the different rates reflects the concept of initiating reservoir refill prior to the peak of smolt outmigration, and while refill should be aggressive, the maximum rate should be limited to provide variation in stream flow while reducing the incidence and magnitude of side-channel dewatering.

During 1999 and 2000 the USACE, in response to requests from the GRFMC, has attempted to store a percentage of inflow rather than a daily fixed volume of water. This alternative storage refill strategy holds promise for benefiting both fishery and water storage needs. The strategy of storing a percentage of inflow will be further evaluated during the PED phase of the AWS project.

Target Baseflows. The instream baseflow targets for the Green River at Auburn based on Tacoma's modeling efforts for refill of the HHD reservoir are:

	Flow Condition		
Month	Wet	Average	Dry
15-28 February	900	900	900
March	900	750	575
April	900	750	575
May through 1 July	linear drop 900 to 400	linear drop 750 to 400	linear drop 575 to 250

Modeling of daily flows over the 32-year period of 1964 to 1995 suggests these target baseflows can be maintained while meeting other fisheries protection standards such as refill rates and freshets. These baseflow targets are goals rather than commitments and can be adjusted based on changes in weather patterns, results of monitoring efforts, and input from fishery resource managers. These target instream flow levels are much higher than the low flow levels that have been previously associated with HHD refill and should benefit downstream fisheries.

From February through June, salmonid fry are emerging and rearing in shallow mainstem channel margins and side-channel habitats of the Green River. Off-channel habitats (i.e., side channels, sloughs) are thought to be vital components of salmonid production in Pacific Northwest rivers (Bustard and Narver 1975; Sedell et al. 1984; Beechie et al. 1994). Peterson and Reid (1984) estimated that, annually, 20 to 25 percent of the total smolt yield in the Clearwater River, Washington, comes from side-channel habitat. In British Columbia, approximately 16,000 juvenile coho salmon overwintered in a side channel in the upper Squamish River (Sheng et al. 1990). Cowan (1991) found that five groundwater-fed side channels on the East Fork Satsop River, Washington, produced between 19 and 71 chum fry per square foot of channel area. Swales (1988) hypothesized that side channels supplied higher water temperatures in the winter due to groundwater inflow and provided greater food availability, which increased overwinter survival of juvenile coho when compared to the mainstem habitats in the Fraser and Keough rivers, British Columbia. A total of 59 side-channel areas were identified in a survey of the middle Green River in 1996 (USACE 1998). Side channels in the Green River provide spawning and/or rearing habitat for all Green River salmonids and, for chum salmon, may provide the majority of spawning habitat (Coccoli 1996). Short-term flow reductions can isolate side-channel habitat from the mainstem channel and cause mortality by trapping juvenile salmonids and exposing them to predation, poor water quality, or reduced food supply.

During the spring, juvenile salmon and steelhead are migrating downstream to the estuary. Many researchers believe there is a general positive relationship between flow and outmigrant survival, although the relationship appears to vary widely for different species under different environmental conditions. In the Green River, researchers in the late 1960s conducted experiments using marked releases of hatchery chinook salmon (Wetherall 1971). They identified a general trend associating increased smolt survival with increased flow in the lower river. Maintaining higher baseflows is assumed to benefit outmigrant survival by increasing their rate of migration through the HHD reservoir and lower mainstem river.

Artificial Freshets. In order to evaluate the range of flexibility afforded by this habitat conservation measure, the daily flow regime was modeled to include the release of two freshets during the spring. The freshets would be timed for April and May to aid downstream migrating salmonids and to temporarily reconnect side channels. Each freshet is assumed to be a maximum flow of 2,500 cfs for 38 hours at the Auburn, Washington, gage during normal years, and 1,250 cfs for 38 hours during dry years. The magnitude and duration of the artificial freshets was identified through analysis of water travel times associated with HHD releases as part of the AWS project (USACE 1998). Recommendations on timing, magnitude, duration, and need to release non-dedicated storage as a freshet would be made by the GRFMC based on the results of monitoring.

Side channels and sloughs provide the majority of chum salmon spawning habitat in the Green River (Coccoli 1996). Isolation of these side channels can increase chum mortality by trapping fry that would otherwise be migrating downstream to the estuary. Chum salmon typically migrate within several days to weeks following emergence. Chum fry that have emerged in side channels but are isolated by low water levels may not survive unless they have access to the mainstem channel.

Past reservoir refill operations have stored or captured naturally occurring short-term fluctuations in flow, also referred to as freshets. In some years, this has resulted in a flat or constant outflow rate during reservoir refill. Results of outmigration studies in the Green River have shown that a sharp increase in flow can stimulate increased downstream movement of smolts (Dilley and Wunderlich 1992, 1993). In the upper Snake River, Idaho, researchers found that a two-fold increase in flow increased the migration rate by eight to 12-fold for hatchery chinook, 3.5- to 4.6-fold for wild chinook salmon, 1.6- to 2.1-fold for hatchery steelhead trout, and 2.4-fold for wild steelhead (Buettner and Brimmer 1996). Knapp et al. (1995) concluded that the initial rise in flow appeared to push fish out, but that sustained fish movement was not positively correlated with prolonged high flows; pulsing water releases appeared to increase the effectiveness of moving fish out of the lower Umatilla River, Oregon. Outmigration studies in the Stanislaus River, California, revealed that a pulse in flow from the release of stored water stimulated a substantial increase in juvenile chinook outmigration. However, increases in fish movement lasted only a few days following an increase in releases of stored water (Demko 1996).

Summary and Example of Proposed Flow Management Strategy using 1995 Daily Flows

Collectively, these flow management measures are intended to help minimize the effects of the USACE storage and release of water at HHD on fishery resources. The HHD downstream fish passage facility allows storage of springtime water much earlier than under existing conditions, while enhancing the downstream passage of salmonid smolts through the HHD project. These features allow reservoir refill to begin earlier than previous HHD management regimes and provide for the use of dedicated and non-dedicated blocks of storage. An example of how the flow management strategy might be implemented using the 1995 daily flow record (average runoff conditions) is provided in Figure 5-2. For comparison purposes, flows in the Green River at Auburn under the adaptive management regime are plotted with the flow regime that would have occurred under a storage regime involving a constant capture of 237 cfs. A constant rate of 237 cfs of storage between mid-February and 31 May would meet the storage target volume and allow natural flow variations to persist through the downstream reaches.

The level of water stored in the various dedicated blocks of water under the 400/300/200 storage refill strategy using 1995 flows are shown by time interval in Figure 5-3. Note that although different blocks of water are described, it simply represents an accounting convention. All water is stored in the single pool behind HHD. By the end of the storage period, water has either been dedicated to specific use (low flow augmentation or municipal water supply) or released to meet downstream needs. The use of the non-dedicated storage block is discontinued by the end of the spring storage period.

February

As previously described, storage of water would begin on 15 February; however, in this example the rate of storage is limited to 108 cfs during February, due to flood control concerns. As shown in the accompanying figure, by 28 February nearly 2,700 ac-ft of water would be held as dedicated storage for municipal water use at the rate of 100 cfs per day. Water held as dedicated storage for municipal use represents that volume available to Tacoma under the SDWR as constrained by the MIT/TPU Agreement. This scenario assumes that 100 cfs per day would be available under the SDWR for the entire 14-day period. The non-dedicated block of storage would hold approximately 300 ac-ft of water.

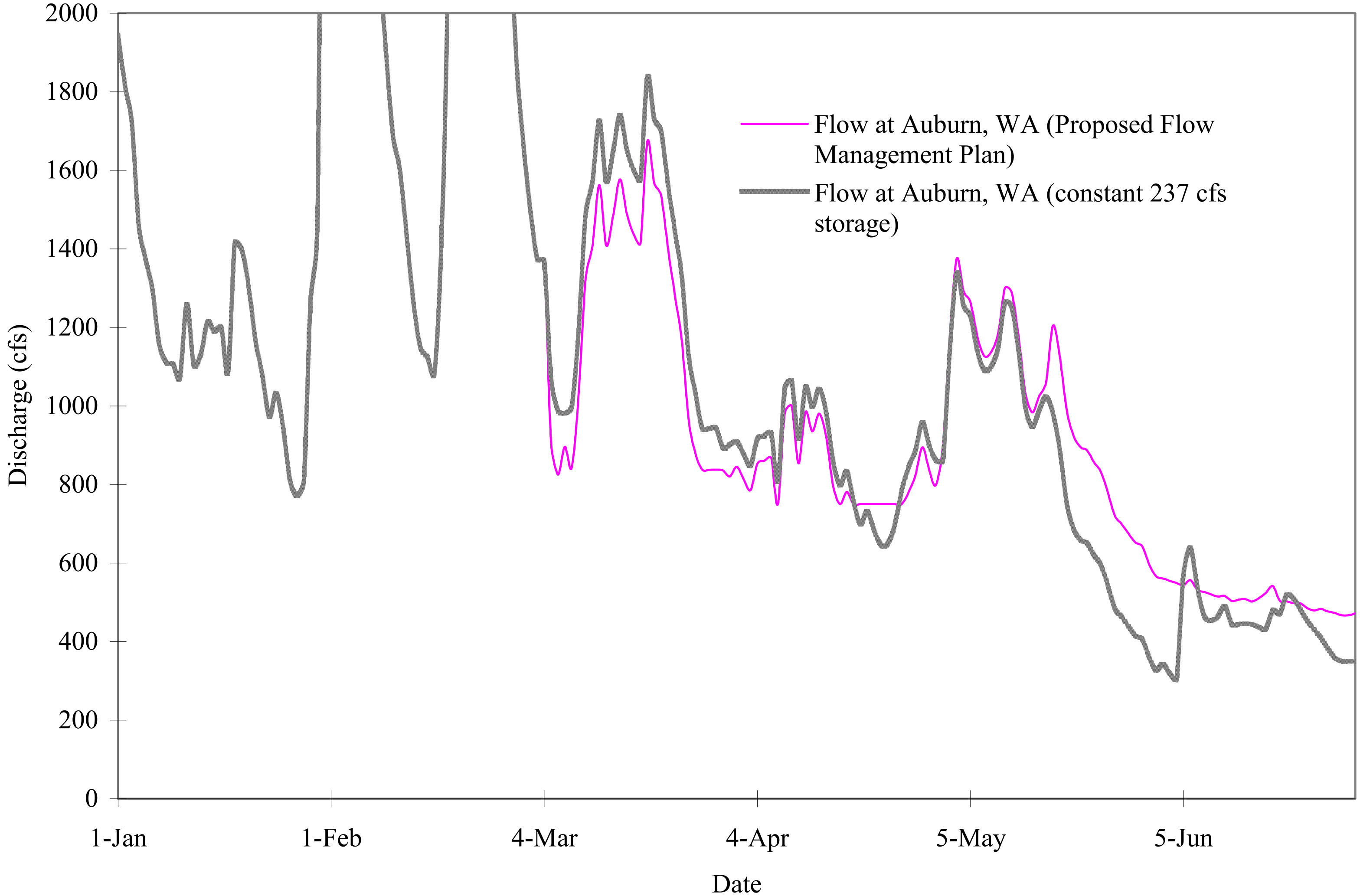
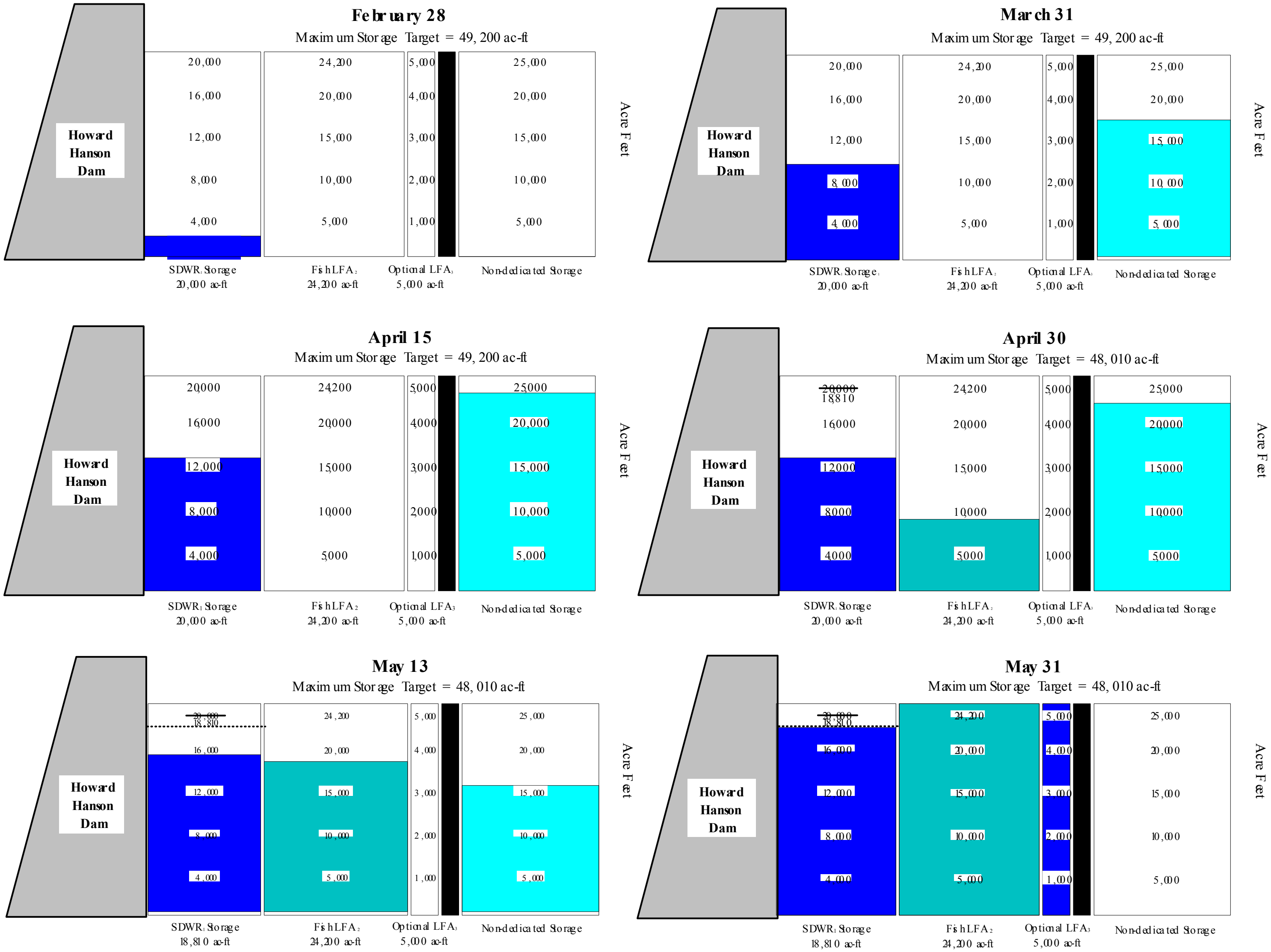


Figure 5-2. Comparison of Green River flows (cfs) at Auburn, WA (USGS Gage No. 12113000) during 1995 under a potential flow management regime developed for the AWS project (USACE 1998) and a 237 cfs constant storage regime.



1 Second Diversion Water Right (SDWR) allows Tacoma to withdraw water up to 100 cfs per day depending on flow rates.
2 24,200 ac-ft of water is stored to augment low flow in the Green River, storage of the water was authorized with the construction of HHD.
3 Optional storage up to 5,000 ac-ft.

Figure 5-3. Maximum storage volumes in Howard Hanson Reservoir, Washington, 1995.

March

During March, the rate of reservoir refill would be increased to 400 cfs and the majority of storage would be held as the non-dedicated block of water. During this period, flows in the Green River would occasionally dip 100 cfs lower than under the constant storage regime but would still be above 800 cfs. By the end of March, the block of water dedicated to municipal use would hold 8,900 ac-ft. Water held as dedicated storage for municipal use represents that volume available to Tacoma under the SDWR as constrained by the MIT/TPU Agreement. Under the terms of the Agreement, Tacoma can exercise the 100 cfs SDWR when flows in the Green River exceed minimum flow requirements of 300 cfs at the Palmer gage site. This scenario assumes that 100 cfs per day would be available under the SDWR for the entire month. The non-dedicated block of water would hold nearly 18,000 ac-ft. No water would need to be dedicated for the low flow augmentation block during March since storage under the USACE 98 percent refill guide curve does not begin until 16 April.

April

During April the refill rate would be reduced to 300 cfs under the 400/300/200 flow management strategy. Flow in the Green River at Auburn under the potential flow management plan would drop to 750 cfs in early April and remain about 100 cfs lower than would have occurred under the constant 237 cfs storage regime. In late April, however, flows under the constant storage regime would have dropped below 650 cfs. Under the 400/300/200 strategy, a portion of the non-dedicated storage would have been released to augment flows and ensure flows do not drop below 750 cfs. If, during this naturally occurring low flow period, flow in the Green River drops below the flow requirements allowing withdrawal/storage of water under the SDWR, the municipal storage target would be reduced by 100 cfs for each day that withdrawals would not have been allowed under the MIT/TPU Agreement. On the days that SDWR withdrawals would have been constrained by low flows in the Green River, no water would be dedicated to municipal use. Assuming SDWR withdrawals would have been disallowed for 6 days, the total municipal storage target would be reduced from 20,000 ac-ft to 18,810 ac-ft. By the end of April, approximately 13,700 ac-ft of water would be dedicated to municipal use, and 9,000 ac-ft would be dedicated to low flow augmentation. Approximately 22,000 ac-ft of water would be held as non-dedicated storage.

May

Under the potential flow management strategy, reservoir refill would be reduced to 200 cfs in May. By 13 May, total reservoir storage would be 48,010 ac-ft. Sufficient non-dedicated water would be held to completely fill municipal and low flow storage requirements, including optional storage of 5,000 ac-ft. The GRFMC would have the option at this point to recommend releasing some of the water as a freshet, to parcel the water out to maintain higher baseflows, or to dedicate the water to municipal or low flow augmentation blocks. If water is released to meet downstream needs, the 200 cfs rate of reservoir refill (interception of inflow) would continue until the municipal and low flow augmentation storage blocks are filled. If water available in the non-dedicated block is transferred to completely fill the municipal and low flow augmentation storage needs, then storage of additional water would cease and use of the non-dedicated storage block would be discontinued.

Under the AWS project flow management strategy, the baseflow target during the period 1 May through 1 July is a gradual linear decline from 750 cfs to 400 cfs. Green River flows at HHD would be augmented to maintain the baseflow target at Auburn. The intent is to maintain flow levels that benefit incubating steelhead redds as the flow regime gradually declines as spring progresses into summer. Under this scenario, flows in the Green River would be more than 200 cfs higher than what would have occurred under the 1996 refill regime. Instead of flows dropping to 305 cfs in early June, the management regime maintains an instream flow of more than 500 cfs.

Summary

Past operation of HHD has been constrained by the structural limitations of project facilities constructed in the early 1960s and by the USACE's precise implementation of congressionally authorized project purposes. As local sponsor of the HHD AWS project, Tacoma is supporting the USACE's efforts at developing operational procedures based on adaptive management to improve the protection of fisheries resources. The construction of a downstream fish passage facility will improve physical water control capabilities at HHD; implementation of a dedicated/non-dedicated flow management strategy will aid in the development of improved operational flexibilities. The increased opportunity for flow management is designed to partially offset the impact of Tacoma's use of the Green River for municipal water supply.

As part of the HHD AWS project, the USACE will store water that is available to Tacoma for municipal use under the SDWR. Following construction of the AWS project, up to 100 cfs of water (198.2 ac-ft per day) will be stored behind HHD beginning in mid-February and dedicated for use by Tacoma. The municipal water storage rate of 100 cfs reflects Tacoma's exercise of the SDWR as constrained by limitations identified in the 1995 MIT/TPU Agreement. Storage of water for municipal use will continue until the maximum municipal storage volume of 20,000 ac-ft is achieved (minimum of 101 days or 26 May). The daily storage of 100 cfs represents a flow limitation of the AWS project, and the increased reservoir storage volume presents a potential delay or barrier to salmon fry moving downstream from the upper watershed.

Water in excess of that dedicated to Tacoma's municipal use (100 cfs) will be available for storage or release under the recommendations of the GRFMC. The maximum refill rate of the Howard Hanson reservoir has been tentatively identified as 400 cfs in March with a lower refill rate in other months. An alternative refill strategy, based on storing a percentage of reservoir inflow, is also being considered. Under either storage regime, the volume of water stored in excess of that dedicated to municipal use can represent the majority of the HHD storage volume by the end of March. Under the dedicated/non-dedicated flow management strategy, the USACE will consider the recommendations of the GRFMC before implementing flow management changes. The USACE is responsible for operation of HHD and will consider input from the GRFMC, but must also comply with project purposes as identified by congressional authorization. Due to the recent listing of chinook salmon as a threatened species, USACE operations must now respect the direction of the NMFS and USFWS through Section 7 consultation under the ESA. While the daily storage of up to 100 cfs of water dedicated to municipal use reflects a limitation of the AWS project, increased operational flexibility is the cornerstone of the dedicated and non-dedicated flow management process.

Under the AWS project, structural changes to HHD, partially funded by Tacoma, will provide increased operational flexibility. Examples of increased operational flexibility include: an earlier storage start date; increased control of rate of refill and release; reservoir surface release instead of bottom release; increased storage capability; and improved fish passage survival at HHD. These structural modifications allow the operational flexibility, which is required for the dedicated/non-dedicated flow management strategy. Under this strategy, water in excess of the 100 cfs dedicated to municipal use can be used to meet immediate downstream fishery resource needs, dedicated to low flow augmentation storage requirements, dedicated to municipal storage to reduce subsequent storage requirements, or held in reserve as non-dedicated storage to meet instream needs later in the refill season. The non-dedicated storage volume is gradually eliminated as the blocks of low flow augmentation and municipal water supply storage are filled.

The flow management strategy has been developed within the framework of an adaptive management program. Key elements of the program include experimentation monitoring, analysis, and synthesis of results, followed by changes to the reservoir storage and release regime and continued monitoring and analysis. The adaptive management program ensures that as additional information is developed, flows can be managed to minimize the detrimental effects of past and ongoing human perturbations and complement basin-wide restoration activities. Ongoing efforts by the USACE and King County, as part of the Green/Duwamish Ecosystem Restoration Project, may provide new opportunities to restore ecological functioning of the Green River. In the face of imperfect knowledge, the adaptive management program provides the greatest chance for the conservation and recovery of threatened and endangered species.

The opportunity to manage flows in the Green River for fisheries benefits is greatly increased under the proposed flow management strategy. However, identifying the effects of alternative flow management strategies will require research of fishery resources during the initial years of project operation. As local sponsor of the AWS project, Tacoma has committed to providing a research fund as described in Chapter 6.

5.2.3 Habitat Conservation Measure: HCM 2-03 Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-03

MEASURE: Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures

Tacoma will contribute funds for a series of habitat rehabilitation projects in the upper Green River as mitigation for inundation of additional reservoir area resulting from Phase I of the AWS project. Projects under this habitat conservation measure will be funded by Tacoma by the start of construction of the AWS project. Project numbers assigned to each activity by the USACE are listed in parentheses below:

Riparian and Stream Habitat Rehabilitation – In Reservoir

Mainstem and North Fork Channel Maintenance (MS-02; TR-04). These projects will maintain instream habitat and bank stability along the mainstem Green River and the North Fork Green River in the new inundation pool. Project features include: 1) addition of LWD to create cover for fish; 2) placement of large boulders in select locations to maintain bank stability; and 3) excavation of sub-impoundments, off-channel ponds, side channels, and dendrites. In addition, inundation-tolerant vegetation will be planted along stream channels within the new inundation zone (1,147 to 1,177 feet mean sea level [MSL]).

HCM 2-03 (continued on next page)

HCM 2-03 (continued)

Tributary Stream Channel Maintenance (TR-05). This project will involve planting of inundation-tolerant vegetation and placement of boulders and LWD within the newly inundated areas of Charley, Gale, Cottonwood, and MacDonald creeks.

Page Mill Pond Mitigation and Protection (VF-05). This project will maintain and improve an existing wetland pond complex within the floodplain of the North Fork Green River within and above the new inundation pool. A series of small ponds will be excavated in the floodplain of the existing pond complex. Native wetland plants will be planted above the new inundation pool, and inundation-tolerant plants will be planted within the new pool. Large woody debris will be placed in the ponds, at the pond outlet and in Page Mill Creek.

Lower Bear Creek (TR-01). This project site includes the lower 3,000 feet of Bear Creek, a large tributary that enters the Green River just below HHD at RM 63.0. Stream channel habitat will be rehabilitated by adding LWD and boulders, in conjunction with limited excavation to recreate meanders and backwater habitats. This project site was identified in the Draft Environmental Impact Statement (DEIS) for the AWS project as a potential conservation measure to offset impacts of reservoir inundation (USACE 1998). During 2000, the USACE, in coordination with the Services, considered replacing AWS project measure TR-01 with an alternative measure involving placement of LWD in the mainstem Green River. The USACE believes that placement of LWD will provide superior environmental benefits to the Lower Bear Creek measure as originally envisioned.

Stream Habitat Rehabilitation - Above Reservoir

Abandoned Mainstem Channel at RM 83.0 (MS-04). A series of LWD jams will be constructed to reroute flow back to the natural channel in the mainstem Green River between RM 83.0 and RM 84.0. Currently, the river has abandoned its historic channel and is eroding the old Lester Airstrip and a mainline road adjacent to the river.

Mainstem LWD Placement (MS-08; TR-09). This project will involve placement of clusters of large trees approximately every 0.5 mile between RMs 71.3 and 80.3 in the mainstem Green River; in 4,600 feet of the North Fork Green River between elevation 1,240 MSL and 1,320 MSL; and in 1,200 feet of Gale Creek between elevation 1,240 MSL and 1,280 MSL.

The final design of these conservation measures will be developed during the PED phase of the AWS project. Large woody debris frequency and size requirements appropriate for the channel type will be determined using habitat criteria such as those recommended by the Washington Watershed Analysis Manual (WFPB 1997) or comparable systems approved by the Services.

Alternate measures will be implemented if any of the above measures are determined to be infeasible, or not cost effective during the final design, or if environmentally superior measures can be implemented at comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS.

Objectives

The objective of this measure is to rehabilitate and/or enhance fisheries habitat in the Green River and its tributaries above HHD.

Rationale and Ecosystem Benefits

Riparian and Stream Habitat Rehabilitation – In Reservoir

Implementation of the AWS project will result in the inundation of additional areas of habitat in the mainstem Green River and lower segments of a number of tributaries, including the North Fork Green River, Gale Creek, and Page Creek. The inundation will convert the lower segments of the streams from riverine to lacustrine (lake) type habitat on a seasonal basis. Rehabilitation activities included in this habitat conservation measure focus on the inundated portions of major tributaries and on existing off-channel rearing sites or nearby highly impacted reaches.

Wildfires burned much of the riparian area in the upper Green River basin early this century, and, in combination with more recent flooding, mass wasting, and timber harvest, are believed to have reduced levels of in-channel LWD and increased deposition of coarse sediment (USFS 1996). The existing LWD frequency is currently less than the two pieces per channel width recommended for channels with “good” habitat conditions (WFPB 1997) in the majority of channels surveyed.

Riparian management zones (RMZ) within the Natural Zone are currently composed primarily of coniferous timber 60 to 90 years of age, and are just reaching the age that they would begin to contribute functional LWD. The riparian management conservation measures are intended to maintain or restore long-term LWD recruitment as stream adjacent stands of timber mature. This conservation measure will provide immediate benefits in the form of increased instream structure and creation of additional off-channel rearing and refuge habitats. The conceptual designs of specific projects to be implemented are described below.

Mainstem and North Fork Channel Maintenance. Approximately 2 miles of habitat in the mainstem Green River and North Fork Green River will be inundated with the additional pool raise. Existing trees within the inundated riparian zones will be retained as described in the Standing Timber Retention Habitat Conservation Measure. Under this habitat conservation measure, bare areas in and along the new seasonal inundation zone will be planted with vegetation that tolerates inundation and boulders, and LWD will be placed to create cover for fish. Planting sedges will protect newly inundated portions of the reservoir from erosion that results from wave action and provide some littoral cover for juvenile fish. It is expected that boulders (b axis >3 feet) will be placed at a rate of 30/1,000 feet (300 total) and LWD (>12 inch diameter and at least 20 feet long) will be placed at a rate of 40 per 1,000 feet (400 total). At least 25 percent of the pieces will be of sufficient volume to meet the requirements for key pieces. If key-sized pieces are not available, LWD will be clumped and anchored to promote stability.

Ponds, side channels, and dendrites will be excavated in the floodplain adjacent to the mainstem and North Fork Green River to increase the quantity of off-channel habitat available when the pool is full. Tentative mainstem off-channel habitat locations include a 1,400 foot side channel on the left bank at elevation 1,153 feet MSL; two small sub-impoundments on the right bank at elevations 1,156 and 1,158 feet MSL, respectively; one side channel or two small sub-impoundments on the right bank at elevation 1160 MSL; and one 600-foot side channel and plus two sub-impoundment on the left bank at elevation 1163 MSL. Two 300-foot-long side channels and two beaded ponds will be developed on the North Fork Green River.

Tributary Stream Channel Maintenance. Approximately 1 mile of habitat will be inundated in Charley, Gale, Cottonwood, Piling, and MacDonald creeks with the additional pool raise. Bare areas in and along the inundated streams will be planted with vegetation that tolerates inundation. Large boulders (b-axis > 3feet) will be placed in the inundated areas at a rate of 40 per 1,000 feet (165 total). Large woody debris will be placed in the inundated areas at a rate of approximately two pieces per channel width (220 pieces total). Placement of LWD and boulders will increase habitat complexity within the inundated areas.

Page Mill Pond Mitigation and Protection. Three new ponds will be created in the existing pond wetland complex located near RM 2.0 on the North Fork Green River where seepage from the North Fork aquifer creates a tributary stream known as Page Mill Creek. The ponds will be excavated from the valley floodplain and log weirs installed as outlet controls. Approximately 20 acres of wetland plants will be planted, and 150 pieces of LWD (at least 12 inches in diameter and 20 feet long) will be placed in Page Mill Creek and the new ponds.

Stream Habitat Rehabilitation - Above Reservoir

Abandoned Mainstem Channel at RM 83.0. Between RM 83.0 and RM 84.0 the Green River has abandoned its historical channel and begun eroding a road adjacent to the river. The new channel is shallow, braided, and has few pools. The former channel has an intact riparian zone, stable banks, and more natural channel morphology. Flow will be diverted back to the historic channel using debris jams and deflector logs. Each debris jam will contain at least one key-sized piece of LWD. In addition, 50 pieces of LWD will be placed in the historic channel. Each piece of LWD will be at least 12 inches in diameter and 20 feet long.

Mainstem LWD Placement. This project is designed as partial mitigation for the area of channel inundated by the AWS project pool raise. Between RM 71.3 and 80.3 in the mainstem Green River, clusters consisting of three or four large trees with attached rootwads (at least 60 feet long; rootwads ≥ 4-feet diameter) will be placed approximately every 0.5 miles. Key-piece-size LWD will also be added to Gale Creek and the North Fork Green River at the rate of one cluster per 0.5 miles of habitat. Clusters will be placed within the channel with rootwads facing upstream, or along the low flow channel margins. Placement of clusters along channel margins is expected to promote the formation of lateral and bar apex jams as additional wood collects on the clusters. Lateral log jams that collect at the outside of meander bends are a common natural structure in streams with bankfull widths greater than 65 feet (Slaney et al. 1997). Bar apex jams form when a single key-sized piece with attached rootwad deposits oriented nearly parallel to flow and smaller pieces of LWD oriented roughly perpendicular to flow collect on the upstream side of the rootwad. This type of jam is common in large, meandering alluvial rivers (Abbe and Montgomery 1996). Assuming that the average frequency of key-sized pieces in large channels is comparable to that observed in smaller channels (i.e., 0.25 pieces per channel width), the target number of key pieces per mile for the mainstem Green River was determined to be seven.

Unless state-of-the-art science suggests otherwise, LWD specifications will call for establishing LWD frequencies of approximately two pieces per channel width in side channels, and in channels less than 65 feet wide (WFPB 1997). Target LWD frequencies in larger channels are less well documented. Large woody debris generally collects in clusters within larger channels in channels greater than 65 feet wide (Slaney et al. 1997), and is often associated with large key pieces. Approximately 25 percent of the LWD placed in larger channels will be key piece sized (volume ≥ 11 yd^3) if such pieces are available; if individual pieces large enough to function as key pieces are unavailable, LWD will be placed in clusters that have a minimum collective volume of 11 yd^3. Large woody debris must be fir, hemlock, cedar, or spruce. Non-key-piece-sized logs will have a minimum diameter of 12 inches and be at least 20 feet long. Rootwads will have a diameter of at least 18 inches at the base of the bole, and a stem that is at least 3 feet long. If future studies or monitoring indicate that such LWD clusters are unstable in channels such as the mainstem Green River, LWD may be anchored pending approval of the services and USACE.

5.2.4 Habitat Conservation Measure: HCM 2-04 Standing Timber Retention

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-04

MEASURE: Standing Timber Retention

Tacoma will retain 229 acres of existing standing timber within the new inundation zone of Howard Hanson Reservoir (1,147 feet to 1,167 feet) resulting from additional water storage under Phase I of the AWS project. Any lands within the inundation area not under Tacoma or USACE ownership will be acquired by Tacoma prior to construction of the AWS project.

Decay of vegetative material in the newly inundated zone may cause water quality problems in water stored behind HHD for municipal use. Such problems are likely to be the result of the decomposition of grasses and low lying brush with retained standing timber adding a minor impact. In the event that such conditions are determined likely to occur, Tacoma agrees to take every effort to avoid actions that would be detrimental to the Green River's natural resources as the City meets its responsibility to maintain water quality and protect public health. In the event of potential contamination of the municipal water supply, Tacoma will consult with the USFWS and NMFS to determine a course of action that will minimize impacts to Green River natural resources.

Objective

The objective of this measure is to accelerate the reestablishment of anadromous fish use of the Green River above HHD if acceleration is found to be beneficial.

Rationale and Ecosystem Benefits

The retention of standing timber (166 acres deciduous forest, 48 acres mixed forest, 15 acres conifer forest) in the HHD inundation zone would create standing snags in an area that would not otherwise support live vegetation. The standing snags would maintain wildlife, riparian, and instream habitat through periods of reservoir inundation. In addition, the snags would provide benefits to juvenile salmonid fish in the reservoir, which tend to congregate in near-shore areas (Dilley 1994).

Tacoma believes that low-lying vegetation in the inundation zone (1,146 feet to 1,167 feet) may cause taste and odor problems in water to be stored behind HHD for municipal use. This area contains a large amount of vegetation that would decay in the reservoir and potentially contaminate the City's water supply. This may pose a major problem for Tacoma since the City's operation as an unfiltered, surface water supply depends in large part on its ability to provide the public with water that meets rigorous federal and state water quality standards.

Tacoma will undertake an evaluation of the potential contamination of its water supply from the vegetation in the inundation zone during the PED phase of the HHD AWS project. This evaluation will consist of hiring a consulting firm or individual knowledgeable in the evaluation of public water supply quality concerns to review this habitat conservation measure in relation to the operation of HHD and the potential for water quality degradation. If deemed necessary, a course of action to protect the quality of the municipal water supply, while minimizing impacts to fish and wildlife habitats, will be coordinated with the Services prior to implementing the action.

Tacoma will assume all financial responsibility for this measure. There is no monitoring plan developed solely for this habitat conservation measure; however, several monitoring activities associated with other measures would determine fish distributions within different sections of the reservoir, and would likely include portions of these areas (see Chapter 6).

5.2.5 Habitat Conservation Measure: HCM 2-05 Juvenile Salmonid Transport and Release

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-05

MEASURE: Juvenile Salmonid Transport and Release

If supplementation of juvenile salmonids into the upper Green River watershed is determined to be beneficial to Green River fish runs by the NMFS and USFWS, Tacoma will transport and release juvenile salmonids above HHD. This measure does not include the production of juvenile salmonids in an incubation and rearing facility, only the transport and release of fish into the upper watershed. This measure complements the transport and release of adult upstream migrating fish at Tacoma's Headworks, and complements the production of juvenile salmonids at the MIT fish restoration facility.

Objective

The objective of this measure is to provide the opportunity to accelerate the reestablishment of anadromous fish production of the Green River above HHD through the transport and release of juvenile fish.

Rationale and Ecosystem Benefits

Tacoma will partially or wholly fund upstream and downstream fish passage facilities to aid in region-wide efforts to restore anadromous fish production to the upper Green River watershed. These facilities will be instrumental to restoring anadromous fish runs above HHD, but other facilities may also be needed to accelerate restoration. Restoring salmon and steelhead runs in the upper watershed could be initiated by transporting and releasing unmarked adult fish above HHD to distribute and spawn naturally in upper watershed, but the rebuilding of harvestable, self-sustaining runs could take many years. A fish restoration facility could be used to "jump-start" or accelerate the natural rebuilding of anadromous fish runs by producing juvenile salmonids for outplanting into the upper watershed to supplement adult returns.

Although not proposed as part of this conservation measure, Tacoma is committed to funding the development and construction of a fisheries restoration facility that will be owned and operated by the MIT. The facility would be constructed adjacent to the Green River, and would be designed to include incubation and rearing facilities for juvenile salmonids patterned after the NMFS natural rearing program (known as NATURES). These rearing procedures create a more natural environment (e.g., natural cover, substrate, and structures) to incubate, rear, and acclimate fish in order to achieve improved survival and productivity. The juvenile fish produced at the fish restoration facility would be used to restore and enhance anadromous fish populations in the Green River, and could serve as the primary source for juveniles to be outplanted in the upper Green River watershed.

The fish restoration facility would include the following attributes (FishPro 1995):

- weir, ladder, and trap to capture adult anadromous fish;
- adult holding facilities for 300 steelhead trout, 400 chinook salmon, and 440 coho salmon;

- incubation and rearing facilities for 350,000 steelhead trout, 500,000 chinook salmon, and 500,000 coho salmon; and [4]
- well water stabilization facility or surface water treatment for incubation (depending upon source).

Tacoma will pay up to $8,500,000 for design and construction of the fish restoration facility and will provide the necessary wells, well houses, and water conveyance facilities. Tacoma will pay the MIT $350,000 per year (1995 dollars) for operation and maintenance costs for the life of the facility. Tacoma will also fund up to $675,000 for monitoring and evaluation of the fish restoration facility to provide the basis for long-term watershed restoration.

The transport and release of juvenile salmonids provided by this measure is contingent upon a number of factors, including approval of the fish restoration facility and its intended uses (i.e., restoration and supplementation of anadromous fish populations in the Green River) by fisheries resource agencies, and obtaining the necessary water rights and permits for the facility. If the fish restoration facility cannot be permitted or is deemed to be infeasible, the MIT will elect to either:

- accept a lump sum of $12,000,000 into MIT's Fisheries Trust Fund to be used for fisheries enhancement within the Green/Duwamish river system; or
- accept any and all unused funds originally targeted for the fish restoration facility into the MIT Fisheries Trust Fund to be used for fisheries enhancement in the Green/Duwamish river system.

Juvenile salmonids produced from the fish restoration facility could be outplanted into the upper watershed until the number of adult fish returning to the upper watershed (via the Headworks trap-and-haul facility) is determined to be sufficient to establish self-sustaining runs. Supplementation on a short-term basis could reduce the period of time required to reach adult escapement goals. In the case of chinook salmon, which are less likely than steelhead to develop self-sustaining runs, supplementation from the fish restoration facility may also be beneficial for addressing short-term declines in adult escapement due to environmental conditions (e.g., temporary population reductions resulting from poor ocean conditions or several years of drought). If limiting aspects of the chinook salmon life cycle cannot be remedied to achieve self-sustaining runs of adult

[4] The capacity of the fish restoration facility may be increased as a result of ongoing discussions between the MIT and Tacoma.

fish (as indicated by the monitoring programs), then long-term supplementation may be required to restore and maintain the production of this species in the upper watershed.

Determining a management plan to recolonize available habitat above HHD is the responsibility of fisheries management agencies. Allowing only adult returns to seed the upper watershed may be an optimal procedure for developing local adaptations, but it would delay habitat saturation. Outplanting juveniles from the fish restoration facility may provide a means of identifying upper watershed outmigrants, or supplementing adult returns may accelerate the rebuilding process. The decision on when, how, or if to use the fish restoration facility will be decided by MIT and appropriate federal and state fish management agencies. The fish restoration facility, and therefore transport of juvenile salmonids into the upper watershed, would only proceed if supplementation of juvenile fish above HHD is found to be beneficial. Even if the fish restoration facility does not proceed, funding of the MIT Fisheries Trust Fund would still provide benefits to fisheries resources within the Green/Duwamish river system.

Tacoma will fund and support the federal, state, and local permitting process for the fish restoration facility, but the MIT, as owners and operators of the facility, will be the permittees if permitting is found to be necessary. If necessary, permits to comply with the ESA will be issued to the MIT and will be sought as a process separate from the Tacoma Green River HCP. Funding of the fish restoration facility provides for monitoring and evaluation to provide the basis for long-term watershed restoration, but details will not be developed until the fish restoration facility proceeds.

5.2.6 Habitat Conservation Measure: HCM 2-06 Low Flow Augmentation

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-06

MEASURE: Low Flow Augmentation

The USACE, with Tacoma sponsorship, will have the option to annually provide up to 5,000 ac-ft of additional summer conservation pool storage in Howard Hanson Reservoir that can be used to augment Green River flows. The actual use of this storage will be determined using an adaptive management approach. Although initially intended to augment minimum flows during drought conditions, there is considerable flexibility in determining the best use of the water for fishery resource benefits. For example, the storage may be used to: 1) augment late spring flows to benefit

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steelhead incubation; 2) provide flows beneficial to downstream water quality conditions (e.g., temperature control); or 3) provide supplemental freshets during late summer to benefit adult salmon migrating up the Green River. The actual use of up to 5,000 ac-ft of storage will consider the input of the resource managers[5] charged with determining the best application of the water to benefit ecosystem health.

Water stored behind HHD and released for fish conservation purposes shall not be subject to appropriation by Tacoma.

Objective

The objective of this measure is to improve instream resource protection by providing additional water that can be released to offset flow management constraints inherent in a system operated for flood control and municipal water supply.

Rationale and Ecosystem Benefits

Under drought conditions, low summer flows in the mainstem Green River can reduce the availability and quality of salmonid rearing habitat. In Puget Sound streams, Gibbons et al. (1985) suggested that the amount of available summer rearing habitat, which is established by the level of instream flow, is directly related to the number of returning adult steelhead. Other researchers confirm this relationship stating “the volume of flow in summer determines the carrying capacity of the stream for juvenile salmonids” (Everest et al. 1985). Research over a 14-year period in Bingham Creek, Washington, showed that the quantity of water during summer accounted for over 95 percent of the inter-annual variation in smolt production (Parkhurst 1994). Similarly, extensive research has indicated that production of coho salmon in Oregon streams was found to be most strongly correlated with the amount of usable rearing habitat rather than other parameters (Mason and Chapman 1965; Everest et al. 1985).

During non-drought years, incubating steelhead eggs are exposed to a risk of dewatering if river flows drop during June through August. The majority of steelhead in the Green River spawn during the months of April and May, and the eggs incubate for 45 to 65 days extending through July or early August (see Appendix A). If steelhead construct their nests (redds) in the channel margins during April and May when flows in the river are high, the eggs are susceptible to dewatering as the seasonal flows drop during the incubation period. During dry years, river flows are often low during the spawning

[5] See footnote No. 3 in HCM 2-02 for description of the Green River Flow Management Committee.

season and the eggs will remain protected from dewatering by Tacoma's commitment to maintain minimum flows. However, during wet years the steelhead spawn higher in the channel margins and as flows naturally drop during June and July, the eggs may be dewatered and have poor survival. During wet years, additional protection for steelhead redds may be provided by maintenance of instream flows that are higher than those mandated by the state or by the MIT/TPU Agreement.

Tacoma is considering implementing this measure through the USACE's Section 1135 Program or as part of the AWS project. The capture and retention of up to an additional 5,000 ac-ft of water will provide supplemental flows that can be used to augment low summer flows during drought conditions, or augment flows during June and July to protect steelhead incubation, or released during late September to aid the upstream migration of adult salmonids. All of these potential uses of an additional 5,000 ac-ft of storage will benefit Green River fishery resources. The actual use of the additional flow will be determined by the NMFS and USFWS in coordination with the USACE and other resource managers.

5.2.7 Habitat Conservation Measure: HCM 2-07 Side Channel Reconnection – Signani Slough

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-07

MEASURE: Side Channel Reconnection – Signani Slough

Tacoma and the USACE will restore and enhance up to 3.4 acres of side-channel fish habitat in Signani Slough near RM 60.0. This will be accomplished through: 1) excavation of fill material; 2) replacement of a 48-inch culvert; 3) addition of LWD and excavation in the floodplain to restore habitat complexity; and 4) diversion of up to 35 cfs flow from the mainstem Green River to provide additional water for the entire channel length. All work will be performed within the historic Green River floodplain. The Headworks road will be breached at two points to provide flow diversion at the upstream end by installing a 2- to 4-foot culvert, and replacing an existing 4-foot culvert (downstream end) with one or two larger, longer culverts. Flow diversion to the upstream end will require starting 600 to 1,000 feet upstream of the breach near RM 59.6. The outlet channel may require realignment and may extend farther downstream than the current channel. This habitat conservation measure is intended to restore habitats that were impacted by the construction of HHD. Tacoma will provide its share of funding for this measure upon completion of this PED phase of the AWS project.

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Alternate measures will be implemented if the above measure is determined to be infeasible, or not cost effective during final design, or if environmentally superior measures can be implemented at comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS.

Objective

The objective of this measure is to provide additional rearing and holding habitat for salmon and steelhead along the Green River.

Rationale and Ecosystem Benefits

Levees, channel degradation, and controlled flows from HHD have reduced the interaction between floodplains and stream channels in many sections of the Green River (Fuerstenberg et al. 1996). Many areas of the floodplain have been converted to other uses, dramatically reducing the interchange of water and materials between the aquatic and terrestrial systems, and isolating floodplain wetlands. The lower 1,000 feet of Signani Slough, a left bank Green River side channel, was filled, channelized, and disconnected during original construction of HHD and realignment of the Burlington Northern Santa Fe Railroad in 1960 and 1961. During construction activities, the channel was filled and temporarily cut off from the Green River, reportedly stranding over 1,000 adult salmon (Signani 1997).

In general, side channels have been shown to provide important habitat for juvenile and smoltified salmon and steelhead (Sedell et al. 1984; Murphy et al. 1989; Marshall and Britton 1990; Sheng et al. 1990; Bonnell 1991; Cowan 1991). The restoration of Signani Slough would add to the overall quantity and quality of fish habitat in the upper middle Green River, in particular for: 1) adult coho salmon and steelhead; and 2) juvenile chinook, coho salmon, and steelhead. The Signani Slough is the only available off-channel spawning and rearing habitat of any significance for the middle Green River, from RM 45.0 to RM 70.0. Being partially fed by groundwater, this slough may represent a critical Green River habitat type. The reconnection of Signani Slough would provide approximately 3.4 acres of critical rearing habitat for juvenile salmonids, and may provide spawning habitat for adult salmon and steelhead and nursery areas and feeding stations for newly emerged fry.

5.2.8 Habitat Conservation Measure: HCM 2-08 Downstream Woody Debris Management Program

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-08

MEASURE: Downstream Woody Debris Management Program

Tacoma, working collaboratively with the USACE, MIT, and federal, state, and local agencies, will develop and implement a woody debris management program designed to pass wood that collects behind HHD downstream to the middle and lower Green River (below Tacoma Headworks). As part of its HHD maintenance operations, the USACE collects woody debris that enters the HHD reservoir and disposes of the wood by burning or transporting it off-site. For this measure, all of the LWD and a portion of the small woody debris that enters the HHD reservoir and is collected by the USACE as part of debris removal operations will be used for ecosystem rehabilitation efforts. The actual volume of wood that will be available for rehabilitation efforts will vary, depending on source material available within the HHD reservoir pool. The wood debris management program may be modified by agreement of signatories to the ITP. Tacoma will fund its portion of this measure upon completion of the PED phase of the AWS project.

Large Woody Debris

Following construction of the AWS project, Tacoma, working with the USACE, will allocate[6] for passage downstream of Tacoma's Headworks at least half of the LWD that is collected by the USACE behind HHD. The size distribution of wood passed or placed below the Headworks shall be approximately the same as that wood entering the reservoir, and will include the largest sizes available. If monitoring indicates that the large wood is too small to be naturally retained, then the proportion of the largest size class will be increased. If more than 10 pieces of LWD are available in any given year, 50 percent of the total number of pieces collected will be allocated for downstream passage. If fewer than 10 pieces of LWD are available in any given year, all LWD pieces will be allocated to downstream passage. If an unusually large volume of wood is collected in any given year, such as contributions from a major landslide, Tacoma reserves the option to reduce the amount of LWD collected, stored, and transported contingent on written approval by the Services. The approximate size

HCM 2-08 (continued on next page)

[6] Large woody debris pieces will be considered allocated if one of the following conditions are met: 1) a permit has been submitted for a project; 2) a project design is being developed; or 3) an entity has made a request for the wood for use in a project in the Green River basin. Large woody debris pieces that remain unused because of the lodging or filing of an appeal or litigation in any forum that has the potential to interfere with the placement of wood under this section shall be considered allocated.

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criteria of the LWD that will be used are as follows: logs will have an average diameter of at least 12 inches at the largest end or bole above the rootwad, if attached, and will be at least 12 feet long; rootwads will have a minimum diameter of 48 inches with or without the basal trunk.

Large woody debris collected by the USACE will be temporarily stored for up to 3 years. At an average frequency of every other year, the LWD allocated for passage downstream will be reloaded and trucked below the Headworks on existing roads. It is anticipated that LWD will be introduced at several locations within the active channel of the Green River prior to winter high flows. The LWD will then be allowed to distribute naturally within the river as flow and the natural transport capacity increase.

In addition to, or as an alternative to placing unanchored LWD downstream of the Headworks, select pieces of LWD may be anchored in the river, rather than allowing flows to distribute the pieces naturally. In this case, the locations and methods for anchoring LWD downstream of the Headworks will be determined in coordination with the MIT, and federal, state and local agencies with jurisdiction over habitat protection and river management. If LWD is anchored, fewer pieces may be added to the river to ensure implementation costs remain comparable to those for placing unanchored LWD.

Following construction of the AWS project, any LWD collected from the reservoir and not allocated for downstream transport below the Tacoma Headworks will be stored and used for other conservation measures identified in this HCP. Once the LWD requirements for those conservation measures have been fulfilled, any remaining LWD will be allocated for use in other USACE-sponsored rehabilitation projects in the Green River basin or offered to Tribal organizations; federal, state, or local agencies; or non-profit organizations for use in habitat rehabilitation projects elsewhere in the Green River basin. If sufficient pieces of LWD are available to meet short-term needs for ecosystem rehabilitation projects, select pieces of LWD will be made available for cultural use by the MIT. If the LWD remains unallocated following 3 years of storage, and provided inter-basin contamination issues can be adequately addressed, and provided that the LWD pieces in storage are decaying to an extent that if not used the LWD pieces will become unusable for ecosystem rehabilitation or habitat projects, unallocated LWD pieces will be made available for ecosystem rehabilitation projects outside of the Green River basin. If any LWD remains unutilized after 5 years of storage, Tacoma will use best available efforts to utilize remaining LWD for regional ecosystem rehabilitation efforts.

Small Woody Debris

In addition to the LWD, five trash-truck loads (total 50 to 75 tons) of small woody debris (if available) will be transported to placement sites downstream of the Tacoma Headworks at an average placement frequency of every other year. The actual

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volume of small woody debris that will be collected, transported, and introduced into the lower river will vary, depending on source material available within the HHD reservoir pool. Small woody debris will consist of small logs, branches, and other wood fragments with an average diameter of less than 12 inches. If five trash-truck loads are not available, then Tacoma will transport the available quantity.

Funding

In addition to costs allocated for the storage and transport of wood for unanchored placement downstream of Tacoma Headworks, a sum of $5,000 will be annually allocated for anchored LWD placement. If not used in any given year, these funds will be carried over to subsequent years to build up a funding bank for future LWD anchoring projects. The volume of woody debris transported downstream can be adjusted predicated on an evaluation of the volume of wood that will effectively contribute to natural stream processes, public health and safety, and flood control impacts. Monitoring activities associated with this measure are described in Chapter 6.

Tacoma will work with the MIT and federal, state, and local agencies with jurisdiction to select wood placement locations. If recommendations for LWD placement require alternate placement procedures such as anchoring, the quantity of LWD placed may be reduced to ensure costs remain comparable. If problematic LWD accumulations in the middle or lower river are identified (as determined by the NMFS and USFWS), the rate of placement may be reduced and funds reallocated to other habitat restoration measures. If monitoring indicates that an increased rate of LWD placement would be beneficial, funds for additional wood transport and placement must come from other sources.

Objective

The objective of this measure is to increase the amount of LWD in the Green River below the Tacoma Headworks, where it has been reduced by timber harvest, construction of HHD, and active removal from the river.

Rationale and Ecosystem Benefits

Woody debris is perhaps the most important link between the aquatic and terrestrial environments. Woody debris interacts with other natural processes (i.e., climate, hydrology, and erosion) to create food, cover, and microclimates suitable for virtually all species of juvenile salmonids at some point during their maturation (Chapman 1966; Murphy et al. 1984; Bjornn and Reiser 1991; Swanston 1991). In the Pacific Northwest, current breaks providing velocity shelter, summer/winter rearing habitat for juvenile salmonids, and spawning gravels for adult salmonids often form in the presence of woody debris (Sedell et al. 1984; Dolloff 1987; Shirvell 1990; Fransen et al. 1993; Peters et al. 1993; Rodgers et al. 1993; Hartman et al. 1996; Fausch and Northcote 1992; Crispin et al. 1993; Cederholm et al. 1997a). The deposition of key woody debris pieces also initiates pool formation (Beechie and Sibley 1997); prompts bar, island, and side-channel formation (Sedell et al. 1984; Abbe and Montgomery 1996); stores sediment (Lisle 1986; Keller et al. 1995); retains organic matter (Bilby and Likens 1980); and affects bedload transport mechanics (Smith et al. 1993).

Woody debris also exerts a significant influence on the productivity of Pacific Northwest streams. Woody debris is important in retaining organic matter in fluvial systems that will later be processed by aquatic macroinvertebrates and converted to fish production (Bilby and Likens 1980). Key woody debris pieces trap smaller woody pieces until a framework is built. Coarse particulate matter collects on the framework and is refined by bacteria and fungi into food for macroinvertebrates. Macroinvertebrates, in turn, are an important food source for salmonid fishes.

Lateral habitats containing LWD are regularly associated with high juvenile salmonid production rates. Peterson and Reid (1984) found that 15 of 17 (88 percent) wallbase channels in the Clearwater River, Washington, were used by juvenile coho and estimated that, annually, 20 to 25 percent of the total smolt yield in the Clearwater River comes from wallbase channel habitat. Some groundwater-fed side channels in British Columbia produce more than one coho smolt per square foot of habitat area (Sheng et al. 1990); by comparison, coastal British Columbia streams produce approximately 0.3 smolts per square foot (Marshall and Britton 1990). Approximately 16,000 juvenile coho salmon overwintered in a side-channel in the upper Squamish River, British Columbia (Sheng et al. 1990). Juvenile chum salmon also utilize side-channel areas for rearing habitat (Sheng et al. 1990; Bonnell 1991; Cowan 1991); however, their freshwater residency is usually limited to 30 days or less (Salo 1991). The density of juvenile chinook using off-channel habitat in the Taku River, Alaska, increased in November, indicating movement into overwinter habitat (Murphy et al. 1989). Everest and Chapman (1972) found post-emergent chinook in Idaho seek backwater habitats, almost exclusively, during spring freshets. Chinook fry are also known to use quiet, shallow waters soon after emergence in the Green River (Jeanes and Hilgert 1999). Off-channel rearing has also been documented for rainbow trout (Everest et al. 1987; Sheng et al. 1990; Hartman et al. 1996), bull trout (Goetz 1994), and cutthroat trout (Sedell et al. 1984; Hartman et al. 1996).

Woody debris is recruited to the stream system in a number of ways. On large, unconfined rivers, lateral migration of the stream channel undercuts banks, delivering whole trees with attached rootwads to the channel (Robison and Beschta 1990). Other sources of woody debris recruitment include landslides, windthrow, and floods. Most (83 percent) of the hardwood woody debris pieces originate within 33 feet of the stream margin as compared to only 53 percent of coniferous woody debris pieces (McDade et al. 1990). This discrepancy is often attributed to the size differences between the two woody debris types.

Once in the stream, most pieces smaller than the bankfull width of the channel are transported considerable distances downstream. The narrow straight reaches of a river are generally considered source reaches, while lower gradient valley floors serve as woody debris traps (Murphy and Koski 1989). In large rivers, the number of woody debris jams are fewer, but individual pieces and jams are usually larger, and often cause secondary channels to form (Sedell et al. 1984). Recently recruited woody debris usually comprises the majority of wood in Pacific Northwest streams (Hyatt 1998). For example, most of the woody debris in the Queets River was depleted within the first five decades of its deposition; however, a few pieces were over 1,000 years old (Hyatt 1998). Older pieces are often found exposed in gravel bars, where they may remain buried beneath alluvial deposits in anaerobic conditions for many years before being exhumed by high flow events. In contrast, recently recruited debris is often found entangled in debris jams.

The deterioration of freshwater habitat is listed as a contributor in the decline of many anadromous fish species, and in many cases that deterioration is linked to loss of LWD (Nehlsen et al. 1991; Weitkamp 1995; Myers et al. 1998). Most alluvial rivers in the Pacific Northwest formerly contained extensive debris jams. Historically, the Skagit River had a debris jam that measured almost 0.75 miles in length and over 1,300 feet wide (Sedell and Luchessa 1982). The Nooksack and Stillaguamish rivers were also choked with debris jams over their lower reaches (Sedell and Luchessa 1982). In 1906, a large logjam on the Puyallup River between Orilla and Kent, Washington, caused major flooding on both the Green and White rivers (Fuerstenberg et al. 1996).

Historically, the middle Green River probably supported much higher frequencies of debris jams. However, the source of woody debris has been reduced drastically through a series of dikes, conversion of forested floodplains to agricultural land uses, and the addition of HHD. Howard Hanson Dam was constructed at the confluence of the three largest tributaries in the upper Green River basin. Prior to creation of the reservoir, these tributaries carried large volumes of LWD downstream to lower reaches of the Green

River. Since creation and operation of the dam and reservoir, normal river transport of wood has been disrupted, as all pieces of wood are either collected and disposed of (via burning or transport and use off-site), or are stranded at higher elevations following a flood pool rise. As recent as 1994, a survey indicated that only 29.6 pieces of woody debris were available per stream mile in the middle Green River downstream of HHD (Fuerstenberg et al. 1996).

Under current conditions, woody debris in the middle Green River (Flaming Geyser State Park downstream to Auburn, Washington) is often closely associated with lateral areas of the mainstem and off-channel habitats (e.g., side channels, sloughs, gravel bar pools, and beaver ponds). In many instances, debris accumulations divert water into side channels. At RM 45.5, the Green River exits the gorge area near Flaming Geyser State Park and enters a broad valley, characterized by a decrease in gradient and deposition of gravel (Perkins 1993). This broad river valley provides the perfect conditions for the accumulation of woody debris and formation of lateral or side-channel habitat (Sedell et al. 1984; Hyatt 1998).

Many habitat rehabilitation projects occurring in the Pacific Northwest include the placement of woody debris in streams (Cederholm et al. 1997b). Among the most common structures used in larger rivers are: log deflectors facing downstream, channel margin log-boulder accumulations, angle logs, boulder-rootwad complexes, trees anchored to the streambank, trees with attached stem cabled to boulders, and boulder-wood debris complexes. Physical and biological design specifications, along with a thorough understanding of the geomorphic processes, are imperative to maximize the benefits of projects of this nature (Cederholm et al. 1997b).

This conservation measure provides a means for restoring recruitment of LWD from the upper to middle and lower reaches of the Green River. In addition to providing in-channel rearing habitat for juvenile salmonids (Fuerstenberg et al. 1996), the release of LWD should interact with the restoration of the Signani Slough and other habitat rehabilitation projects to improve the overall quality of instream habitat in the Green River below the Headworks. By guaranteeing that at least half of the wood delivered to Howard Hanson Reservoir is passed downstream of the Headworks and either allowed to distribute freely or placed in the channel using techniques such as those described above, Tacoma expects to substantially increase the amount of functional LWD in the middle Green River.

Large woody debris delivered to the reservoir is collected in log booms that are approximately 1 acre in size. Approximately 2 to 7 acres (about 100 to 150 tons) of wood are collected annually (Olson 1999). The actual amount collected varies widely since LWD input and transport are episodic in nature, and tends to be highest in years with major flood events. If more than 10 pieces are collected in any year, 50 percent of the pieces collected will be made available for other habitat restoration projects. If allowed to freely distribute, LWD allocated for downstream passage will be input at least every second year. If it is determined that anchoring individual pieces or groups of LWD is the preferred means of restoring LWD to the river, the wood may be stored for up to 5 years and then input all at once, to maximize construction efficiency and cost effectiveness.

Large and small woody debris placed in the river from subsequent distribution by high flows will be input on exposed gravel bars within the active channel during low flows. Specific locations chosen for in-channel LWD placement will be identified in coordination with the Services, USACE, MIT, and King County. Placement locations must be accessible to trucks and heavy equipment and must not require crossing of wetted channels or unstable banks. The number of placement locations will vary depending on the amount of wood to be placed in any given year.

Large woody debris must be greater than 12 cubic yards by volume (24 inches in diameter and over 100 feet long) to be considered a stable, key piece in such channels (NWIFC 1997). The Green River is a wide, high-energy stream channel. Hardwood species (alder or cottonwood) generally decay more rapidly and are less durable than conifers. Therefore only LWD from coniferous species, including fir, hemlock, cedar, or spruce, will be used for anchoring projects in the mainstem Green River. In addition, LWD anchored in the channel will have a volume of least 12 cubic yards, or will be installed in groups that have a collective volume of 12 cubic yards, which is consistent with the minimum key-piece size for larger rivers (WFPB 1997). The total volume may consist of a single piece with an average diameter of 24 inches that is at least 105 feet long, shorter pieces with larger diameters (NWIFC 1997), or a group of smaller pieces with a collective volume of at least 12 cubic yards. Other design criteria (e.g., orientation, anchoring method) will be determined in coordination with the Services on a site-specific basis.

5.2.9 Habitat Conservation Measure: HCM 2-09 Mainstem Gravel Nourishment

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-09

MEASURE: Mainstem Gravel Nourishment

Tacoma and the USACE will provide annual funding sufficient to place up to 3,900 cubic yards of screened gravel suitable for use by spawning salmonids within the mainstem Green River between RM 64.5 and RM 32.8. The amount of screened gravel to be placed each year will be approximately 3,900 cubic yards, but not exceed 3,900 yards. The size range and composition of gravel suitable for use by spawning salmonids will be defined in coordination with the Services as part of, and during, the PED phase of the AWS project. The amount of gravel to be placed will be reduced only: 1) at the specific request of the Services; or 2) if the preferred placement strategy calls for placement of a lesser amount of gravel in conjunction with construction of structures deliberately designed and placed to retain gravel, independent of the placement of wood under HCM 2-08. Preliminary analyses indicate that the middle Green River just below the Green River Gorge near RM 45.0 is the preferred placement site (USACE 1998). Should Green River restoration efforts by other parties place gravel in the RM 45.0 area, the USACE/Tacoma gravel nourishment site will be switched to an area immediately below Tacoma's Headworks at RM 61.0. If deemed beneficial by the Services, gravel may be placed between HHD (RM 64.5) and Tacoma's Headworks. Gravel will be transported by truck and placed (with front-end loader or back-hoe) just within the active channel to be subsequently transported and distributed during high flow conditions. Actual sites for placement of the gravel will be selected based on river access. This program is focused on augmenting the supply of gravel within the middle Green River.

Should high flows be insufficient to redistribute all of the gravel placed in a given year, subsequent annual placements may be shifted to the reach between the Headworks and the Green River Gorge or between HHD and Tacoma Headworks, conditional upon approval by the Services. One alternative would be to place the entire annual increment just downstream of the Headworks as described above. Another option would be to install gravel retention structures at selected locations to facilitate gravel storage in this high-energy reach. Actual placement strategies will be modified based on the results of monitoring.

Tacoma will work with the MIT and federal, state, and local agencies with jurisdiction to select gravel placement locations. If recommendations for gravel nourishment require alternate placement procedures, the quantity of gravel may be reduced to ensure costs remain comparable. If problematic gravel aggradation in the lower river is identified (as determined by the NMFS and USFWS), the rate of placement may be reduced and funds reallocated to other habitat restoration measures. If monitoring indicates that an increased rate of gravel nourishment would be beneficial, funds for additional gravel must come from other sources. Changes in the volume or location of placement sites will require approval by the Services and written notification to WDFW, MIT, King County, and the USACE. Tacoma will fund its portion of this measure upon completion of PED phase of the AWS project.

Objective

The objective of this measure is to increase the amount of spawning gravel in the mainstem Green River below the Tacoma Headworks, where it has been reduced by construction of HHD.

Rationale and Ecosystem Benefits

Studies have shown that the existing supply of gravel within the mainstem river is being influenced by the operation of HHD, resulting in changes in channel morphology and in bed armoring (Perkins 1993; Dunne and Dietrich 1978). In addition, HHD essentially captures all gravel that may be recruited from the upper watershed, thereby precluding the natural replenishment of spawning gravel to segments of the river below the dam. Over time, this will ultimately result in the gradual degradation of suitable spawning habitats in the mainstem river, thereby reducing the anadromous fish production potential. Other concerns relate to the perching (disconnection) of off-channel habitats from the mainstem as channel downcutting occurs and the bed becomes armored. King County researchers have documented a loss of suitable-sized spawning gravel with resultant bed armoring from below HHD (RM 64.5) to below Flaming Geyser State Park (~RM 45.0) (Perkins 1993). This armoring layer is estimated to be advancing downstream at the rate of 700 to 900 feet per year.

As noted in the AWS project DFR/DEIS, Appendix F1, Section 4B: gravel nourishment in the middle and upper Green River (USACE 1998), the 3,900 cubic yards of gravel to be distributed to one or more sites in the river, is intended to maintain "an increment" of existing spawning habitat in the middle Green River. The objective of gravel nourishment is to slow or stop the downstream extension of streambed armoring and to replenish certain areas currently deficient in spawning-sized sediments. Preliminary analysis suggests that gravel of a size suitable for use by spawning salmonids would have a short residence time in the channel upstream of Kanasket State Park (USACE 1998); therefore, the reach immediately downstream of the gorge was identified as the preferred placement site. The extent to which gravel nourishment successfully stops continued streambed armoring would be identified through monitoring and evaluation. A major concern, voiced by the USACE, of adding gravel-sized sediments to the middle Green River, is the potential effect on flood control measures in the lower river. As described in Chapter 6, a monitoring plan will minimize the risk of problematic aggradation downstream of gravel placement sites.

The ecosystem restoration aspects of the AWS project are capped by financial constraints under federal authorization. If problematic gravel aggradation in the lower river is identified, the rate of gravel nourishment may be reduced. If monitoring identifies the value of an increased rate of gravel nourishment, funds for additional gravel must come from other sources. The responsibilities of the USACE for the effects of HHD operations under the ESA have not yet been identified through formal Section 7 consultation, and additional gravel nourishment may be a Section 7 requirement. The Green/Duwamish River Basin Ecosystem Restoration Study sponsored by the USACE and King County is also considering placement of gravel in the Green River.

5.2.10 Habitat Conservation Measure: HCM 2-10 Headwater Stream Rehabilitation

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-10

MEASURE: Headwater Stream Rehabilitation

Tacoma will fund its portion of this measure upon completion of the PED phase of the AWS project. Tacoma will contribute funds to rehabilitate a portion of the habitat lost by construction of HHD and inundation of the existing pool. Project numbers assigned to each activity by the USACE are listed in parentheses. Projects currently expected to be funded by Tacoma as part of the AWS project under HCM 2-10 include:

Mainstem and Valley Floor Habitat Rehabilitation (MS-03). This project will rehabilitate habitat in approximately 8,000 feet of channel between RM 69.0 and RM 72.0 (elevation 1,177-1240 feet MSL), just upstream of the new inundation zone. Boulders will be placed along the thalweg, and LWD will be embedded in the banks or anchored to placed boulders. Relict side channels or beaded ponds will be excavated within the floodplain to increase the quantity of off-channel habitat, and LWD will be placed to improve the quality of newly excavated habitat features.

Tributary Habitat Rehabilitation (TR06; TR07). These projects will rehabilitate habitat between 1,177 feet MSL and 1,240 feet MSL in the North Fork Green River, Charley, Gale, McDonald, Cottonwood, Piling creeks and three unnamed tributaries. Large woody debris and boulders will be placed in approximately 14,000 feet of channel. Relict side channels or beaded ponds will be excavated within the floodplain of larger tributaries to increase the quantity of off-channel habitat, and LWD will be placed to improve the quality of newly excavated habitat features.

The final design of these conservation measures will be developed during the PED phase of the AWS project. Large woody debris frequency and size requirements appropriate for the channel type will be determined using habitat criteria such as those recommended by the Washington Watershed Analysis Manual (WFPB 1997) or comparable systems approved by the Services.

HCM 2-10 (continued on next page)

> *HCM 2-10 (continued)*
>
> Alternate measures will be implemented if any of the above measures are determined to be infeasible or not cost effective, or if environmentally superior measures can be implemented at a comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by NMFS and USFWS.

Objective

The objective of this measure will be to rehabilitate and/or enhance fisheries habitat in the Green River and selected tributaries above HHD.

Rationale and Ecosystem Benefits

The construction of HHD resulted in the inundation of several miles of mainstem and tributary habitat. The primary objective of projects identified in this measure is to mitigate for a portion of that lost riverine habitat by rehabilitating habitat in several important tributary streams in the upper watershed. Surveys of the mainstem Green River, North Fork Green River, Charley and Gale creeks in 1991 reported that LWD frequencies ranged from 1.2 to 47.6 pieces of LWD per 1000 feet (Wunderlich and Toal 1992). This generally corresponds with the low end of the range of LWD frequencies (9 to 140 pieces/1,000 feet) reported by Peterson et al. (1992) for comparable large streams (>75 feet BFW) flowing through undisturbed forests. Large woody debris frequencies in the smaller tributaries (Cottonwood and Piling creeks, and three unnamed tributaries) were higher, ranging from 26.9 to 179 pieces per 1,000 feet (USFWS 1992). However, the LWD frequency in those smaller tributaries is generally much lower than the 122 to 244 pieces per 1,000 feet reported for comparable medium size streams (15 to 32 feet BFW) flowing through undisturbed forests (Peterson et al. 1992). The riparian prescriptions to be implemented under this HCP are expected to eventually provide higher levels of LWD recruitment once stream-adjacent stands of timber mature. This conservation measure will provide immediate benefits in the form of increased instream structure, and is expected to improve juvenile salmonid rearing habitat and potentially increase spawning habitat for adult steelhead or salmon.

The existing LWD frequency is currently less than the two pieces per channel width recommended for channels with "good" habitat conditions (WFPB 1997) in the majority of channels surveyed. Placement of LWD at an average rate of 40 pieces per 1,000 feet is expected to increase the LWD frequency to more than two pieces per channel width in all of the treated segments. Addition of large boulders at a rate of 30 boulders per 1,000 linear feet will further increase channel complexity, and will provide stable obstructions to help retain both naturally recruited and placed LWD. Construction of beaded ponds and side channels increases the availability of off-channel habitats that are utilized for spawning and rearing by most salmonid species. The addition of LWD and creation of off-channel habitat just upstream of the inundation zone is expected to increase the amount of available instream juvenile rearing habitat, and to potentially increase spawning habitat for adult steelhead or salmon released above HHD.

The final design of these projects will be developed during the PED phase of the AWS project. Alternate measures will be implemented if any of the above projects are determined to be infeasible or not cost effective during the final design. Any alternate projects will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by NMFS and USFWS.

5.2.11 Habitat Conservation Measure: HCM 2-11 Snowpack and Precipitation Monitoring

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-11

MEASURE: Snowpack and Precipitation Monitoring

Tacoma will provide funding to assist the USACE with the installation of three snowpack and precipitation monitoring stations in the upper Green River basin. Unless superior technology becomes available at a comparable cost, snowpack and precipitation monitoring stations will consist of the standard equipment installed by the Natural Resource Conservation Service at its Snowpack Telemetry (SNOTEL) stations. Continuous snowpack monitoring will be accomplished by installing snow pillows within 1,000-foot elevation bands (2,500 to 3,500 feet MSL; 3,500 to 4,500 feet MSL; and 4,500 to 5,500 feet MSL). Snow pillows are fluid-filled pillows in which fluid pressure responds to the weight of snow that is lying on top of the pillow. The pressure of the fluid in the pillow is measured with a manometer or pressure transducer that is interfaced with a digital data recording and transmission system. In addition to monitoring the snowpack, each site will also be equipped with a rain gage and instruments that measure air temperature and snow depth. Data will be collected from the snow pillows on an hourly basis by the Natural Resource Conservation Service, and provided to the USACE for incorporation into its streamflow forecasting procedures. The snow pillows will be monitored using a continuous data recorder, and data will be transmitted to the Natural Resource Conservation Service Centralized Forecasting System using meteorburst telemetry. Manual snow surveys will be conducted at each new SNOTEL site for the first 2 years of operation to verify the reliability of telemetered data. The number of snowpack and precipitation monitoring stations may be reduced if the Natural Resource Conservation Service determines that

HCM 2-11 (continued on next page)

HCM 2-11 (continued)

additional sites do not improve the ability of the USACE to forecast spring and summer flows in the mainstem Green River. Less than three SNOTEL stations may also be installed if technology becomes available that will provide a comparable level of runoff forecasting with fewer than three additional sites.

Alternate measures will be implemented if any of the above measures are determined to be infeasible, or not cost effective during final design, or if superior measures can be implemented at comparable cost. Any alternate measures will have benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS. Tacoma will fund its portion of this measure before water available to Tacoma under its SDWR is stored behind HHD.

Objective

The objective of this measure is to improve the ability of the USACE to predict stream flows in the Green River.

Rationale and Ecosystem Benefits

Precipitation that falls as snow is temporarily stored in the snowpack during the winter, thus estimates of runoff can be made well in advance of its occurrence. Forecasts of runoff are based primarily on measurements of precipitation, snow water equivalent, and seasonal runoff to date. Water supply forecasting for the Green River basin is currently the responsibility of the USACE, and is used to guide flood control operations, reservoir refill, and the summer flow release schedule. The USACE currently relies on a combination of data obtained from: 1) six snow courses within the Green River basin that are surveyed monthly between January and May; 2) daily telemetry data (obtained between 1 November and 1 July) from five existing SNOTEL sites, only one of which is located within the Green River basin; and 3) temperature and precipitation data from HHD. The USACE has developed regression equations for 1 March, 1 April, and 1 May to predict spring runoff based on the amount of snow on the ground and year-to-date rainfall. Forecasts produced using the existing models and data network are accurate to within 25,000 ac-ft over the period of April through July.

Runoff forecasts become more accurate as more of the parameters affecting runoff are measured directly within the basin of interest. Rain, snowfall, and melt rates may vary widely with elevation, snow depth, snow water equivalent, snowpack condition aspect, and vegetation cover. Additional snow pillows installed at higher and lower elevations within the upper Green River basin will provide data that are more representative of conditions throughout the basin than SNOTEL sites outside of the basin. The availability of additional data on actual basin snowpack conditions, and daily and hourly precipitation and air temperatures throughout the flood season will enhance the ability to predict and respond to flood events during the fall and winter (Murphy 1999). The availability of local, near real-time snowpack data has been shown to dramatically improve correlations between actual and predicted runoff (Moore 1998).

The availability of continuous data from the upper Green River basin will also facilitate more frequent spring runoff forecasts, and increase the accuracy of long-term spring runoff predictions. Currently, April through July runoff forecasts based on data derived from the snow course surveys and rainfall are made on 1 March, 1 April, and 1 May. Snowpack telemetry sites within the Green River basin would make mid-month spring runoff forecasts possible. Mid-month spring runoff forecasts would be particularly helpful during years when an early start to refill is necessary (Murphy 1999). More accurate predictions will allow the GRFMC more flexibility in designing a spring refill and summer release program that minimizes impacts to downstream resources while meeting water storage requirements for municipal use and summer instream flow augmentation. Snowpack and precipitation data obtained through this measure will be available via the Internet or comparable public access database beginning 15 February of the year that water available to Tacoma under its SDWR is stored behind HHD.

Snowpack telemetry sites funded by other resource management agencies or data users are installed and maintained by Natural Resource Conservation Service personnel. The Natural Resource Conservation Service recommends, and may assist with, manual snow surveys at the snow pillow site during the first 2 years following installation (Pattee 1999). Manual monthly surveys are used to evaluate the reliability of the telemetered data and identify any site characteristics (e.g., overhanging trees, drainage, deposition patterns on the pillow surface) that may need to be adjusted. Annual maintenance visits will be conducted by Natural Resource Conservation Service personnel during the summer to drain the precipitation gage, replace the antifreeze solution and conduct an electronic analysis of the data logger and other system components.

Snow pillows are currently the most common means of collecting continuous snowpack data from remote measurement sites. However, snow pillow data may be off by 10 percent or more due to bridging of compact snow around the edges of the pillow (Gibbs 1999). Improved technologies are under development (Gibbs 1999). If more accurate snowpack or precipitation monitoring devices become available at a comparable cost, Tacoma may modify the snowpack and precipitation monitoring system in coordination with the USACE and Natural Resource Conservation Service. If alternative technologies are utilized, Tacoma will notify the Services and provide a description of the alternative systems prior to their installation.

5.3 Habitat Conservation Measures – Type 3

Habitat conservation measures defined as Type 3 are designed to offset Tacoma's non-water withdrawal activities in the Green River watershed, primarily those associated with commercial forestry operations.

5.3.1 Habitat Conservation Measure: HCM 3-01 Upland Forest Management Measures

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01A

MEASURE: Forest Management Zones

Tacoma will manage lands within the HCP Area above the Headworks (Upper HCP Area) according to one of three designations: Natural Zone, Conservation Zone, and Commercial Zone. Zone designations for existing lands in the Upper HCP Area will be as shown in Figure 5-4. Zone designations for lands added to the Upper HCP Area in the future will be made by Tacoma, in coordination with the WDFW, USFWS, and NMFS. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to designate management zones in the upper Green River watershed that are consistent with maintenance of water quality and protection of fish and wildlife habitat.

Rationale and Ecosystem Benefits

Tacoma owns and manages approximately 14,888 acres in the upper Green River watershed. These lands are managed to: 1) protect water quality; 2) provide habitat for fish and wildlife; and 3) generate revenues through the limited harvest of timber to fund the overall land management program and finance the acquisition of additional lands in the watershed (Ryan 1996). The protection of water quality is the primary management objective throughout the watershed, but varying amounts of active management can occur to meet the other two objectives without compromising water quality. The amount of management that can occur in a given area without negatively impacting water quality is

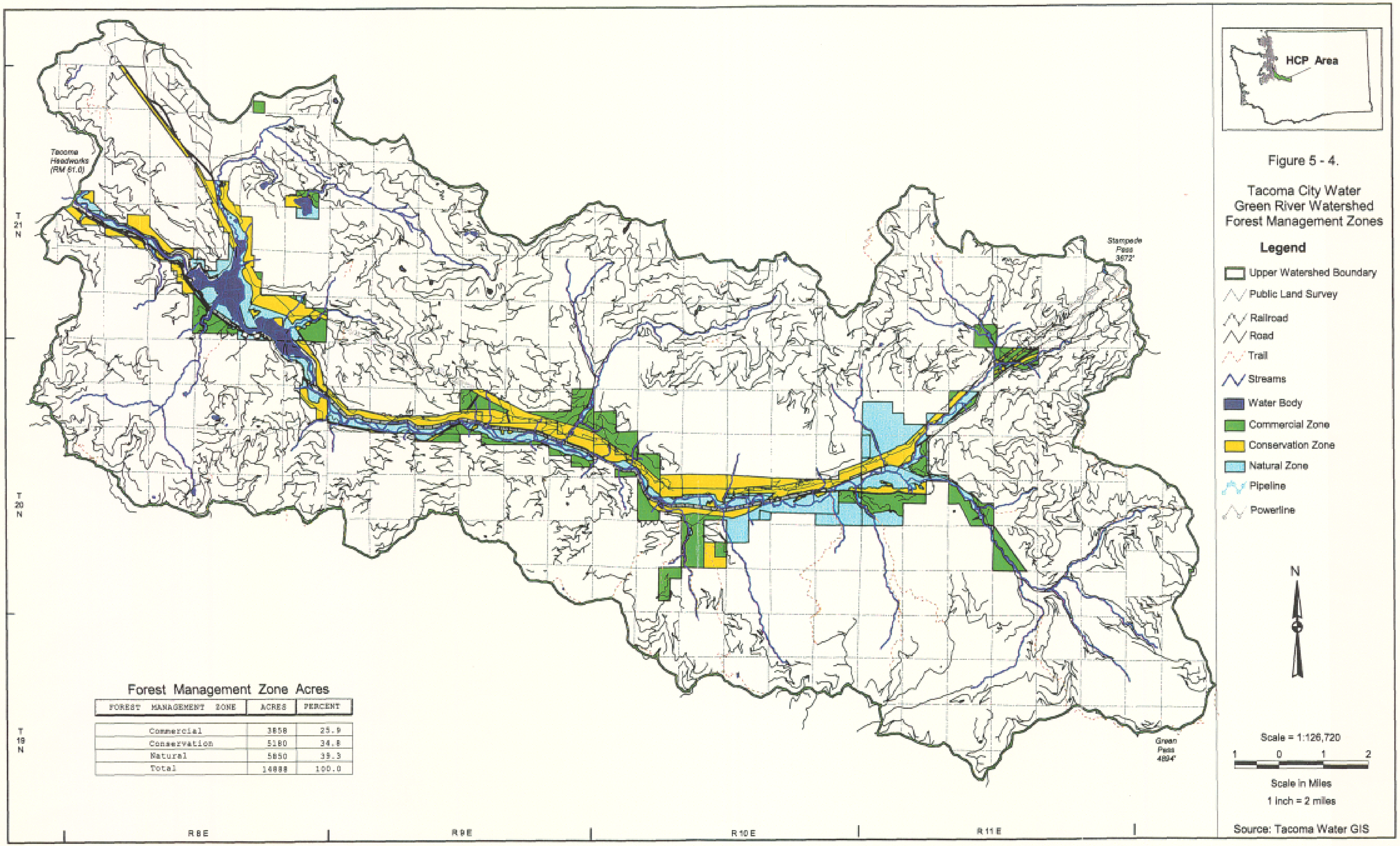

Figure 5 - 4.

Tacoma City Water
Green River Watershed
Forest Management Zones

Forest Management Zone Acres

FOREST MANAGEMENT ZONE	ACRES	PERCENT
Commercial	3858	25.9
Conservation	5180	34.8
Natural	5850	39.3
Total	14888	100.0

largely a function of proximity to surface water, particularly to the mainstem Green River and its major tributaries. To account for these site-specific differences in the level of concern for water quality, the ownership has been divided into three management zones (Natural, Conservation, and Commercial) and management measures have been developed specific to each zone. Those management measures with relevance to fish and wildlife habitat have been incorporated into this HCP. As additional lands are acquired by Tacoma in the future and added to the HCP (in accordance with provisions of the Implementation Agreement [IA]), Tacoma and the federal Services will review the newly acquired lands and place them into the management zone that is most consistent with the three objectives stated above (i.e., water quality, habitat, and timber revenues, in order of priority).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01B

MEASURE: Natural Zone

Tacoma will conduct no timber harvesting in those portions of the Upper HCP Area designated as Natural Zone, except to modify fish or wildlife habitat (with prior review by WDFW, and written approval of the USFWS and NMFS) or to remove danger trees within 150 feet of roads. This zone contains 5,850 acres. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all the costs associated with this measure.

Objective

The objective of this measure is to identify and appropriately manage those lands in the upper Green River watershed most important to the maintenance of surface water quality.

Rationale and Ecosystem Benefits

The Natural Zone encompasses lands within and directly adjacent to the Green River, Howard Hanson Reservoir, other lakes, and major tributary streams, where intensive forest practices could have a negative impact on water quality. This zone extends upland from the ordinary highwater mark of these waterbodies for a minimum of 200 feet, or until encountering a property boundary or major physical boundary (e.g., road or powerline right-of-way). The Natural Zone also includes two large blocks of upland mid-successional forest (80 to 90 years old) considered important to spotted owl conservation in the region. Management in the Natural Zone will be directed at preserving the health and vigor of the vegetative cover to reduce erosion and provide habitat for fish and wildlife. The long-term goal for the zone is to let forest stands develop into late-seral conditions through natural forest succession. No timber harvesting will occur in the

Natural Zone, except for the selective removal of danger trees within 150 feet of roads, and harvest activities specifically conducted to improve habitat for one or more fish or wildlife species. If these do occur, they will be reviewed by the WDFW and Services, and approved in advance by the federal Services to ensure they are consistent with this HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01C

MEASURE: Conservation Zone

Tacoma will conduct no even-aged harvesting in conifer-dominated stands (> 50 percent conifer species by basal area) in the Conservation Zone, and no harvesting of any kind (except selective removal of danger trees within 150 feet of roads and habitat modification that complies with snag, green recruitment tree and log retention standards in measures HCM 3-01F and 3-01G) in conifer-dominated stands over 100 years old in the Conservation Zone (where stand age is determined as the average age of dominant and codominant trees). Any habitat modification in conifer-dominated stands over 100 years old will be reviewed by the WDFW and approved in advance by the USFWS and NMFS. Tacoma may conduct uneven-aged harvesting in conifer-dominated stands less than 100 years old for the purpose of accelerating and/or enhancing the development of late-seral forest conditions. When conducting uneven-aged harvesting, Tacoma will leave a minimum of 50 healthy dominant or codominant conifers per acre (where available) dispersed across the harvest unit, and individual openings of no more than 10 acres. Green recruitment trees left to meet the requirements of snag and green recruitment tree retention will count toward the 50 trees left to meet this measure. Tacoma will conduct uneven-aged harvesting on an average of no more than 2 percent of the conifer-dominated stands in the Conservation Zone per year, averaged over the term of the HCP, unless a higher rate of harvest is necessary to meet fish and wildlife habitat or water quality goals reviewed by WDFW and approved by USFWS and NMFS. The maximum size of uneven-aged harvest units will be 120 acres. Uneven-aged harvest units will be monitored in accordance with EMM-03. This zone contains 5,180 acres. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all the costs associated with this measure.

Objective

The objective of this measure is to identify and appropriately manage lands in the upper Green River watershed where active manipulation of the vegetation (including logging) can be used to improve habitat for fish and wildlife.

Rationale and Ecosystem Benefits

The Conservation Zone lies directly upland of the Natural Zone and includes a number of forested lands, powerline rights-of-way, open fields, rock outcrops, and wetlands. The long-term goal for the Conservation Zone is similar to that for the Natural Zone (maintenance of late seral-forest), but a wider range of management tools is allowed in the Conservation Zone because of reduced sensitivity to potential water quality impacts from forest practices. No timber harvesting (except selective removal of danger trees within 150 feet of roads and habitat improvements) will occur in late-seral forest stands (those over 100 years old), and only uneven-aged harvesting methods will be used in younger coniferous forest stands. There will be no clearcutting larger than 10 acres in young coniferous stands, and uneven-aged harvesting will be done only for the purpose of accelerating the development of late-seral conditions. Once conifer stands in the Conservation Zone reach an age of 100 years, there will be no further harvesting other than selective removal (or topping when it is safe) of danger trees within 150 feet of roads and habitat modifications approved in advance by the Services. The uneven-aged harvest retention standard of 50 or more healthy dominant or codominant trees per acre will ensure sufficient trees are remaining after harvest to develop into a fully stocked stand of large trees by the time the stand is 100 years old. Although uneven-aged harvesting is considered largely a habitat improvement measure in this zone, Tacoma will limit the harvest that occurs in any 1 year to an average of 2 percent of the total conifer-dominated stands in the zone. This will provide a safeguard on water quality.

Stands dominated by hardwood species in the Conservation Zone may be converted to conifers (through clearcutting) as further habitat improvement, but this will only occur on sites capable of supporting coniferous forest stands. Once converted to conifers, those stands will only be subjected to uneven-aged harvesting, if necessary, until age 100, and no harvest (other than danger tree removal and habitat improvement) will occur after age 100.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01D

MEASURE: Commercial Zone

Tacoma will manage coniferous forest stands in the Commercial Zone on an even-aged harvest rotation of 70 years. Tacoma will conduct even-aged harvesting of stands dominated by coniferous trees (> 50 percent conifer species by basal area) only when stands are at least 70 years old, and will conduct even-aged harvesting on an average of no more than 1.5 percent of the conifer-dominated stands in the

HCM 3-01D (continued on next page)

HCM 3-01D (continued)

Commercial Zone per year, averaged over the term of the HCP. When conducting commercial thinning in the Commercial Zone prior to even-aged harvest, Tacoma will leave a minimum of 50 healthy dominant and codominant coniferous trees per acre, where available, and will comply with the snag, green recruitment tree and log retention standards of measure HCM 3-01G. This zone contains 3,858 acres. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all the costs associated with this measure.

Objective

The objective of this measure is to identify and appropriately manage lands in the upper Green River watershed where commercial timber harvest can occur without impacting surface water quality or significantly affecting fish and wildlife habitat.

Rationale and Ecosystem Benefits

The Commercial Zone includes those areas upland of the Natural and Conservation zones where forest practices can occur consistent with the protection of water quality and maintenance of fish and wildlife habitat. The objective in this zone is to grow and harvest commercial timber on a sustainable basis while minimizing impacts to water quality, fish and wildlife, and their habitats. Tacoma will manage coniferous forest stands in this zone on a 70-year, even-aged rotation, which is roughly 1.6 times the average commercial forest rotation in western Washington. This will result in a low average rate of harvest in the zone (1.5 percent per year) and will eventually lead to an even distribution of second-growth forest age classes within the zone.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01E

MEASURE: Hardwood Conversion

Stands in the Conservation Zone and Commercial Zone dominated by hardwood species (> 50 percent hardwoods by basal area) on sites capable of producing conifers of commercial size (Douglas-fir 50-year site index ≥ 80) may be converted to conifers by clearcutting the existing trees and replanting with conifers as specified in the reforestation habitat conservation measure. There will be no limit on the number of acres of hardwood-dominated stands that can be harvested and converted to conifers in a given year. All other even-aged harvest measures in this HCP will apply to hardwood conversions. Hardwood conversion will not occur in no-harvest riparian buffers. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all the costs associated with this measure.

Objective

The objective of this measure is to encourage the conversion of hardwood forest to coniferous forest in order to improve surface water quality and enhance habitat for fish and wildlife.

Rationale and Ecosystem Benefits

Hardwood species such as red alder (*Alnus rubra*), bigleaf maple (*Acer macrophylum*), and black cottonwood (*Populus trichocarpa*) are natural components of the coniferous forest landscape in western Washington, but their abundance has increased significantly over the past century as a result of commercial timber harvest. Where they were once limited to sites with moist soils and/or frequent natural disturbances (such as forested wetlands and low gradient stream corridors), they are now common on upland sites where alteration of soil conditions and/or poor regeneration practices in the past have delayed the return of coniferous species that existed prior to harvest. The Upper HCP Area will continue to support these hardwood tree species (and the wildlife that utilize them) in riparian corridors, forested wetlands, upland sites with frequent disturbances and throughout the Natural Zone, but other sites that supported mature conifer stands prior to earlier timber harvesting will be converted back to conifers by clearcutting existing hardwoods and replanting with seedling Douglas-fir (*Pseudotsuga menziesii*) or other suitable conifers. The eventual benefits to fish and wildlife will be those associated with the presence of late-seral coniferous forest habitat (in the Conservation Zone) and second-growth coniferous forest (in the Commercial Zone).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01F

MEASURE: Salvage Harvesting

Tacoma may conduct salvage timber harvesting in forested areas affected by windthrow, insect infestation, disease, or fire, subject to the following conditions:

- No salvage harvesting will occur in the Natural Zone or in stands over 100 years old in the Conservation Zone, except for selective removal (or topping when it is safe) of trees within 150 feet of roads for safety purposes. Trees felled will be left as wildlife habitat, or removed to be used elsewhere to meet one or more of the conservation measures of this HCP.
- No salvage harvesting will occur within no-harvest portions of riparian or wetland buffers, or within forested areas with a Douglas-fir 50-year site index of ≤ 80 (i.e., Upland Management Areas [UMAs]). Trees felled for safety purposes within no-harvest riparian buffers will be placed on the streamside portion of the buffer.

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HCM 3-01F (continued)

- Individual salvage harvest areas will include no more than 120 contiguous acres.
- Salvage harvesting will be conducted in a manner that complies with the snag, green recruitment tree and log retention requirements of measure HCM 3-01G, except the total number of safe snags required to be left will not exceed six per acre.
- Salvage harvesting in stands less than 100 years old in the Conservation Zone will be conducted in a manner that complies with the uneven-aged harvesting requirements of measure HCM 3-01C, except there will be no limitation on the number of acres of salvage harvesting in any year.
- Salvage harvesting may occur in stands less than 100 years old in the Conservation Zone when insects, fire, windthrow, or disease reduces total canopy closure to less than 40 percent over 2 or more acres.
- Salvage harvesting may occur in the Commercial Zone when insects, fire, windthrow, disease, or flood reduces total canopy closure to less than 40 percent over 2 or more acres.
- No tree, or portion of a tree, that has entered the stream channel will be salvaged.
- Live healthy coniferous trees will not be felled during salvage harvesting unless such felling is necessary to access dead and damaged trees in a safe and economical manner.

Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect surface water quality and habitat for fish and wildlife by establishing restriction on the salvage harvest of timber.

Rationale and Ecosystem Benefits

Salvage harvesting will help maintain the health of the forest in the Commercial Zone and contribute to the economic return from these lands, ultimately benefiting the other watershed management programs that require funding. However, salvage harvesting can have negative impacts on water quality and habitat if not conducted properly. Measures are therefore necessary to avoid any negative impacts of salvage harvesting.

No salvage harvesting will occur within no-harvest riparian buffers, or in areas not suited to commercial production of conifers (i.e., those with a site index of ≤ 80). Salvage harvesting will also be restricted in the Natural Zone and in stands over 100 years old in the Conservation Zone because it is counter to the objective of creating and maintaining late-seral forest conditions. In the Commercial Zone and the remainder of the Conservation Zone, fire, wind, or disease must reduce the canopy closure below 40 percent over 2 or more acres before salvage harvesting can occur. This will limit salvage operations to those instances where there is the potential for a significant area within the zone to be without a forest cover as a result of disturbance. Smaller disturbances, and all disturbances caused by flooding in the Conservation Zone, will be allowed to recover naturally without intervention or salvage harvesting.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01G

MEASURE: Snags, Green Recruitment Trees, and Logs

When conducting even-aged harvesting, uneven-aged harvesting, or commercial thinning in the Upper HCP Area, Tacoma will retain all safe snags and at least four green recruitment trees ($\geq$ 12 inches diameter at breast height [dbh]) and four logs ($\geq$ 12 inches diameter; $\geq$ 20 feet long) per acre, where available. At least one of the green recruitment trees will be $\geq$ 20 inches dbh, and another will be $\geq$ 16 inches dbh. If sufficient green recruitment trees of this size are not available, the largest available green trees will be left. No more than two of the green recruitment trees can be hardwoods. Preference will be given to leaving large, live defective green recruitment trees. If at least six safe snags ($\geq$12 inches dbh; $\geq$ 20 feet tall) are not available per acre of harvest, additional green recruitment trees ($\geq$ 12 inches dbh) will be left at a replacement ratio of 1 to 1. If at least two safe snags $\geq$12 inches dbh and $\geq$ 20 feet tall are not available per acre of harvest in stands with an average stand dbh $\geq$ 12 inches, up to two of the larger green recruitment trees will be topped, girdled, inoculated with fungus or otherwise killed to create new snags at the time of harvest. Green recruitment trees will be killed at a replacement ratio of 1 to 1, so that at least two snags or recently killed recruitment trees are left per acre of harvest, averaged over the harvest unit. Snags and green recruitment trees will be scattered or clumped within harvest units, depending on pre-harvest distribution, harvest limitations, safety and likelihood of long-term survival. In the Commercial Zone, the preferred method will be to leave snags and green recruitment trees in clumps along stream and wetland buffers, adjacent to UMAs or along harvest unit boundaries. In the Conservation Zone, Tacoma will attempt to leave snags more evenly distributed among the 50 or more dominant or codominant trees remaining after harvest. In the Natural Zone all snags will be allowed to persist naturally unless determined to be safety hazards in accordance with measure HCM 3-01F. The distance between clumps will be no greater than 600 feet. Clumps will include 10 or more snags and/or green recruitment trees, and four or more logs. Snags and green trees left to meet riparian buffer

HCM 3-01G (continued on next page)

HCM 3-01G (continued)

requirements or left in UMAs will count toward meeting the requirements of this measure for one harvest unit directly adjacent to each riparian buffer or UMA. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect and enhance habitat for cavity-dwelling wildlife in the upper Green River watershed.

Rationale and Ecosystem Benefits

Snags, residual live trees, and logs provide several essential habitat elements to fish and wildlife. Snags and large trees in riparian areas contribute LWD for instream cover, pool formation, sediment trapping, bank stabilization, and nutrient input. Snags, large trees, and logs in riparian and upland areas also provide nests, burrows, perches, and foraging substrate for a wide range of wildlife species, some of which would not occur in a given area without the presence of these habitat features. Most wildlife species covered by this HCP make use of snags, large trees and/or logs; two (Vaux's swift and pileated woodpecker) are dependent on them. In the past, common practice in the Pacific Northwest was to eliminate snags, large trees, and logs during timber harvest because they presented hazards to worker safety, interfered with harvest operations, occupied space potentially available to new tree seedlings, and/or had commercial value if removed from the forest. These concerns still exist today, but Washington Forest Practices Rules and Regulations now require retention of certain numbers of snags, trees, and logs at the time of even-aged harvest, subject to maintaining safe and economic working conditions. The measure for snag, green recruitment tree, and log retention in this HCP is double the current state requirement in terms of the number of pieces to be retained. This HCP measure also requires that at least some of the trees be of a larger size than required under state regulation. The maximum allowable spacing between snags and green recruitment trees is also less in this HCP than in state regulations, to account for species with small home ranges that may require these habitat elements to be distributed more evenly across the landscape. The two HCP species of most concern relative to snags (Vaux's swift and pileated woodpecker) are addressed in species-specific measures elsewhere in this HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01H

MEASURE: Harvest Unit Size

Even-aged harvest units (i.e., clearcuts) in the Upper HCP Area will not exceed 40 acres in size. Uneven-aged and salvage harvest units will not exceed 120 acres in size without prior review by WDFW and approval by the USFWS and NMFS. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize the effects of timber harvest on water quality, fish, and wildlife by limiting the size of individual harvest units.

Rationale and Ecosystem Benefits

Even-aged harvesting is an essential management tool in western Washington, where commercially valuable coniferous species such as Douglas-fir are intolerant of shade and will not regenerate under existing forest canopies. Even-aged harvesting is also environmentally less damaging under certain circumstances because it can be conducted with fewer roads and less ground impact on steep slopes than can uneven-aged harvesting. However, even-aged harvesting can be detrimental to water quality and fish and wildlife habitat if conducted in large harvest units or in multiple small units over a very short period of time. To avoid such impacts, even-aged harvest units in the Upper HCP Area will be limited to 40 acres in size.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01I

MEASURE: Even-aged Harvest Unit Adjacency Rule

Even-aged harvesting will only occur when the surrounding forestland is fully stocked with conifer trees a minimum of 5 years old or a minimum of 5 feet high. This measure will not apply to lands incapable of supporting fully stocked forest stands or lands converted to a non-forest use adjacent to harvest units. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize the effects of timber harvest on water quality, fish, and wildlife by limiting the rate of harvest in a local area.

Rationale and Ecosystem Benefits

As noted under other habitat conservation measures, even-aged harvesting can be conducted with minimal impact to water quality and habitat if the size of harvest units is limited. This measure exceeds current Washington State Forest Practices Rules and Regulations, which require that at least 90 percent of the perimeter of a harvest unit be surrounded by trees at least 5 years old or at least 4 feet tall, and that the stands of surrounding forest be at least 300 feet wide. Proposed habitat conservation measures, combined with the limited area in which even-aged harvesting occur (Commercial and Conservation zones only) and the very low rate of harvest (average of 1.5 to 2.0 percent per year by zone, respectively), ensure that the negative effects of even-aged harvesting will be avoided in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01J

MEASURE: Harvest Restrictions on Sites with Low Productivity

Timber harvesting in the Upper HCP Area will occur only on lands with a Douglas-fir 50-year site index of 80 or greater. Lands with lower site indices will be designated as UMAs and managed without timber harvest for the term of the HCP. Snags and green trees left in a UMA will count toward meeting the requirements of HCM 3-01G for one harvest unit directly adjacent to each UMA. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize the long-term ecological impacts of timber harvest by restricting harvest on sites with low productivity.

Rationale and Ecosystem Benefits

Timber harvesting in the Upper HCP Area will occur only on sites capable of sustained timber production under a 70-year, even-aged rotation. For purposes of this HCP, harvestable sites are defined as those with a Douglas-fir 50-year site index of 80 or greater. Site index is the height (in feet) that a dominant tree of a given species will reach within the specified period of time. Site index for Douglas-fir at 50 years in the western Washington Cascades can be as high as 160, but most commercial stands have site indices between 80 and 140. Sites with lower productivity are still capable of producing trees of commercial size, but the sites are often expensive to harvest, difficult to regenerate, and susceptible to water quality impacts because of erodable and/or easily compacted soils. They are not well suited to repeated harvesting at 70-year intervals. To avoid the potential impacts associated with harvesting and subsequent regeneration of these areas, Tacoma will protect them from harvest and retain them as permanent habitat. There are approximately 103 acres in the Conservation Zone and 150 acres in the Commercial Zone that have been set aside as UMAs. They range in size from 1 to 30 acres, and are mostly dominated by Douglas-fir growing on thin soils.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01K

MEASURE: Contractor, Logger, and Employee Awareness

All successful timber purchasers, loggers, and other forestry contractors operating in the Upper HCP Area will be provided copies of the pertinent HCP measures and required to comply with all relevant terms and conditions of the HCP while conducting any activities in the Upper HCP Area. All full-time Tacoma employees working in the Upper HCP Area will be instructed in the identification of all species covered by this HCP and their nests, dens, and preferred habitat. Copies of pertinent HCP requirements will be provided to contractors within 6 months of ITP issuance and Tacoma employees regularly working in the upper Green River watershed will be trained in the identification of HCP wildlife species within 1 year of ITP issuance. Tacoma will fund all costs associated with this measure.

Objective

The objective of this measure is to ensure successful implementation of the Tacoma HCP by informing and instructing employees and contractors working in the HCP Area.

Rationale and Ecosystem Benefits

The effectiveness of this HCP will ultimately depend on the successful implementation of all mitigation measures in the field. To that end, all operators, contractors and full-time Tacoma employees working in the Upper HCP Area will be provided the necessary information to ensure they conduct their activities in compliance with the HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01L

MEASURE: Logging Slash Disposal

Tacoma will burn no logging slash in the Natural Zone, unless the burning is part of a habitat modification effort reviewed by WDFW and approved in advance by the USFWS and NMFS. Logging slash generated during timber harvesting operations in the Conservation and Commercial zones may be treated by mechanical- and/or hand-piling followed by burning (both zones), or by broadcast burning (Commercial Zone

HCM 3-01L (continued on next page)

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and powerline rights-of-way within the Conservation Zone only). Harvested areas on slopes of 30 percent or less may be mechanically scarified with low-ground-pressure tractors if slash and/or brush interfere with replanting. No mechanical scarification will occur on slopes greater than 30 percent. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize the effects of timber harvest on water quality and habitat for fish and wildlife by restricting the burning of logging slash.

Rationale and Ecosystem Benefits

Harvest-related slash (tree tops, limbs, bark, and brush) can create a fire hazard and interfere with forest regeneration. Burning is an effective means of eliminating slash, preparing soils for regeneration, and reducing future competition between brush and tree seedlings. Burning can have negative impacts, however, if it reduces soil fertility, contributes to soil erosion, and eliminates snags, logs, and shrub cover that can provide fish and wildlife habitat. Tacoma will conduct no slash burning in the Natural Zone, unless specifically prescribed as a habitat improvement measure. In the Conservation Zone, Tacoma will burn slash only in piles (i.e., no broadcast burning except under powerline rights-of-way to improve forage) to avoid soils impacts and allow for the retention of snags, logs, and brush away from piles. In the Commercial Zone, the use of broadcast burning will be minimized to those areas where it is necessary to reduce fire hazard and achieve adequate regeneration. Pile burning will be the preferred method of slash disposal in the remainder of the Commercial Zone. Mechanical scarification, which is an alternative to burning, will be employed where it will achieve the same results as burning without the negative impacts to soils and habitat. Mechanical scarification can lead to problematic erosion on steep slopes, so Tacoma will conduct no mechanical scarification on slopes over 30 percent.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01M

MEASURE: Reforestation

All even-aged harvest areas will be replanted with 300 to 400 suitable tree seedlings per acre by the first spring following harvesting. Douglas-fir will be the preferred species for planting, but shade-tolerant western hemlock, western red cedar, or true fir

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HCM 3-01M (continued)

will be planted on sites not suitable for Douglas-fir. Openings in uneven-aged harvest areas will be replanted with 50 to 100 shade-tolerant conifers per acre. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to ensure long-term productivity and optimal habitat benefits of commercial timberlands in the upper Green River watershed by requiring reforestation after harvest.

Rationale and Ecosystem Benefits

Quick and effective regeneration of harvested areas will be important to meeting the HCP objectives of maintaining water quality and providing habitat for fish and wildlife. Tacoma will replant harvest units at the earliest logical date (the first spring following harvest, when conditions are favorable for seedling establishment) and will plant sufficient numbers of seedlings of the appropriate species to achieve a healthy, diverse forest stand in the shortest time practicable.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01N

MEASURE: Harvest on Unstable Slopes

Tacoma will conduct harvest activities on unstable landforms in accordance with prescriptions developed through watershed analysis, unless the watershed analysis prescription(s) would be less restrictive than one or more HCP measures specific to timber harvest. Tacoma personnel responsible for harvest unit layout will receive field training in the identification of potentially unstable landforms within 1 year of ITP issuance.

In Watershed Administrative Units (WAUs) where a slope stability assessment and draft and final prescriptions have not been completed through the formal Washington Department of Natural Resources (WDNR) Watershed Analysis process within 2 years of issuance of the ITP, Tacoma will fund the assessment and mapping of lands within the Tacoma ownership using landforms described in previous analyses, or by identifying new landforms if necessary. Interim prescriptions completed to fulfill commitments made in this HCP will equal or exceed existing state rules and will be submitted to the WDNR for review via the usual Forest Practices Application process and be approved by the Services. Draft prescriptions developed to address slope stability associated with timber harvest on similar landforms in the Lester, Howard Hanson/Smay and Upper Green/Sunday Watershed Analyses will be applied until official Watershed Analyses have been completed and approved. Tacoma will fund all of costs associated with this measure.

Objective

The objective of this measure is to protect long-term productivity of commercial timberlands in the upper Green River watershed and minimize the effects of timber harvest on water quality and fish habitat by restricting timber harvest on sites with a potential for slope failure.

Rationale and Ecosystem Benefits

Mass-wasting assessments conducted to date in the Upper HCP Area have identified a relatively consistent suite of landforms that are considered to have a moderate to high mass-wasting potential. These landforms, called Mass Wasting Mapping Units (MWMUs) include earthflow toes, bodies and scarps; inner gorges; headwalls; glaciofluvial terrace escarpments, and steep undissected hillslopes in various geologic units (Plum Creek 1996; USFS 1996).

Maps depicting the general location of the MWMUs have been completed for five of the six WAUs in the Upper HCP Area, and prescriptions have been developed to reduce the risk of future management-related mass-wasting from those MWMUs with a moderate to high mass-wasting potential (Appendix D). Implementation of many of these prescriptions requires field delineation of the mapping units. The descriptions of the MWMUs are intended to be used as guides to delineate the actual boundaries of the map unit in the field during layout of proposed harvest units. To facilitate identification of potentially unstable mapping units, Tacoma will require employees or contractors responsible for harvest unit layout to attend a field course in the identification of unstable slopes at least once every 5 years.

Draft and final prescriptions developed to date require field mapping of inner gorges, headwalls, zero-order basins with slopes greater than 70 percent, and areas of active mass wasting or potential instability. Harvest units located on steep zero-order basins, snow avalanche chutes, slump/earthflow toes, escarpments along the Green River, and within bedrock hollows or within 100 feet of recent slumps that feed into inner gorges or linear draws in canyons of mainstem tributaries must be reviewed by a slope stability specialist. No harvest will be allowed in headwalls, inner gorges (extending 20 feet beyond the slope break or at least 50 feet from the ordinary high water mark where no slope break is present), within one crown width (approximately 20 feet) of steep Type 4 and 5 streams with sideslopes greater than 70 percent on slump/earthflow bodies or within 20 feet of active landslides.

Tacoma will implement existing draft and final watershed analysis prescriptions upon issuance of the ITP regardless of whether the analyses have been formally approved by the WDNR. Upon completion and approval of future watershed analyses, Tacoma will implement any additional prescriptions that may be approved.

In WAUs where assessments have not yet been completed, Tacoma will utilize descriptions of landforms developed for other WAUs within the upper Green River watershed to map and assess slope stability on lands within the HCP Area, or will develop new landform descriptions if necessary. The assessment will be completed by a slope stability specialist certified to conduct a Level 2 Mass Wasting Analysis under the WDNR training program. Until formal watershed analyses have been completed and approved, Tacoma will implement prescriptions that have been developed and approved for similar landforms in adjacent WAUs.

5.3.2 Habitat Conservation Measure: HCM 3-02 Riparian Management Measures

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-02A

MEASURE: No-Harvest Riparian Buffers

In addition to the general harvesting restriction in the Natural Zone (HCM 3-01B), the limitation on harvesting in the Conservation Zone (HCM 3-10C) and the implementation of a 70-year sustainable harvest rotation in the Commercial Zone (HCM 3-01D), Tacoma will retain no-harvest riparian buffers along all streams and around wetlands in the Upper HCP Area. Minimum widths of riparian buffers will be as shown in Figure 5-5 and Tables 5-2 and 5-3. Riparian buffer widths may be increased (but not decreased) through a formal Washington State Forest Practices Board Watershed Analysis. Timber management activities will occur within no-harvest portions of riparian buffers only to modify fish or wildlife habitat or further other goals of this HCP, and only with prior review by WDFW and concurrence of the USFWS and NMFS. Trees cut as a result of such activities will be left within no-harvest riparian buffers.

Timber yarding may occur across stream Types 4 and 5 riparian buffers, but such yarding will be limited to full or partial suspension cable yarding (no ground-based yarding) and will affect no more than 15 percent of the total length of buffer within or adjacent to a given harvest unit. Yarding corridors across landforms with a moderate to high mass-wasting potential will be no wider than 30 feet and located on slopes < 80 percent with no indication of seasonal saturation or recent slope movement. Full log suspension will be utilized in all potentially unstable landforms and within 20 feet of stream channels in areas of high sediment delivery potential. Any trees within a riparian buffer that are killed or damaged by yarding operations will be left in the buffer (i.e., they will not be salvaged). Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure. See following Figure 5-5 and Tables 5-2 and 5-3.

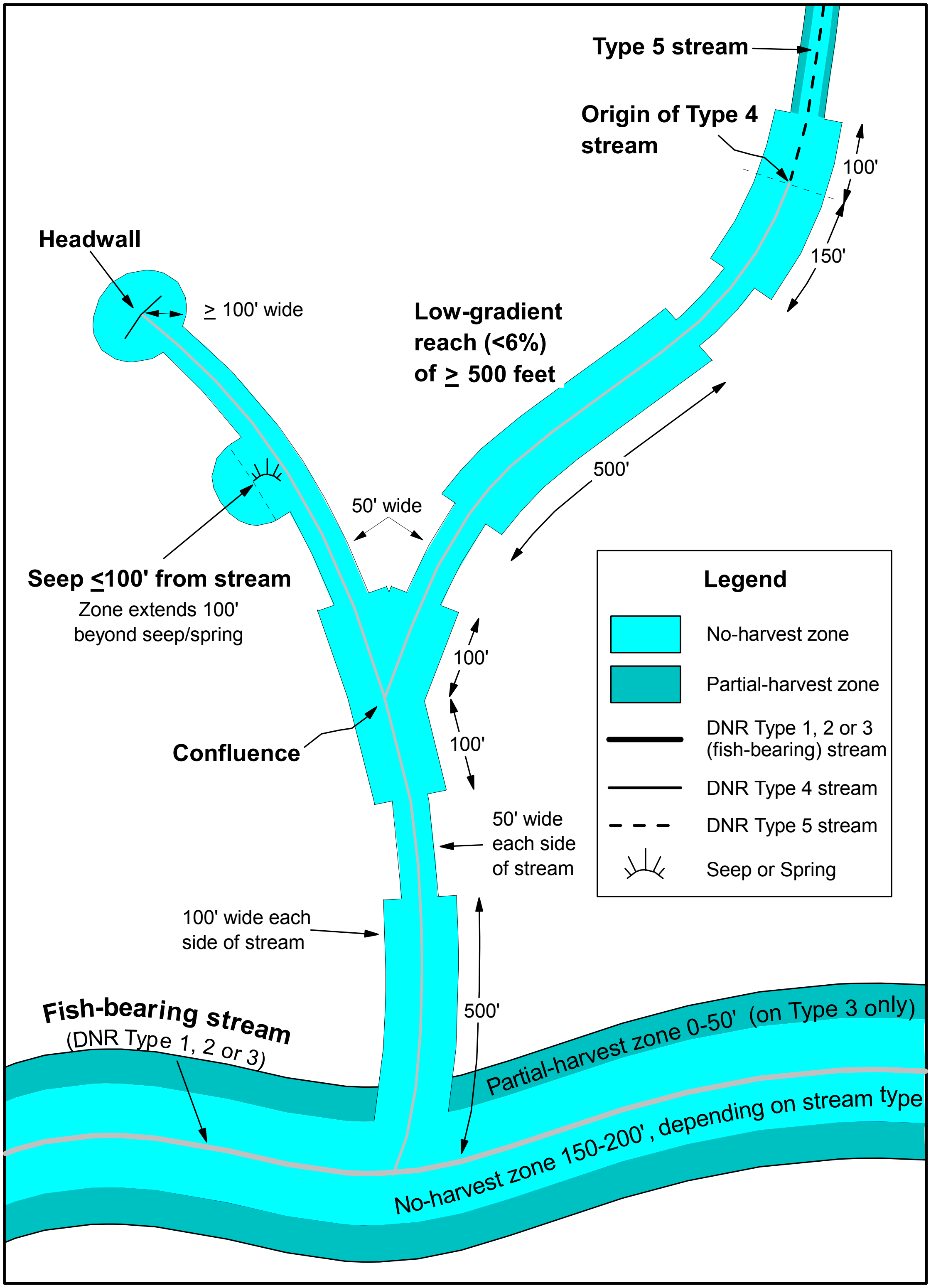

Figure 5-5. Diagram of Type 4 stream buffer zone implementation.

Table 5-2. Stream buffer widths for the Tacoma Green River HCP.

WDNR Stream Type [1]	No-Harvest Buffer Width [2, 4]	Partial-Harvest Buffer Width [3, 4]
Types 1 and 2	200 feet	0
Type 3	150 feet	50 feet
Type 4	50 to 100 feet [4, 5]	0
Type 5	25 feet	25 feet

[1] All streams (currently mapped or unmapped) within 200 feet of a proposed forest practice will be evaluated in the field in accordance with current Washington Forest Practices Rules and Regulations prior to submission of a Forest Practices Application to determine if they should be reclassified.

[2] Buffer widths will be measured horizontally from the edge of a stream's bankfull width or the outer edge of its channel migration or channel disturbance zone, whichever is greater, along each side of the stream. Buffer width around Howard Hanson Reservoir will be measured horizontally from elevation 1,177 feet above mean sea level. Only fish and wildlife habitat mitigation work will be allowed to occur in this buffer.

[3] Partial-harvest buffer width will be measured horizontally from the outer edge of the no-harvest zone along each side of the stream. Partial harvest will leave not less than the 70 largest conifer trees per acre in buffers along Type 3 waters, and not less than the 50 largest conifer trees per acre in buffers along Type 5 waters.

[4] The presence of road or right-of-way will not affect width of buffers. Only that portion of any wood protruding within 10 feet of the road tread can be cut to eliminate a safety hazard.

[5] The no-harvest buffer along Type 4 streams will be a minimum of 50 feet wide, and will be expanded to 100 feet wide:
- at the upstream origins of Type 4 streams (including 100 feet upstream and 150 feet downstream);
- at headwalls and along steep and unstable slopes (this width may be further increased by watershed analysis);
- at confluences with other Type 4 streams (including 100 feet upstream and 100 feet downstream);
- at confluences of Type 4 streams with fish-bearing streams (including 500 feet upstream);
- around springs and seeps within 100 feet of Type 4 streams; and
- along low-gradient reaches of Type 4 streams (i.e., those with a gradient of ≤ 6 percent for 500 or more contiguous feet).

Table 5-3. Wetland buffer widths for the Tacoma Green River HCP.

Wetland Type [1]	Wetland Size	No-Harvest Buffer Width [2]
Non-forested Wetlands with ≥ 0.5 acre open water		
Type A (all)	> 5.0 acres	200 feet
Type A (all)	0.5 to 5.0 acres	100 feet
Type A (bogs/fens only)	0.25 to 0.5 acre	100 feet
Non-forested Wetlands with < 0.5 acre open water		
Type B (all)	> 5.0 acres	100 feet
Type B (all)	0.25 to 5.0 acres	50 feet
Forested Wetlands(>30 percent canopy cover)		
Type C (all)	> 5.0 acres	50 feet
Type C (all)	0.5 to 5.0 acres	25 feet

[1] All wetland definitions follow Washington Forest Practices Rules and Regulations, WAC 222-16-035, effective July 1995.

[2] Buffer width will be measured horizontally from the edge of the wetland.

1

Objective

The objective of this measure is to protect and enhance water quality and habitat for fish and wildlife by timber harvest directly adjacent to streams.

Rationale and Ecosystem Benefits

Riparian zones are areas with unique soil, vegetation and resource values, comprised of an aquatic ecosystem, seasonally flooded banks or terraces and adjacent upland areas that have a direct influence on the aquatic habitat. Numerous authors have identified a need for riparian buffers along streams for the purpose of maintaining or enhancing key riparian functions (Bisson 1987; Castelle et al. 1994; Belt and O'Loughlin 1994). One of the primary functions of the riparian buffer is the recruitment of LWD. McDade et al. (1990) observed that ninety percent of the LWD delivered to streams in unmanaged, mature Douglas-fir/hemlock stands in western Washington and Oregon were derived from within 100 feet of the stream channel. Similar studies by Murphy and Koski (1989) in old-growth Sitka spruce and hemlock forests southeast Alaska indicate that 99 percent of the in-channel LWD was recruited from 100 feet of the stream. Robison and Beschta (1990) suggested that buffer strips with widths on each stream bank at least equal to tree height would provide for maximum amounts of LWD. Large woody debris loading is related to the number of mature trees along the stream, and to local geologic and channel morphologic conditions (Martin in press; Keller et al. 1995).

Trees and undisturbed understory vegetation within riparian buffers also stabilize banks, filter sediment, and provide shade and nutrients. The contribution of root strength to maintenance of bank stability declines at distances greater than one-half the crown diameter (Burroughs and Thomas 1977). Filter strips 200 to 300 feet wide are generally effective in controlling sediment that is not channelized (Haupt 1959). Broderson (1973) found that buffers 200 feet wide effectively controlled sedimentation, even on steep slopes. The effectiveness of the riparian buffers at providing shade varies with topography, channel width and orientation, and forest structure, particularly the extent of both understory and overstory vegetation (USDA et al. 1993). As with shade, the distance away from the stream from which litter inputs originate depends on site-specific conditions, but riparian forests of widths equal to or greater than 100 feet are believed to be sufficient to maintain nutrient inputs and biotic community structure in streams (USDA et al. 1993).

Riparian forest also plays an important function as habitat for plants and animals. Due to their high overall productivity and their wide range of gradients, aspects, soils and moisture conditions, riparian forests support a diversity of plant and animal life that typically exceeds that of the adjacent upland and aquatic habitats (Odum 1971). Riparian forests provide thermal cover for streamside amphibians that require cool, moist habitats; travel corridors for species that hunt along streams and/or have very large home ranges (e.g., Pacific fisher); and escape cover for most other species that travel to streams on a regular basis for water (Thomas 1979; Taber 1976; Tabor 1976). Riparian forests often also have higher diversities and densities of understory plant life than surrounding uplands, thereby providing habitat to certain birds and mammals that cannot be found in uplands (Stevens et al. 1977). In the shifting mosaic of a managed forest landscape, riparian areas can serve important habitat functions by providing both a stable source of closed-canopy forest and edge habitat at the interface between the riparian forest and recent clearcut.

The Upper HCP Area contains approximately 110 miles of streams (Table 5-4). Except for the presence of the Green River (including Howard Hanson Reservoir) and its major tributaries in the Natural Zone, the distribution of total stream miles is roughly equivalent among the three management zones. The distribution of stream miles among the WDNR stream types is typical of western Washington, with Type 1 and Type 5 being the most abundant.

Table 5-4. Stream miles within the Upper HCP Area.

WDNR Stream Type	Miles of Stream			
	Commercial Zone	Conservation Zone	Natural Zone	All Zones
1	0.71	2.30	41.07[1]	44.08
2	0.08	0.00	0.15	0.23
3	3.06	4.27	8.32	15.65
4	4.81	7.53	5.95	18.29
5	11.95	10.54	9.62	32.11
Total	20.61	24.64	65.11	110.36

[1] Natural includes 7.92 miles of reservoir shoreline

All 65 stream miles in the Natural Zone will be protected because, in accordance with measure HCM 3-01B, there will be no commercial forestry. Habitat alteration will occur in the Natural Zone only to improve fish and/or wildlife habitat, and only with the prior approval of the Services. Harvesting will take place on a limited basis in the Conservation Zone, and to a greater (although still limited) basis in the Commercial Zone. Measures specific to the protection of riparian and aquatic habitats are appropriate for these zones. Measure HCM 3-02A therefore calls for no-harvest zones of 25 to 200 feet in width along each side of streams in the HCP Area, the width depending on the stream type. Along larger streams (WDNR Types 1, 2 and 3) where stream temperature, LWD and streamside habitat are most critical, no-harvest buffers will be at least 150 feet wide (exceeding the minimum recommendations of Murphy and Koski [1989], USDA [1993] and others). On smaller perennial streams (WDNR Type 4) the no-harvest buffers will be at least 50 feet wide, and will be expanded to 100 feet wide at all sensitive areas such as confluences, low-gradient reaches, seeps, headwalls and stream origins. Type 5 streams are the intermittent headwaters of larger streams. While they provide limited habitat themselves, they lead to larger waters downstream and contribute to the temperature, nutrient levels, and LWD in those larger streams. For those reasons, all Type 5 streams will also have no-harvest buffers of 25 feet in width.

The total area included within no-harvest riparian buffers will be 2,126 acres (Table 5-5). In addition to maintaining riparian functions in all streams in the Upper HCP Area, the no-harvest riparian zones will develop into a core of late-successional coniferous forest habitat available to riparian as well as upland wildlife species in the watershed. The 686 acres of no-harvest buffer included within the Commercial and Conservation zones represent 9.8 percent of the total forested area within those zones (686 ÷ 7,025).

Table 5-5. Acres of habitat included within riparian management zones in the Upper HCP Area.

WDNR Stream Type	No-harvest Buffer Width (feet)	Partial-harvest Buffer Width (feet)	Acres of Commercial Zone [1]	Acres of Conservation Zone [1]	Acres of Natural Zone	Total Acres [1]
1	200	0	123	89	1158	1370
2	200	0	2	0	4	6
3	150	50	148 (+ 49)	103 (+ 34)	188	439 (+ 83)
4	≥50	0	56	59	48	163
5	25	25	68 (+ 68)	38 (+ 38)	42	148 (+ 106)
Total			397 (+ 117)	289 (+ 72)	1440	2126 (+ 189)

[1] Numbers in parentheses reflect acres in partial-harvest buffers.

Cable yarding of harvested timber will be allowed through riparian buffers along Type 4 and 5 streams in the Commercial and Conservation zones to minimize the amount of new road construction in these areas. Given the high density of smaller streams in the HCP Area, it is difficult, if not impossible, to reach all harvestable areas without either building temporary logging roads or lifting felled timber across streams with cable yarders. Forest roads have been identified as a major contributor to stream sediment in western Washington, so it is one objective of this HCP to minimize new road construction. This will necessitate occasional yarding across streams. All yarding will be done by cable, with one or both ends of the log suspended above the ground, so soil disturbance will be minimized. The typical result will be damage (i.e., limb breakage and/or topping) of trees in the yarding corridor. With the long harvest rotations of 70 years or more in the HCP Area (i.e., long return intervals for any one stream segment) and the limitation of no more than 15 percent disturbance to any stream segment, the impacts of yarding across stream corridors will be more than offset by the benefits of reducing new road construction.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-02B

MEASURE: Partial-Harvest Riparian Buffers

Tacoma will retain partial-harvest riparian buffers along Type 3 and 5 streams as specified in Table 5-2 and shown in Figure 5-5. Timber harvesting in partial-harvest buffers will comply with all other pertinent measures in this HCP, and will result in leaving the 70 largest coniferous trees per acre along Type 3 streams and the 50 largest coniferous trees per acre along Type 5 streams. At the time of partial-harvesting, preference will be given for leaving: 1) trees that are damaged and/or leaning toward the stream; 2) trees that, due to soil conditions, slope, or proximity to the stream, have a high likelihood of delivering LWD to the stream; 3) trees with deformities or other features that provide unique wildlife habitat elements; and 4) trees with signs of wildlife use (e.g., nests, cavities, foraging holes, etc.). All other considerations being equal, trees nearer the stream will be given preference over trees toward the outer edge of the riparian buffer, so that the density of leave-trees may be higher near the stream and lower near the outer edge of the buffer.

Objective

The objective of this measure is to protect and enhance water quality and habitat for fish and wildlife by restricting timber harvest near riparian areas.

Rationale and Ecosystem Benefits

As described under the rationale for measure HCM 3-02A, forested riparian buffers are important to fish, wildlife and water quality. As a margin of safety on Types 3 and 5 streams, Tacoma will manage an additional 25 to 50 feet as partial-harvest beyond the no-harvest riparian buffers. These areas will provide additional LWD, shading and upland forest habitat along streams, to the benefit of species using these areas. More importantly, Tacoma will have the ability to enter these zones and encourage the development of large coniferous trees by removing hardwoods and smaller conifers. This will ultimately lead to improved conditions for both fish and wildlife. Given the post-harvest tree retention standards for these areas, and the long intervals between entries (70 years or more in the Commercial Zone, and no more than one entry in the Conservation Zone during the term of the ITP) these areas will differ from adjacent no-harvest buffers for only one to two decades after harvest.

5.3.3 Habitat Conservation Measure: HCM 3-03 Road Construction and Maintenance Measures

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03A

MEASURE: Watershed Analysis

Tacoma will participate in all watershed analyses performed according to the Washington Forest Practices Board process for lands within the Upper HCP Area. Tacoma will implement all prescriptions prescribed through watershed analysis, unless they would be less restrictive than measures described in this HCP. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to encourage comprehensive watershed assessment and management in the upper Green River watershed.

Rationale and Ecosystem Benefits

In 1992, the Washington Forest Practices Board adopted a watershed analysis process for developing individual watershed plans based on a comprehensive understanding of basin-wide processes (Chapter 222-22 WAC). The watershed analysis process includes an evaluation of mass wasting, surface erosion, hydrology, riparian function, channel geomorphology, fish habitat, public works, and water quality. It is a collaborative scientific process involving Tribes, resource specialists, landowners, agencies, and interested members of the public.

In a watershed analysis, qualified scientists gather information and develop interpretations of watershed processes, resource conditions, and sensitivities at the watershed scale. The basic premise of the analysis is that a change in sediment delivery, hydrology, or riparian function resulting from forest practices is significant when it is sufficient to cause an adverse change in a public resource (fish habitat, water quality, and public works). Risks to public resources are identified and supported with data generated by the analyst team. The results of a watershed analysis are presented using maps of sensitive areas and reports describing the nature of the sensitivity. Land managers and resource agency representatives use the information to develop management prescriptions that have been tailored to watershed conditions in response to resource concerns identified by the scientific investigation. Monitoring plans are often recommended to track the effectiveness of prescriptions and to provide feedback as to whether resource conditions are actually improving as a result of the prescriptions. Relevant data collected as part of the HCP monitoring process will be provided to analysts upon request.

Upon completion of the draft assessment report and prescriptions, an environmental checklist is completed, as required under the State Environmental Policy Act, and the report and prescriptions are forwarded to the WDNR Resource Protection and Service Assistant Regional Manager for Threshold Determination and Final Approval. Tacoma implements draft prescriptions once they have been completed, adjusting them as necessary if changes are made during the approval process. Products of the watershed analysis are assumed to be valid for 5 years, at which time the process may be repeated and prescriptions modified if necessary.

The existing WDNR watershed analysis process is designed primarily to protect fish habitat, water quality, and capital improvements of the state from impacts resulting from forest practices. The process provides protection for public resources through prescriptions designed for regulatory application. Problems or events not regulated by forest practices may also be identified in the analyst report. The process may identify opportunities for resource enhancement or restoration that can be undertaken voluntarily outside of regulation. Upland forest habitats for terrestrial plants and animals are protected only incidentally, although incidental protection can be substantial, especially for other aquatic species.

The state of Washington has been divided into WAUs ranging in size from 10,000 to 50,000 acres. The HCP Area contains six WAUs. The WDNR is responsible for prioritizing and conducting watershed analyses. Individual landowners with more than 10 percent of the non-federal forestlands within a WAU may initiate a watershed analysis. Tacoma will actively participate in all watershed analyses performed according to the Washington Forest Practices Board process for lands in the Upper HCP Area. Active participation will include attending start-up, synthesis and hand-off meetings and supplying at least one prescription team member. Tacoma has been and is participating in five of the six watershed analyses that have been completed or are currently under way. Tacoma will also participate in the North Fork Green watershed analysis as it proceeds. Appendix D contains an example of prescriptions governing surface erosion, mass wasting, and hydrology from the Lester WAU. Draft prescriptions developed to date for other WAUs are generally similar to the prescriptions contained in Appendix D. Table 5-6 summarizes the current status of WDNR Watershed Analyses in the Upper HCP Area in which Tacoma has participated or will participate.

Table 5-6. Status of watershed analyses in the upper Green River Basin as of February 1999.[1]

WAU	Acres	Start	Draft Assessment	Draft Prescriptions	SEPA	Final Assessment and Prescriptions
Lester Creek	32,803	10/11/94	9/11/95	3/25/96	7/29/96	3/16/98
Sunday Creek	15,571	7/10/95	6/97	2/99	*12/00*	*6/01*
Green Headwaters	23,688	7/10/95	6/97	2/99	*12/00*	*6/01*
Howard Hanson	46,501	10/23/96	6/97[2]	2/99	*3/01*	*9/01*
Smay Creek	14,415	10/23/96	6/97[2]	2/99	*3/01*	*9/01*
North Fork Green	17,728	*7/00*	*3/01*	*6/01*	*9/01*	*12/01*

[1] Italics indicate expected completion date.

[2] Field work complete but reports not yet available for review.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03B

MEASURE: Road Maintenance

Tacoma will continue to construct and maintain roads throughout all three zones in the Upper HCP Area (subject to compliance with other measures in this HCP) to facilitate watershed management, forestry activities and implementation of this HCP. Within two years of issuance of the ITP, Tacoma will complete a Road Sediment Reduction Plan (RSRP) for all roads on Tacoma lands describing the priorities and schedule for road maintenance, improvement and abandonment activities that will be implemented to reduce road sediment inputs to less than 50 percent of the estimated natural background sediment production rate. The RSRP will include an evaluation of surface erosion concerns for roads in subbasins that currently have moderate to high estimated road sediment yields (>50 percent over background). In addition, all existing roads in areas with a moderate to high mass-wasting potential will be reviewed by a specialist in slope stability and road construction/repair. The results of the specialist's evaluation and proposed correction or mitigation activities will be included in the RSRP. The RSRP will include a prioritization and timetable for road repairs. Problems classified as high priority will be corrected by the third year following approval of the RSRP.

HCM 3-03B (continued on next page)

HCM 3-03B (continued)

In WAUs where a watershed analysis has been completed and approved, Tacoma will contribute funding for a road inventory and participate in the development of the RSRP in cooperation with other landowners in the WAU. Funding will be proportional to the percentage of land owned by Tacoma in each subbasin. In WAUs where a watershed analysis has not been formally approved within 2 years of issuance of the ITP, Tacoma will take primary responsibility for funding and preparation of a RSRP that covers roads on or used to access the Tacoma ownership.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed through proper road maintenance.

Rationale and Ecosystem Benefits

Sedimentation of salmonid spawning habitat is a concern throughout the Pacific Northwest. A positive correlation has been observed between the area of logging roads in a basin and levels of fine sediment in downstream spawning gravel (Cederholm et al. 1981). As the level of fine sediment in spawning gravel increases, survival of salmonid eggs and fry declines (Tappel and Bjornn 1983; Reiser and White 1988; Young et al. 1991).

Surface erosion assessments performed for the Lester, Sunday, Green, Howard Hanson and Smay Watershed Analyses indicate that road-related sediment inputs currently exceed background levels by more than 50 percent in a number of subbasins in the Upper HCP Area. Sediment yield increases greater than 50 percent may be chronically detectable and have the potential to adversely affect aquatic resources (WFPB 1997). Final or draft prescriptions for watershed analyses conducted to date in the Upper HCP Area call for each landowner to complete an RSRP that describes planned road maintenance, improvement and abandonment activities, including the priorities and schedule for activities that will be implemented to reduce road sediment inputs. The RSRP must be submitted within 1 year following approval of the analysis. Plans must be submitted to WDNR each year until the objective of reducing road sediment delivery below 50 percent of background has been achieved. Sources of road erosion classified as high priority must be treated by the end of the third year following analysis. All remaining work prescribed under the plan must be treated within 5 years of approval. The road surface erosion model used in the Surface Erosion Module Version 3.0 shall be applied annually following completion of road maintenance activities to evaluate the adequacy of efforts implemented to satisfy the 50 percent background objective.

Mass-wasting assessments conducted as part of the Lester, upper Green/Sunday, and Howard Hanson/Smay Watershed Analyses have also identified a relatively consistent suite of landforms that are considered to have a moderate to high mass-wasting potential. These landforms include earthflow toes, bodies and scarps; inner gorges; headwalls; glaciofluvial terrace escarpments; and steep undissected hillslopes in various geologic units (Plum Creek 1996; USFS 1996). Draft and final prescriptions developed to date require that existing roads on landforms with a moderate or high mass-wasting potential must be field-evaluated by a specialist in slope stability and road construction/repair within 1 year of approval of the watershed analysis.

Landforms with moderate to high mass-wasting potential have been mapped for five of the six WAUs in the Upper HCP Area. Those maps, and the corresponding descriptions of each mass-wasting map unit will be used to determine the specific location of moderate to high hazard areas in the field, and in WAUs where watershed analysis assessments have not been completed. To facilitate accurate field identification of landforms with moderate to high mass-wasting potential, Tacoma employees responsible for harvest unit and new road layout will receive training in field identification of unstable lands.

Tacoma will implement both draft and final watershed analysis prescriptions upon issuance of the ITP regardless of whether the analyses have been formally approved by WDNR. In WAUs where assessments have been approved, Tacoma is providing funding for a comprehensive road inventory and developing a RSRP in cooperation with other landowners. Funding for development of the RSRP and for major maintenance activities is directly proportional to the percentage of land area owned by Tacoma that is tributary to that road segment. Funding for annual maintenance is proportional to the annual use (i.e., number of loads hauled) by each landowner.

In WAUs where assessments have not yet been completed, Tacoma will assume that all subbasins have the potential for moderate increases in sediment yield (>50 percent) and that all landforms identified as having a moderate to high mass-wasting hazard in past watershed analyses will have similar hazards. If the RSRP cannot be developed in cooperation with other landowners within 2 years of issuance of the ITP, Tacoma will provide 100 percent of the funding needed to complete surveys of roads on or used to access Tacoma's lands, and will develop an annual road maintenance, improvement and abandonment plan for those roads. Upon completion of future watershed analyses, Tacoma will implement any additional prescriptions that may be approved.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03C

MEASURE: Road Construction

Tacoma will continue to construct roads throughout all three zones in the Upper HCP Area (subject to compliance with other measures in this HCP) to facilitate watershed management, forestry activities and implementation of this HCP. Tacoma will implement prescriptions developed by watershed analysis specific to construction of new temporary or permanent roads across unstable landforms in the Upper HCP Area. Tacoma will cause no net increase in permanent road miles within the Natural Zone over the term of this HCP. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed through proper road construction.

Rationale and Ecosystem Benefits

Watershed analysis includes an assessment of mass-wasting hazards associated with forest management practices, including road building. The potential hazards and mechanisms that may trigger landslide activity vary by landform MWMU; thus, specific prescriptions for road construction are developed for each landform. Mass-wasting assessments conducted as part of the Lester, upper Green/Sunday, and Howard Hanson/Smay Watershed Analyses have identified a relatively consistent suite of landforms that are considered to have a moderate to high mass-wasting potential. These landforms include earthflow toes, bodies and scarps; inner gorges; headwalls; glaciofluvial terrace escarpments; and steep undissected hillslopes in various geologic units (Plum Creek 1996; USFS 1996). The preferred alternative is to avoid road construction in these landforms. However, locating roads so that they do not cross unstable landforms may result in unacceptable increases in the total length of road constructed.

Draft and final prescriptions for WAUs in the Upper HCP Area generally require that a slope stability specialist review all proposed new roads on slump-earthflow toes, avalanche chutes, headwalls, escarpments along the Green River and areas prone to slumping along mainstem tributary canyons. In most cases, full bench construction techniques and end-hauling are required, natural drainage patterns must be maintained, road drainage must be directed away from the unstable landform where possible, and unless the geotechnical review indicates otherwise, stream crossings should be either hardened fords, bridges, or temporary, oversized culverts that are removed within 3 years of construction.

Upon issuance of the ITP, Tacoma will implement all draft and final mass-wasting prescriptions specific to new road construction in WAUs where watershed analyses are approved or pending. In WAUs where assessments have not been completed within 2 years following issuance of the ITP, Tacoma will complete a slope stability analysis as described in HCM 3-01N. Tacoma will assume that all landforms identified as having a moderate to high mass-wasting hazard in past watershed analyses will have similar hazards, and utilize the same prescriptions. To facilitate accurate field identification of landforms with moderate to high mass-wasting potential, Tacoma employees responsible for harvest unit and new road layout will receive training in field identification of unstable lands. Tacoma will fund 100 percent of the cost required to ensure that roads are constructed in accordance with all applicable prescriptions derived from watershed analysis.

Roads will continue to be necessary in the Natural Zone to facilitate access for watershed management activities and to comply with Tacoma's requirements to allow access to adjacent landowners. Limiting roads in the Natural Zone to the current road density may require Tacoma to provide funds for permanently abandoning existing roads according to standards outlined in the Washington State Forest Practices Rules (Chapter 222-24-050 WAC). Tacoma will fund 100 percent of the costs of abandoning existing roads should such activities become necessary to offset construction of new roads.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03D

MEASURE: Roads on Side Slopes Greater Than 60 Percent

When constructing roads on side slopes greater than 60 percent, Tacoma will use full bench construction with no side-casting of excavated materials. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed by restricting the methods of road construction used on steep slopes.

Rationale and Ecosystem Benefits

Studies of the relationship between forest roads and mass wasting in the Pacific Northwest indicate that inappropriate design, location and construction methods have historically been the primary cause of increased failure rates (Harr and Nichols 1993; Swanston and Swanson 1976). Road construction on steep slopes using cut-and-fill design increases the slope angle, redistributes weight, and may lead to the incorporation of organic materials into road fills, resulting in an increased risk of failure on otherwise stable sites. Full bench road construction on steep slopes has reportedly substantially reduced the incidence of road-related landslides (Sidle et al. 1985). Full bench road construction involves cutting a bench equal to the width of the road into the rock or soil and hauling excess material off-site to a stable storage location (Weaver and Hagans 1994).

Road fill failures were identified as one of the main causes of increased sediment delivery to channels in the Green River watershed by a recent watershed analysis (USFS 1996). By utilizing only full bench construction techniques on steep slopes, Tacoma will minimize the incidence of future road fill failures, and thus reduce the delivery of sediment to stream channels. Reducing the amount of sediment delivered to stream channels is expected to reduce substrate embeddedness and the proportion of fine sediment in spawning gravel while increasing pool depths.

Full bench construction can cost four to seven times more than cut-and-fill methods (Weaver and Hagans 1994). Tacoma will fund 100 percent of the costs associated with implementing road construction standards beyond those required by Washington State Forest Practices Rules (WAC 222) on steep slopes.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03E

MEASURE: Erosion Control

When constructing or reconstructing roads, Tacoma will place mulch and/or grass seed on all unvegetated road cuts and fills with slopes over 40 percent or near water crossings, as well as in all locations on Tacoma lands where there is the possibility of severe erosion or slumping above or below the road. All mainline, primary and secondary roads that Tacoma is responsible for maintaining in the HCP area will be surfaced with gravel. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed by implementing proper erosion control measures.

Rationale and Ecosystem Benefits

The level of traffic and composition of road surfaces are major determinants of the amount of sediment produced from forest roads. In general, unpaved dirt roads produce almost twice as much sediment per unit area as comparable roads surfaced with a 2- to 6-inch layer of gravel (WFPB 1997). Tacoma will work cooperatively with other landowners in the Upper HCP Area to ensure that gravel surfacing is maintained on all mainline, primary and secondary haul roads.

Watershed analyses in Washington and Oregon have shown that unvegetated road cutslopes and fillslopes within 200 feet of the stream channel supply fine sediment to stream channels even during periods of light traffic use (Madsen 1998; Veldhuisen 1998). The rate of sediment delivery is a function of slope steepness (Ketcheson and Megahan 1996). Mulch and grass seeding of cut-and-fill slopes may reduce surface erosion by up to 70 percent (Megahan 1987).

By mulching or seeding exposed road cuts and fills in steep terrain, Tacoma will reduce the amount of fine sediment delivered to stream channels via overland flow or drainage ditches. Reducing the amount of sediment delivered to stream channels is expected to reduce substrate embeddedness and the proportion of fine sediment in spawning gravel, while increasing pool depths. Tacoma will fund 100 percent of the costs required to mulch or establish vegetative cover on road cut-and-fill slopes on Tacoma lands within the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03F

MEASURE: Stream Crossings

In the limited instance when constructing new roads across streams and through riparian buffers is necessary, Tacoma will: 1) minimize right-of way clearing; 2) cross streams and riparian corridors at right angles (wherever possible); 3) minimize disturbance to the natural flow of streams; 4) minimize side-casting of excavated materials; and 5) provide for upstream and downstream passage of fish if the stream reaches are fish-bearing. Culvert design criteria to support upstream and downstream passage of salmonids will be developed in coordination with WDFW, USFWS, and NMFS. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by properly designing, constructing, and maintaining stream crossings.

Rationale and Ecosystem Benefits

Where roads cross stream channels, provisions must be made to pass flow under the road while maintaining up- and downstream fish passage. Drainage structures should be large enough to pass flood flows, and should be installed at a grade equal to or slightly lower than the original stream channel gradient so that normal velocity is maintained and so fish do not have to jump up into the structure. Roads should cross the channels at right angles if possible, and culverts should be aligned with the stream channel so that the inlet will not plug, and flow from the outlet is not deflected into the channel bank (Weaver and Hagans 1994).

Stream-crossing sites are also the most frequent source of erosion and sedimentation (Rothwell 1983). Because stream crossings are the location where roads come in closest contact with flowing water, it is important to minimize disturbance of riparian buffers, to construct roads using as little fill material as possible, and to dispose of excavated materials outside of the floodplain (Weaver and Hagans 1994). Vegetation removal should be limited, and exposed slopes should be quickly replanted. Fills should be compacted and armored, with excavated material disposed off-site.

When constructing or reconstructing roads through riparian buffers, Tacoma will minimize right-of-way clearing, cross streams at right angles, and minimize side-casting of excavated materials. Stream-crossing structures will be designed so that upstream and downstream fish passage is maintained on fish-bearing streams. Application of these measures will reduce the amount of soil disturbance and deposition of loose fill material within the floodplain, thus minimizing sediment-related impacts to fish habitat. Tacoma will provide 100 percent additional design and construction costs required to meet these high road standards.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03G

MEASURE: Road Closures

Where Tacoma has control over road use, the City will maintain locked gates to restrict use of roads in the Upper HCP Area by the general public, except where U.S. Forest Service (USFS) or WDNR policy requires that roads remain open. Tacoma will also discontinue heavy truck traffic under its control (e.g., log hauling) when there is a potential for excessive damage to the road or for water quality impacts that would adversely affect fish. For purposes of this measure, excessive damage means damage beyond normal wear to the road surface. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by restricting vehicle traffic on Tacoma roads in the upper Green River watershed.

Rationale and Ecosystem Benefits

The amount of sediment generated from road tread surfaces is largely a function of traffic (Reid and Dunne 1984). Increased sediment concentrations associated with heavy truck traffic have been documented throughout western Washington (Bilby et al. 1989; Reid and Dunne 1984; Wooldridge 1979). Sediment produced by vehicle traffic on forest roads is predominantly silt and clay-sized material that is rapidly flushed through the system at even moderate discharges (Bilby et al. 1989; Bilby 1985). Because of the small size of sediment generated by road use, it rarely deposits or intrudes into the substrate except in the smallest streams (Bilby et al. 1989) or during periods of low flow (Bilby 1985). However, fine sediment generated by road use may increase turbidity, which can decrease primary productivity (Gregory et al. 1987), interfere with the ability of juvenile salmonids to capture prey (Lloyd et al. 1987), and detrimentally impact water quality (EPA 1993).

By restricting access to the Upper HCP Area and suspending log hauling when there is a potential for extraordinary water quality impacts, Tacoma will minimize the impact of the production of sediment caused by road traffic. Road use restrictions are expected to prevent excessive turbidity from impacting aquatic species or water quality. Incidental benefits to terrestrial wildlife that may be disturbed by frequent vehicle traffic may also occur. Tacoma will fund 100 percent of the costs required to construct and maintain locked gates in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03H

MEASURE: Roadside Vegetation

Tacoma will maintain low-growing vegetation along roadsides to stabilize soils and minimize erosion. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by reducing surface erosion from disturbed soils.

Rationale and Ecosystem Benefits

Surface protection of road cut-and-fill slopes can reduce erosion during storms and prevent or restrain the downslope movement of soil slumps (EPA 1993). Swift (1986) found that vegetated cut-and-fill slopes were more effective than mulched fill at reducing the downslope movement of soil from road cut-and-fill surfaces, and could reduce sediment production by over 90 percent.

Maintaining low-growing vegetation along roadsides in the Upper HCP Area will minimize the production of sediment from road cut-and-fill slopes and reduce the likelihood of sediment-related impacts to fish habitat and water quality. Tacoma will fund 100 percent of the costs required to maintain vegetation along roadsides within the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03I

MEASURE: Road Abandonment

Tacoma will abandon roads in the Upper HCP Area that are no longer needed for adjacent landowners to access their property, watershed management, forestry operations, or implementation of this HCP. Within 2 years of issuance of the ITP, Tacoma will prepare and prioritize plans to abandon unnecessary existing roads. Within 5 years of issuance of the RSRP, Tacoma will complete the abandonment of the unnecessary existing roads. New roads constructed in the Conservation and Commercial zones that are not needed for the above purposes will be abandoned within 2 years after their use is complete. Roads will be abandoned by: 1) removal of culverts, fills, water blocks and unstable landings; 2) stabilization of ditch lines and cut banks to a slope of 1.5:1; 3) crowning of road surfaces and placement of water bars

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HCM 3-03I (continued)

every 200 feet; 4) placement of biomatting on steep erodable slopes; 5) revegetation of disturbed soils and biomatted areas with grass and appropriate tree seedlings; and 6) placement of berms or walls of stumps, rootwads, or logs at former entrances to roads. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by properly abandoning roads that are no longer necessary in the upper Green River watershed.

Rationale and Ecosystem Benefits

There are many reasons for abandoning a forest road, including improving fish and wildlife habitat, excessive maintenance costs, lack of future need due to improved harvest methods, or continuing water quality problems (Weaver and Hagans 1994). In the past, roads were closed by simply prohibiting access. However, sediment yields from closed roads often increase, as severe gullies may form on poorly drained road tread surfaces, and unmaintained drainage structures frequently become plugged and fail catastrophically. Planned abandonment is an inexpensive technique that can prevent future damage to the active road system as well as to aquatic resources by removing potentially unstable drainage structures and fills, restoring the natural drainage network, and revegetating disturbed soils.

By abandoning roads within the HCP area that are no longer needed for watershed management, forestry operations or implementation of this HCP, Tacoma will minimize the potential for future mass wasting and sediment production from unmaintained roads within the Upper HCP Area. In addition, the total length of the road network may decrease, reducing annual sediment inputs as well as the need for expensive long-term maintenance. Tacoma will provide 100 percent of the funding necessary to permanently abandon unneeded roads.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03J

MEASURE: Culvert Improvements

In conjunction with the RSRP, Tacoma will inventory all roads on Tacoma lands to identify artificial barriers that create blockages to fish passage. Within 2 years of completion of the RSRP, Tacoma (in coordination with other affected landowners, MIT

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HCM 3-03J (continued)

and WDFW) will prepare and prioritize plans for eliminating artificial blockages on roads they are responsible for maintaining. Within 5 years of issuance of the RSRP, Tacoma will complete the elimination of artificial blockages on Tacoma lands in the HCP Area as requested and approved by the Services. New culverts, if needed, will be designed and constructed to pass 100-year flood flows and allow up- and downstream fish passage. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to increase fish utilization of habitats in the upper Green River watershed by removing man-made blockages to upstream and downstream movement.

Rationale and Ecosystem Benefits

A single poorly installed culvert can eliminate the fish population of an entire stream system (Murphy 1995). Stream-crossing conditions that block fish passage include: excessive water velocity, insufficient flow depth, absence of pools that provide resting or jumping space at culvert outlets, and culvert outlets that are too high above the streambed (Furniss et al. 1991). Undersized culverts are likely to become blocked or to fail during major storm events (Veldhuisen 1997).

Adult salmon access to the upper watershed is currently precluded; however, the HCP contains provisions to trap adult fish at the Headworks and release them above HHD. Restoring passage at culvert blockages identified in the Upper HCP Area will ensure that anadromous fish have access to habitat within the upper watershed, and will allow unimpeded migration and genetic transfer for resident fish populations.

By completing a systematic inventory of all roads on its lands Tacoma will be able to identify culverts that create blockages to fish passage.

Artificial blockages will be prioritized for treatment as follows:

1) barriers to habitat known to have historically been utilized by listed species will be treated first;

2) habitat that could be used by anadromous fish as spawning or overwintering areas will be treated second; and

3) for blockages affecting resident fish, population risk factors will be considered, such as:

- ▹ blockages that prevent the ability of populations to recolonize original habitats; and
- ▹ blockages that have fragmented existing populations, thereby contributing to poor genetic integrity.

Under each category, the length of habitat upstream of the blockage and the location of the blockage relative to planned management activities and major road maintenance projects will also be considered. Within 2 years, plans will be completed for reestablishing upstream and downstream passage at sites where such action is deemed necessary by the Services. Artificial blockages on Tacoma lands will be treated as requested by the Services within 5 years of issuance of the RSRP.

Road Sediment Reduction Plans prepared as part of the watershed analysis prescription addressing existing hazards (Lester watershed analysis) include a methodology for inspecting stream crossings in landforms with a moderate to high mass-wasting potential following major storm events. Post-storm inspections will ensure that blockages resulting from high return interval events following the initial inventory are identified and corrected in a timely manner. Stream-crossing culverts replaced during the term of the ITP will meet all criteria required to maintain fish passage.

Tacoma will provide 100 percent of the funding required to conduct a systematic road inventory and repair all road-related passage barriers.

5.3.4 Habitat Conservation Measure: HCM 3-04 Species-Specific Management Measures

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04A

MEASURE: Grizzly Bear Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, or silvicultural activities involving the use of helicopters within 1 mile of any known active grizzly bear den from 1 October through 31 May. At other times of year, Tacoma will contact the USFWS and WDFW prior to any timber harvest or road construction within 3 miles of a known grizzly bear den, and the three parties will discuss possible steps that can be taken to minimize impacts to potential denning habitat. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize human disturbance of denning grizzly bears in the upper Green River watershed.

Rationale and Ecosystem Benefits

The HCP Area lies outside the North Cascades Recovery Zone for the grizzly (USFWS 1993), but it is connected to the recovery zone by contiguous habitat. Recent sightings of grizzly bears have been made in the vicinity of the Upper HCP Area outside the recovery zone (Almack 1993, cited in USACE 1996), suggesting that occasional use of the Upper HCP Area may already be occurring. If grizzly bear populations increase in the recovery zone as a result of recovery efforts, individual animals could range into the Upper HCP Area.

Grizzly bears are particularly sensitive to the presence of humans, and will avoid areas of human activity (USFWS 1997). The denning season, which begins in the early fall and extends through spring, is a particularly vulnerable time of year for the grizzly bear. Late initiation of denning or early abandonment of a den as a result of human disturbance can force a bear out of hibernation at a time of year when food is scarce and metabolic demands are high. Agitation of bears within dens, even if it does not lead to abandonment, can impact bears by increasing metabolic demands during hibernation. Such impacts can be avoided by restricting human activity around active dens. The den site protection measures are consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][c]), and are designed to avoid incidental take of grizzly bears during the denning season.

While grizzly bears seldom reuse specific den sites (Interagency Grizzly Bear Committee 1987), they often den within 0.3 to 3.1 miles of previous dens, and are known to den repeatedly within a radius as small as 1.7 miles. Because the HCP Area is not typical grizzly bear habitat, it is impossible to identify specific activities that should or should not take place in the proximity of grizzly bear dens that might occur in the future. Tacoma will, however, contact the USFWS prior to conducting activities that could alter suitable habitat within 3 miles of known den sites, so that appropriate precautions can be identified.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04B

MEASURE: Grizzly Bear Sightings

Tacoma will suspend all forest management and road construction activities under its control in the Upper HCP Area within 1 mile of confirmed grizzly bear sightings for 21 days following the last confirmed sighting. Confirmation of grizzly bear sightings will be made by WDFW, USFWS, or Tacoma personnel trained in the identification of grizzly bears according to HCM 3-01K. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize human displacement of grizzly bears from the upper Green River watershed.

Rationale and Ecosystem Benefits

As noted above, grizzly bears are particularly sensitive to the presence of humans. Human activity during summer months can cause grizzly bears to avoid specific areas, some of which may be important seasonal feeding areas. While it may be feasible to suspend human activities around fixed points, such as dens that grizzly bear will occupy for extended periods of time, it is not feasible to suspend all activities over broad areas during the summer when grizzly bears are active. Rather, Tacoma will implement restrictions around specific areas where grizzly bears are sighted, and the City will continue restrictions for periods of time sufficient to allow the animals to move unimpeded by the presence of humans.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04C

MEASURE: Grizzly Bears and Roads

Tacoma will not construct roads across non-forested blueberry fields (*Vaccinium* spp.) and black huckleberry fields (*Vaccinium membranaceum*), meadows, avalanche chutes, or WDNR Type A or B wetlands in the Upper HCP Area. Tacoma will begin to implement this measure upon ITP issuance.

Objective

The objective of this measure is to minimize the disturbance and/or destruction of key foraging habitats for grizzly bears.

Rationale and Ecosystem Benefits

Grizzly bears are known to avoid roads, particularly those with frequent or regular human use (USFWS 1997). Roads are a necessary component of a managed watershed, however, and cannot be excluded altogether from the Upper HCP Area. To minimize the potential for impacting grizzly bear activities with the presence of roads, Tacoma will construct no roads through areas of particular importance to grizzly bears. Berry fields, meadows, avalanche chutes, and wetlands make up a relatively small percentage of the Upper HCP Area, but they are important foraging areas for grizzly bears. Avoiding the construction of roads through these areas will substantially reduce the potential for road-related impacts to bears.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04D

MEASURE: Grizzly Bear Visual Screening

If grizzly bear presence is documented in the Green River watershed, Tacoma will retain visual screens along the margins of preferred habitats (e.g., meadows, riparian areas, and berry fields) or along roads that are within 1 mile and in direct line of sight of preferred habitats. Visual screens at a minimum will consist of non-merchantable trees and shrubs, where they are available, which can obscure 90 percent of a grizzly bear standing on all four feet at a distance of 100 feet. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize human displacement of grizzly bears from important foraging habitats in the upper Green River watershed.

Rationale and Ecosystem Benefits

As noted above, meadows, wetlands and berry fields are important feeding areas for grizzly bears, and human activity in or near these areas can cause bears to avoid them (Interagency Grizzly Bear Committee 1987). Disturbance-related impacts can be avoided by providing visual screening between roads and key feeding areas. This measure will provide that type of screening. Given that grizzly bears are currently quite rare in the Upper HCP Area, this measure will not take effect unless the presence of bears is documented. However, current management practices and native vegetative conditions in the Upper HCP Area are such that visual screening will exist along most roads throughout the term of the HCP, regardless of grizzly bear presence. This measure is simply an added layer of protection in the event that grizzly bear numbers increase in the future.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04E

MEASURE: Grizzly Bears and Trash

Tacoma will continue to take measures to prevent the dumping of putrescent trash that could attract grizzly bears. This will include: 1) restricting general public access to the Upper HCP Area below the town of Lester; 2) prohibiting City employees and other authorized watershed users from dumping or disposing of trash in the Upper HCP Area; and 3) cleaning up any newly discovered trash disposal sites in the Upper HCP Area as soon as possible. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to prevent grizzly bears in the upper Green River watershed from habituating to the scent and/or presence of humans.

Rationale and Ecosystem Benefits

As omnivores, bears are well known for their tendency to feed at human garbage dumps (Interagency Grizzly Bear Committee 1987). Grizzly bear use of garbage dumps is undesirable because it can cause bears to become habituated to the scent and presence of humans, and ultimately lead to interactions that necessitate the removal or destruction of individual bears. Conflicts can be avoided if garbage is controlled and disposed of properly.

The Upper HCP Area, as a municipal watershed, is closed to the general public. Permitted users in the Upper HCP Area are required to comply with stringent trash and garbage control policies (TPU 1993). Continued adherence to these policies, as described in this measure, will ensure there are no problem bear situations in the future.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04F

MEASURE: Grizzly Bears and Firearms

Tacoma will prohibit firearms within the vehicles of contractors working for Tacoma in the Upper HCP Area, except when being used for security purposes, for WDFW-approved hunts, or in conjunction with Native American Tribal hunting. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to prevent the unauthorized shooting of a grizzly bear in the upper Green River watershed.

Rationale and Ecosystem Benefits

Unauthorized shooting of grizzly bears is a potential problem whenever this formidable creature comes into contact with humans. Shootings can be minimized by limiting the use of firearms by humans working in grizzly bear country. Certain individuals working in the Upper HCP Area (such as watershed patrols) may need to carry firearms, but all other persons under the jurisdiction of Tacoma will be prohibited from carrying firearms while in the area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04G

MEASURE: Gray Wolf Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting, or silvicultural activities involving the use of helicopters within 1 mile of any known active gray wolf den from 15 March through 15 July. Tacoma will conduct no timber felling, yarding, road construction, blasting or silvicultural activities involving the use of helicopters within 0.25 mile of any known active gray wolf “first” rendezvous sites from 15 May through 15 July. A “first” rendezvous site is the first such site used by a wolf pack after leaving the whelping den in the spring. Tacoma will contact the USFWS and WDFW prior to conducting harvest activities outside the denning season within 0.25 mile of a known den site to minimize management impacts on future den site use. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect denning gray wolves in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The gray wolf is extremely rare in Washington, but sightings have been made in the Cascade Mountains as far south as Randle, Washington (USFS 1998), and the species could use the Upper HCP Area on an occasional basis. Gray wolves use dens for 6 to 10 weeks in the spring and early summer if they are rearing pups. Once the pups are whelped, they are typically moved by the adults to a rendezvous site where they stay while the adults are hunting. They are sensitive to human presence during this entire time, and may abandon a den or rendezvous site if disturbed (USFWS 1987). The den site protection measures are consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][b]), and are generally considered adequate to avoid take of gray wolves during the denning season. Rendezvous site protection measures are added to this HCP to provide an additional disturbance buffer during that phase of wolf reproduction.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04H

MEASURE: Pacific Fisher Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting, or silvicultural activities involving the use of helicopters within 0.5 mile of any known active Pacific fisher den from 1 February through 31 July. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect denning Pacific fishers in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The fisher is rare throughout the western United States. Populations were severely depressed by trapping in the last century, and they have been slow to recover because of naturally low reproductive rates and a general loss of habitat to logging of old coniferous forest (Powell and Zielinski 1994). Management of the Natural and Conservation zones and riparian corridors in the Commercial Zone of the Upper HCP Area will, over time, create suitable denning habitat for the fisher (mature forest with large snags and logs), and the potential for fisher occurrence in the area will increase. Den site protection measures will be necessary in the HCP Area to ensure that human activities do not prevent the use of otherwise suitable habitat. While human activity has not been demonstrated as a significant factor in determining fisher use of an area, the importance of successful reproduction to the overall conservation of the species warrants measures such as Pacific fisher den site protection to limit human activity around established dens.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04I

MEASURE: California Wolverine Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting, or silvicultural activities involving the use of helicopters within 0.5 mile of any known active wolverine den from 1 October through 31 May. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect denning California wolverines in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The wolverine is a species of alpine and subalpine forests (Banci 1994), and may occur on an occasional basis in the upper reaches of the Green River watershed (USFS 1996). Tacoma lands in the Green River watershed are concentrated along the river (at the valley bottom), where wolverines are unlikely to occur, but den site protection measures are included in this HCP in the event that Tacoma acquires lands at higher elevations in the future. The wolverine is generally considered a wilderness species that avoids human contact, but recorded instances of wolverines in close association with humans raise questions as to whether wolverines actually avoid humans or they simply prefer habitats that currently are not heavily exploited by humans (Banci 1994). Given the uncertainty as to wolverine sensitivity to human presence, it is considered prudent to include den site protection measures in this HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04J

MEASURE: Canada Lynx Den Site and Denning Habitat Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting or silvicultural activities involving the use of helicopters within 0.5 mile of any known active Canada lynx den or potential lynx denning habitat from 1 May through 31 July. For the purposes of this HCP, potential lynx denning habitat is defined as areas above

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3,500 feet in elevation, with dead and downed logs, and adjacent to or near lynx foraging habitat. Canada lynx forging habitat is defined as 10- to 30-year-old coniferous forest with high stem density and crown closure of 75 to 80 percent. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect denning Canada lynx in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The Canada lynx inhabits the boreal forests of Canada and Alaska, and extends south into the lower 48 states in the isolated areas where boreal forest conditions exist (Koehler and Aubry 1994). In Washington, the distribution of the lynx is largely restricted to high-elevation pine and spruce forests of eastern Washington (Johnson and Cassidy 1997), but rare sightings have been made in the Green River watershed (USFS 1996). The Upper HCP Area does not contain habitat typically considered suitable for the lynx, and it is not likely to in the future under the proposed management. Nevertheless, den site protection measures are included in this HCP to ensure that any dens that are documented in the area receive adequate protection. This measure is based on recommendations from the WDFW contained within the WDNR Lynx Habitat Management Plan (WDNR 1996).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04K

MEASURE: Seasonal Protection of Peregrine Falcon Nests

Tacoma will conduct no timber felling, yarding, road construction, or silvicultural activities involving the use of helicopters within 0.5 mile or blasting within 1 mile of any known active peregrine falcon nest from 1 March through 31 July. If an active nest fails or is otherwise found to be unoccupied after 1 June, seasonal protection will be removed for that year. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect peregrine falcon nest sites from human alteration and destruction.

Rationale and Ecosystem Benefits

Peregrine falcons nest on high cliff ledges or man-made structures (Cade et al. 1996), and hunt over large wetlands or marine shorelines (USFWS 1982). A number of peregrine falcon nest sites are known to occur in the Cascade Mountains, but currently there are none in the Green River watershed. The potential exists for nesting in the future because of the presence of several suitable cliff ledges and recent sightings of peregrine falcons flying through the area (USFS 1996). Like many large birds of prey, peregrine falcons are sensitive to human activity around nests (USFWS 1982). The disturbance avoidance measures included in the seasonal protection of peregrine falcon nests are consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][f]), and are generally considered adequate to avoid take of peregrine falcons during the nesting season.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04L

MEASURE: Long-Term Protection of Peregrine Falcon Nest Sites

Tacoma will conduct no timber felling or other habitat alteration within 100 feet of any known peregrine falcon nest site and all potential nest cliffs greater than 75 feet in height (measured horizontally) in the Upper HCP Area. During timber harvesting within 660 feet of known peregrine falcon nest sites, Tacoma will retain all "super dominant" trees (i.e., those dominant trees that are significantly larger and taller than the remaining trees in the stand, and extend above the dominant/codominant canopy). Retained super dominant trees will count toward meeting the snag and green recruitment tree requirements of measure HCM 3-01G. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect nesting peregrine falcons in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

As noted in seasonal protection of peregrine falcon nests, peregrine falcons currently do not nest in the Green River watershed, but the potential exists for nesting in the future. One cliff with suitable nesting ledges exists within the Upper HCP Area, and a buffer of 100 feet will be placed around the cliff to ensure that future timber harvesting activity will not remove any visual screening that may contribute to the suitability of the site. Beyond the visual screen, the retention of large super dominant trees up to 660 feet from nests will ensure a source of potential perch trees for adult peregrines during the nesting season. While there are currently no other areas considered suitable for nesting within the HCP Area, this measure will also provide for 100-foot buffers should peregrines establish nests in other atypical locations.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04M

MEASURE: Seasonal Protection of Bald Eagle Nests and Communal Winter Night Roosts

Tacoma will conduct no timber felling, yarding, road construction, or other habitat alteration within 0.25 mile (or within the direct line of sight, up to a minimum of 0.5 mile), no silvicultural activities involving the use of helicopters within 0.5 mile, and no blasting within 1 mile of any known active bald eagle nest from 1 January through 31 August and any known bald eagle communal winter night roost from 15 November through 15 March. Activity restriction around nests will apply 24 hours per day; activity restrictions around roosts will apply from 1 hour before sunset until 1 hour after sunrise. If eaglets have fledged from a nest prior to 31 August, seasonal protection will be removed for that year. If an active nest fails or is otherwise found to be unoccupied after 1 May, seasonal protection will be removed for that year. If wintering eagles fail to use a communal night roost in a given year, or vacate a roost prior to 15 March, seasonal protection will be removed for that year. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect nesting and roosting bald eagles in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

Bald eagles are relatively common in western Washington (Smith et al. 1997), where they nest near large lakes, rivers and marine waters and spend the winter along rivers with anadromous fish runs (USFWS 1986). They do not currently nest or winter in the Upper HCP Area, but they are often seen in the area of Howard Hanson Reservoir. They could begin nesting or wintering in the area in the future if populations of fish and/or waterfowl increase. Winter feeding and roosting, if it occurs, will likely be in the Natural or Conservation zones where late-seral forest conditions will develop along larger waterbodies. Additional measures to protect bald eagle winter use of the Upper HCP Area are not necessary, particularly since it would occur during a season of relatively little human activity in the surrounding forest. Nesting, on the other hand, could occur in any of the zones where large trees are present, and would come at a time of year when potentially disturbing activities such as timber harvesting are taking place. Nest site protection measures are therefore included in this HCP to limit human disturbance of active bald eagle nests. These measures are generally consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][a]), and are designed to avoid incidental take of bald eagles during the nesting season.

Bald eagles also rely heavily on the use of communal winter night roosts in western Washington (Stalmaster 1987). These are typically areas of mature coniferous or deciduous forest with favorable microclimates and proximity to winter feeding areas. The specific requirements of communal roosts are not well understood, so emphasis is placed on protecting areas of known use. While no winter roosts are currently known to occur in the Upper HCP Area, there exists a potential for them to occur in the future as a result of increases in both bald eagle populations and fish populations in the Green River. This measure and the following measure (HCM 3-04N) will allow for the protection of roosts if they are established. Buffer distances are those recommended in the Recovery Plan for the Pacific Bald Eagle (USFWS 1986).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04N

MEASURE: Long-term Protection of Bald Eagle Nests and Communal Winter Night Roosts

Tacoma will conduct no timber felling or other habitat alteration within 400 feet of any known bald eagle nest or communal winter night roost in the Upper HCP Area. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect bald eagle nest and roost sites in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

Adult bald eagles mate for life and typically return to the same nesting area year after year (Stalmaster 1987). They will use the same nest for several years, or alternate between two or more nests in the same general area. This behavior is not surprising, given the amount of energy required to construct a nest and the difficulty finding trees with the appropriate size, structure, and location. Protection of existing nests in the non-nesting season is therefore considered important to the overall conservation of the species. The long-term protection of bald eagle nests will ensure that any bald eagle nests in the Upper HCP Area will be protected from habitat alteration during timber harvesting or other potentially disruptive activities.

> **HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04O**
>
> **MEASURE: Seasonal Protection of Northern Spotted Owl Nests**
>
> Tacoma will conduct no timber felling, yarding, road construction, or silvicultural activities involving the use of helicopters within 0.25 mile (1,320 feet) or blasting within 1 mile (5,280 feet) of the activity center of any known northern spotted owl pair from 1 March through 30 June, unless the spotted owls inhabiting the activity center have been found, through USFWS protocol surveys, to be non-reproductive or to have failed to successfully reproduce during a given year. Determinations as to the reproductive status of a given spotted owl pair will be made no earlier than 15 May of the year in question. Tacoma will fund begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect nesting northern spotted owls in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The Green River watershed has been surveyed extensively for spotted owls since the federal listing of the species as threatened in 1990. There is one spotted owl activity center on Tacoma lands within the Upper HCP Area, nine activity centers within 0.7 mile of the Upper HCP Area and six more within 1.8 miles of the Upper HCP Area. Timber harvesting activities by Tacoma could influence the amount of habitat available to the spotted owls inhabiting these 16 activity centers and alter the behavior of some of the spotted owls at the activity centers closest to Tacoma lands.

Any short-term decreases in habitat for spotted owls that may result from timber harvesting in the Upper HCP Area will be more than offset in the mid- and long-terms by the development and maintenance of suitable nesting, roosting and foraging habitat throughout most of the Natural and Conservation zones. Roughly 78 percent of Tacoma’s land is forested, and two-thirds of this (7,812 acres) is within the Natural and Conservation zones that will be managed specifically to promote and maintain late-seral forest habitat conditions for spotted owls. Extended harvest rotations (70 years), extensive no-harvest riparian buffers, and increased rates of snag/green tree retention in the Commercial Zone will result in a significant portion of that zone functioning as habitat for spotted owls as well. Additional measures specific to the creation and maintenance of spotted owl habitat at the landscape level are not necessary.

Timber harvesting and related activities also have the potential to affect spotted owls by disturbing actively nesting pairs and causing them to interrupt or abandon nesting attempts. This situation will be avoided by implementing seasonal protection of the northern spotted owl, which will require buffers of 0.25 mile around all known activity centers during the nesting season until it can be determined whether spotted owls are nesting. If nesting owls are present, protection will continue through the fledging and dispersal period for the young birds.

The *Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls* (USFWS 1992) specifies that determination of nesting status in a given year must be made prior to 1 June, and can be made as early as 16 April if the appropriate behaviors are observed. As a margin of certainty, Tacoma will conclude no determinations prior to 15 May. All determinations will be made according to the protocol developed by the USFWS (1992).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04P

MEASURE: Year-Round Protection of Northern Spotted Owl Nests

Tacoma will conduct no timber felling or other habitat alteration within 660 feet of the activity center of any known northern spotted owl pair or resident single located in the Upper HCP Area, until it has been found, through USFWS protocol surveys, that a given activity center has been unoccupied for at least 36 months. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect occupied northern spotted owl nests in the upper Green River watershed from direct human alteration and destruction.

Rationale and Ecosystem Benefits

As noted in the seasonal protection of the northern spotted owl, potential nesting habitat for spotted owls will be created and maintained with no even-aged harvesting on over 52 percent of the Upper HCP Area. Management of the Commercial Zone (approximately 20 percent of the Upper HCP Area) will emphasize commercial timber production, but extended rotations (70 years), wide no-harvest riparian buffers, and snag/green tree retention measures will create the potential for spotted owl nesting in this zone as well. It is the intention of this HCP to promote spotted owl nesting in the Natural and Conservation zones, while minimizing the impacts to nesting owls in the Commercial Zone. The year-round protection of northern spotted owl nests will minimize the effects of timber harvesting near nest sites in the Commercial Zone by retaining approximately 31 acres of forested buffer around nest sites until they are abandoned. It is not expected that 31 acres will be sufficient habitat to support long-term nesting if the adjacent habitat is harvested, but when combined with the high overall amount of habitat throughout the Upper HCP Area, it will minimize direct impacts to nesting spotted owls and allow for transition of displaced owls to unoccupied habitat elsewhere in the area. Tacoma will not monitor all known spotted owl activity centers in all years, but Tacoma will monitor known activity centers according to USFWS (1992) protocol prior to any determinations of status change.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04Q

MEASURE: Seasonal Protection of Northern Goshawk Nests

Tacoma will conduct no timber felling, yarding or road construction within 0.25 mile, no silvicultural activities involving the use of helicopters within 0.5 mile, and no blasting within 1 mile of any known active northern goshawk nest from 1 March through 31 August. If an active nest fails or is otherwise found to be unoccupied after 1 June, seasonal protection will be removed for that year. Prior to conducting timber felling, yarding, road construction, silvicultural activities, or blasting within 0.25 mile of coniferous forest over 75 years of age during the period of 1 March through 31 August, Tacoma will survey the area for nesting goshawks. Surveys will cover all coniferous forest over 75 years of age within 0.25 mile of the proposed activity. Surveys will follow the methodology of Bosakowski and Vaughn (1996), or another survey protocol that is mutually acceptable to Tacoma and the USFWS. Surveys will not be conducted if an active goshawk nest is already known to exist within 1 mile of the proposed activity. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect nesting northern goshawks in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The Green River watershed, including the Upper HCP Area, contains several thousand acres of forest habitat capable of supporting nesting and hunting by northern goshawks.

Given the number of recent sightings in the watershed (USFS 1996), it is likely they occur in the Upper HCP Area. Management under the HCP will result in increases in suitable habitat for goshawks in all three zones, so there is an even higher likelihood that nesting will occur in the future. Goshawks will continue to use forest habitat in all three management zones of the Upper HCP Area because of the high density of mid- and late-seral forest that will occur, even in the Commercial Zone. Even-aged harvests (i.e., clearcuts) will not preclude the presence of goshawks if the overall density of forested habitat is adequate, but harvesting activities could displace goshawks if they are conducted too close to active goshawk nests. To minimize impacts to nesting goshawks, Tacoma will implement the seasonal buffers described in the seasonal protection of northern goshawk nests.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04R

MEASURE: Year-Round Protection of Northern Goshawk Nests

Tacoma will conduct no timber felling or other habitat alteration within 660 feet of any known active northern goshawk nest in the Upper HCP Area, unless it has been determined that the nest has been unoccupied for at least 8 consecutive years. Prior to conducting timber harvesting in coniferous forest stands over 75 years of age, Tacoma will visually inspect the harvest area, and all other coniferous forest over 70 years of age within 660 feet of the harvest area for the presence of goshawk nests. Inspections will be done by persons trained to recognize nests of the northern goshawk. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect occupied northern goshawk nests in the upper Green River watershed from direct human alteration and destruction.

Rationale and Ecosystem Benefits

Goshawks will nest and hunt in managed forest landscapes if there is a sufficient density of suitable habitat (Reynolds et al. 1992). They are also known to nest in relatively young forest (≥ 40 years old) (Bosakowski and Vaughn 1996) if it contains at least a few trees of sufficient size to support nests. The Natural Zone will be free of timber harvesting, and should provide nesting opportunities for goshawks throughout the term of the HCP. Timber harvesting in the Conservation Zone will be uneven-aged and infrequent, and should not lead to nest site abandonment by goshawks if the area immediately surrounding the nest is protected. Timber harvesting in the Commercial

Zone, while it will be even-aged, will involve small units and infrequent harvest entries. Again, long-term presence of nesting goshawks may be possible if the habitat immediately around nest trees is maintained. This habitat conservation measure will provide for year-round protection of nest sites, and should help ensure the continued presence of goshawks in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04S

MEASURE: Pileated Woodpecker Nest, Roost, and Foraging Trees

Tacoma will give preference to leaving green recruitment trees with visible signs of pileated woodpecker nesting, roosting, and/or foraging when selecting snags and trees to meet other habitat conservation measures. Persons authorized to select snags and green recruitment trees will be instructed in how to identify signs of pileated woodpecker use. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect and enhance habitat for the pileated woodpecker in the upper Green River watershed.

Rationale and Ecosystem Benefits

Pileated woodpeckers are common in western Washington, but their numbers are probably reduced from historic levels as a result of habitat loss. They are particularly susceptible to conventional forest practices because of their need for large dead trees (snags) for foraging, nesting and roosting (Bull and Jackson 1995). Snags are typically removed during commercial timber harvesting to satisfy concerns for worker safety and fire prevention. Large snags are hard to replace in subsequent managed stands because most even-aged rotations are not long enough to grow trees of the size required by pileated woodpeckers. A number of measures in this HCP will act to avoid the effects of conventional forestland management and maintain habitat for pileated woodpeckers. Specifically, the retention of all existing forest habitat in the Natural Zone, the management for late-seral conditions in the Conservation Zone, the maintenance of wide no-harvest buffers on fish-bearing streams and smaller no-harvest buffers on all other streams, and the retention of large numbers of snags and residual green recruitment trees in conjunction with all timber harvesting will provide large trees and snags across most of the Upper HCP Area. The pileated woodpecker nest, roost, and forage tree habitat conservation plan is intended to focus on green recruitment trees so that the trees selected for retention at the time of commercial timber harvesting provide the maximum benefit to pileated woodpeckers. Persons responsible for selecting and marking trees to be left will be trained in the identification of pileated use so that these features can be preserved in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04T

MEASURE: Vaux's Swift Nest and Roost Trees

Tacoma will give preference to leaving green recruitment trees with visible signs of current Vaux's swift nesting and/or roosting and those with the potential for future use when selecting snags and trees to meet other habitat conservation measures. Tacoma will attempt to leave other green recruitment trees clumped around trees with signs of Vaux's swift use to protect the swift trees from windthrow and moderate microclimates at potential roosts. Persons authorized to select snags and green recruitment trees will be instructed in how to identify signs of Vaux's swift presence as well as snags and trees with the potential for future use. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect and enhance habitat for the Vaux's swift in the upper Green River watershed.

Rationale and Ecosystem Benefits

The Vaux's swift uses a wide range of managed and unmanaged forest habitats for foraging, but it is very specific in its selection of nest and roost sites; it requires large, hollow ("chimney") snags (Bull 1991) or large decadent trees with pileated woodpecker cavities or natural hollows (Bull and Cooper 1991). Under conventional forest management, these snags and decadent trees are considered hazards to worker safety and forest fire prevention, and so are felled. They are rarely replaced under the short, even-aged rotations typical of the Pacific Northwest, so they can subsequently become limiting factors to the presence of the Vaux's swift. The snag, green recruitment tree, and log retention measure will ensure that large snags and large green recruitment trees are left at the time of harvesting in the Upper HCP Area, and the Vaux's swift nest and roost tree measure will direct the selection of green recruitment trees that offer potential benefits to the Vaux's swift.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04U

MEASURE: Larch Mountain Salamander Habitat Protection

Tacoma will survey potential Larch Mountain salamander habitat prior to activities that might substantially reduce forest canopy and/or result in substantial disturbance to the substrate. Areas that are surveyed and found to be occupied by Larch Mountain salamanders will be protected as described below. For purposes of this conservation measure, potential habitat is defined as: 1) coniferous forest over 100 years of age; or 2) any site with greater than 0.25 acre of contiguous substrate of exposed, coarse unconsolidated substrate, regardless of the vegetative cover.

Activities that might substantially reduce forest canopy, remove or disturb coarse woody debris, and/or result in substantial disturbance to the substrate will be preceded by surveys for Larch Mountain salamanders if they are to be conducted in potential habitat. These activities include: 1) clearcut harvesting; 2) salvage logging; 3) commercial thinning; 4) new road construction; 5) road reconstruction that involves work outside the existing road prism; and 6) creation of new rock/gravel extraction sites. The continued use and/or expansion of existing rock/gravel extraction sites will not require surveys.

Potential habitat surveys and habitat protection will occur according to the following steps:

1. Potential habitat (as defined above) will be surveyed prior to the activities listed above. Surveys will follow 1999 USFS protocol (Crisafulli 1999).

2. Potential habitat found to be occupied by Larch Mountain salamanders during surveys will be protected and buffered with 50-foot no-harvest buffers. Except as noted below, none of the activities listed above will occur within the occupied habitat or the buffer.

3. The total area protected (including buffer) within any one planned activity area (e.g., harvest unit or planned road segment) will not exceed 10 percent of the total planned activity area. When occupied habitat covers more than 10 percent of the planned activity area, Tacoma and the USFWS will determine which areas will receive protection.

4. New roads will be rerouted around occupied Larch Mountain salamander habitat unless alternate road locations would substantially increase the total miles of roads in the affected area, or if alternate locations would have greater impacts to fish, wildlife or water quality

Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to minimize impacts to Larch Mountain salamanders and their habitat in the upper Green River watershed during the course of road construction and other forest management activities.

Rationale

The Larch Mountain salamander is a little-known species that appears to have a strong association with coarse substrates, where it resides in the cool, moist spaces between rocks (Nussbaum et al. 1983; Leonard et al. 1993). Recent evidence also suggests the salamander finds habitat beneath coarse woody debris in mature and late-seral coniferous forest (Crisafulli 1999). Habitats of this type often occur in widely scattered patches across the landscape, and it is not known how quickly disturbed habitats can be reoccupied by salamanders from other patches of potential habitat. It is therefore considered important to protect all significant patches of potential habitat, at least until more is known about the habitat requirements, dispersal abilities and full geographic distribution of the species.

A number of other habitat conservation measures will result in the protection of potential Larch Mountain salamander habitat. Measure HCM 3-01B will protect several thousand acres of habitat in the Natural Zone, including several hundred acres of mature upland coniferous forest in the upper reaches of the watershed. Measure HCM 3-01C will provide similar protection to coniferous forest stands over 100 years old in the Conservation Zone. Measure HCM 3-01J will protect upland sites with low productivity (several of which are on coarse, rocky soils) as UMAs, and measure HCM 3-02A will protect several hundred acres of upland forest that may be potential Larch Mountain salamander habitat along streams. The only areas not covered by these other measures are the lands in the Commercial and Conservation zones that will be subject to commercial timber harvesting, road construction and gravel extraction. Measure HCM 3 04U will cover these areas.

All areas of potential habitat (as defined above) will be surveyed for Larch Mountain salamanders, and protected from disturbance if found to be occupied. Certain areas and activities will be explicitly or implicitly excluded from the survey requirement. Forest stands less than 100 years old will not require surveys because they have less residual woody debris, and thus less potential for supporting Larch Mountain salamanders (Crisafulli 1999). Contiguous areas of coarse soil less than 0.25 acre in size will not require surveys because they collectively comprise a small amount of potential habitat, but they could result in a substantial amount of survey effort. Areas subject to salvage harvesting from roads will not require surveys because the potential for ground disturbance will be negligible. Finally, existing rock and gravel extraction sites are excluded from the survey requirement because they are already being developed as gravel sources (disturbed sites) and these facilities are essential to the proper maintenance of roads in the watershed. There are currently 11 developed rock/gravel extraction sites on the covered lands, for a total of 26 acres. The closing of an existing rock/gravel extraction site would require the opening of another, and likely result in greater overall impact. Conversely, the total amount of potential Larch Mountain salamander habitat represented by these developed sites is small.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04V

MEASURE: Sightings of Covered Species

Tacoma will notify the USFWS in a timely manner of any reported sighting of a spotted owl, marbled murrelet, grizzly bear, gray wolf, Pacific fisher, California wolverine, or Canada lynx in the Upper HCP Area. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure. Protocols for recording and reporting sightings of covered species will be developed within 1 year of ITP issuance (see Chapter 6, CMM-15).

Objective

The objective of this measure is to assist the USFWS and other responsible resource agencies in the effective management of federally-listed species in the upper Green River watershed.

Rationale and Ecosystem Benefits

The spotted owl, marbled murrelet, grizzly bear, gray wolf, Pacific fisher, California wolverine, and Canada lynx are all rare in the Washington Cascades. Each confirmed sighting of these species is important to ongoing conservation and recovery efforts. The USFWS, which coordinates recovery efforts for listed species, should be informed as quickly as possible of any occurrences so that appropriate research and management actions can be taken.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04W

MEASURE: Seasonal Protection of Occupied Marbled Murrelet Nesting Habitat

Tacoma will conduct no timber felling, yarding, or road construction within 0.25 mile, no silvicultural activities involving the use of helicopters within 0.5 mile, and no blasting within 1.0 mile of habitat where “occupancy” by nesting marbled murrelets has been documented, in habitat where “presence” of marbled murrelets has been reported but occupancy status has not been determined, and in suitable nesting habitat that has not been surveyed for marbled murrelets. This avoidance measure will be implemented all times of day from 1 April through 5 August, and from 1 hour before sunrise until 2 hours after sunrise and 1 hour before sunset until 1 hour after sunset from 6 August through 15 September. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect nesting marbled murrelets in the upper Green River watershed from human disturbance.

Rational and Ecosystem Benefits

Marbled murrelets recently have been detected in the upper Green River watershed, and “occupancy” behaviors have been observed on federal lands adjacent to the covered lands. “Occupancy” behavior is assumed to indicate nesting, according to the Pacific Seabird Group (PSG) survey protocol (Ralph et al. 1994). While the effects of human activity on nesting marbled murrelets are not well understood, it is assumed that disturbance of the type created by logging, road construction, and the use of low-flying aircraft can contribute to nest failure. Tacoma anticipates no harvest of suitable marbled murrelet nesting habitat on the covered lands during the term of the ITP, but management activities on the covered lands could occur near occupied marbled murrelet nesting habitat on adjacent lands. This mitigation measure will avoid disturbance-related impacts to nesting marbled murrelets on and near the covered lands. All information available to Tacoma, including the results of marbled murrelet surveys conducted by neighboring landowners, will be used to determine when and where this measure should be applied.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04X

MEASURE: Site-Specific Protection for Northwestern Pond Turtles

Tacoma will develop site-specific protection plans to minimize impacts to Northwestern pond turtles if the turtles are found to occur on or near the covered lands and it is determined that one or more of the covered activities has the potential to impact the turtles. Protection plans will be prepared in cooperation with the WDFW, USFWS, and NMFS and will address only the performance of covered activities on the covered lands. Tacoma will begin to implement this measure upon ITP issuance and, as needed, will fund all costs associated with this measure.

Objective

The objective of this measure is to protect Northwestern pond turtles and their habitat on the HCP area lands from human alteration and destruction.

Rationale and Ecosystem Benefits

Northwestern pond turtles are not currently believed to occur on or near the covered lands, but the potential exists for them to occur in the future. The development of site-specific protection plans in coordination with the appropriate agencies offers the best opportunity for effective mitigation.

Literature Cited

References cited in this chapter are provided in Chapter 10 of this HCP.

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6. Monitoring and Research Program

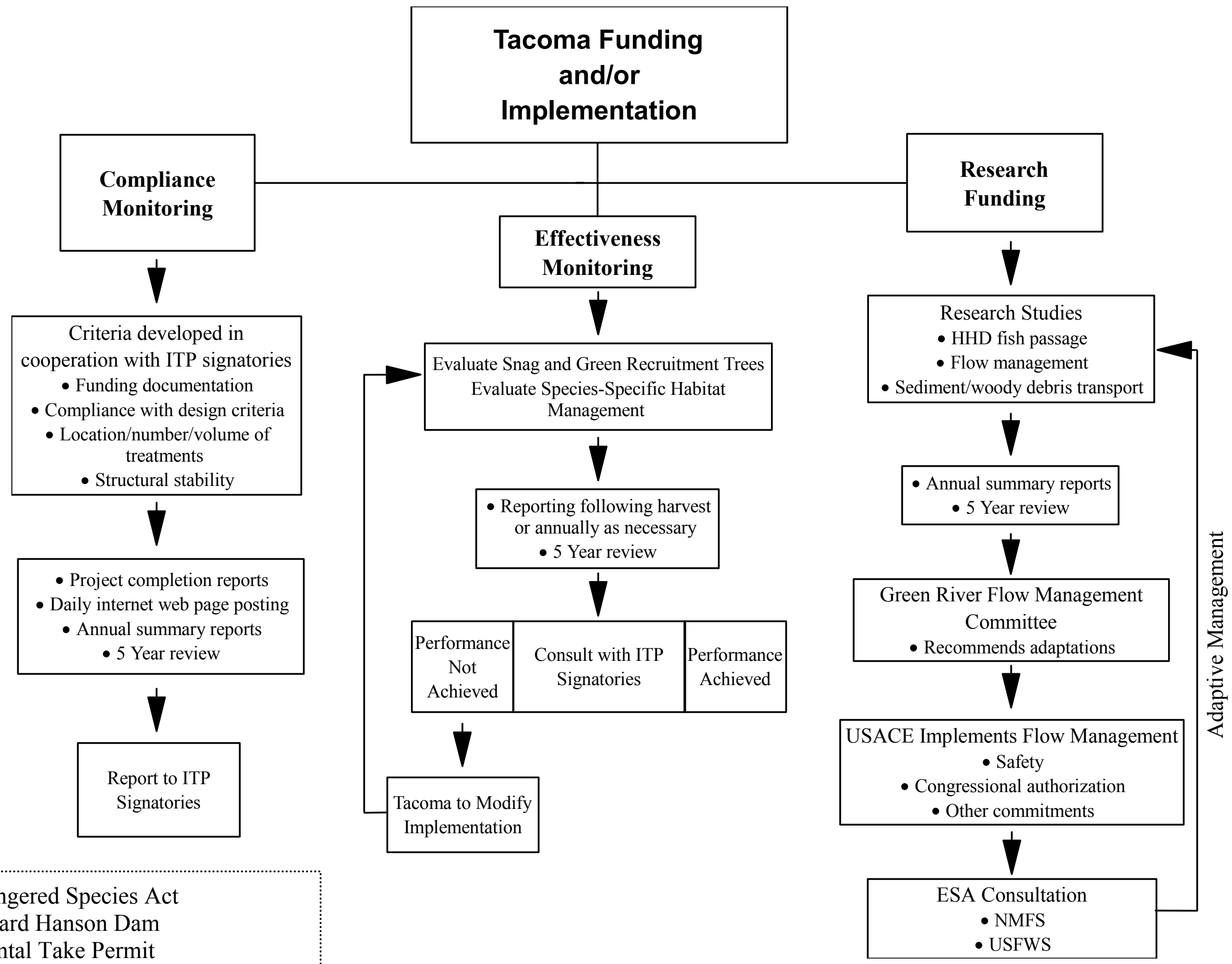
Monitoring and evaluation of the habitat conservation measures identified in Chapter 5 is integral to the success of this Habitat Conservation Plan (HCP). Monitoring is required to ensure measures are implemented according to specified standards. Measures must also be evaluated to ensure the results conform to expectations. In some cases, conservation measures are innovative or experimental in nature and may require testing that potentially leads to adaptive management to achieve desired results. Monitoring and evaluation of the habitat conservation measures provide the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), collectively known as the Services, the certainty that the measures achieve the anticipated level of impact minimization and mitigation required under Section 10 of the Endangered Species Act (ESA).

This chapter describes monitoring and research measures that Tacoma Water (Tacoma) has agreed to fund solely or jointly (in conjunction with the U.S. Army Corps of Engineers [1] [USACE] and other federal agencies) as part of this HCP. The measures have been subdivided into three major types: compliance monitoring to ensure conservation measures are implemented according to specified standards; effectiveness monitoring to provide feedback to improve performance and functionality of measures where Tacoma is responsible for ensuring results; and research designed to provide resource agencies and the Muckleshoot Indian Tribe (MIT) information needed to adaptively manage the natural resources of the Green River on a real-time basis (Figure 6-1). Monitoring will continue for the duration of the Incidental Take Permit (ITP), or until full compliance with the criteria and commitments identified in the following sections is achieved. A timetable for implementing and reporting is included within the monitoring and research summary tables (Tables 6-1, 6-2, and 6-3), and a summary implementation schedule is contained in Chapter 8, Table 8-4 of the HCP.

Compliance Monitoring

Compliance monitoring measures are designed to provide documentation to the Services that the conservation measures have been implemented as specified in the HCP. Compliance criteria, developed in cooperation with the Services, ensure that:

[1] The cost-share percentages referenced in this document between Tacoma Water and the USACE are subject to changes in the Water Resource Development Act or other congressional funding initiatives, which may adjust the cost-share formula between the parties.



ESA = Endangered Species Act
HHD = Howard Hanson Dam
ITP = Incidental Take Permit
NMFS = National Marine Fisheries Service
USACE = U.S. Army Corps of Engineers
USFWS = U.S. Fish and Wildlife Service
ITP Signatories = NMFS and USFWS

Figure 6-1. Monitoring and research program provided by City of Tacoma's Green River HCP.

- engineered structures, such the fish ladder and fish screens meet design criteria;
- the number, size, location and stability of stream rehabilitation measures such as woody debris, sediment, and vegetation plantings satisfy specified commitments;
- management activities within the HCP area comply with specified constraints or restrictions; and
- resource utilization, such as water withdrawals and timber harvest, are accomplished within established limitations.

Evidence of compliance with the HCP requirements will be documented through a combination of project completion reports, annual reports, or Internet web page postings or equivalent public access database. Compliance will be evaluated at 5-year intervals in cooperation with the Services. Provided that Tacoma has implemented the measures as specified, no further action will be necessary beyond reporting requirements specified in individual measures. Funds required to implement compliance monitoring will be provided by Tacoma solely or in conjunction with other funding agencies. Cost reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

Effectiveness Monitoring

Monitoring and adaptive management are processes for combining scientific research with applied management. They are used to address uncertainty about the response of natural ecosystems to management activities while management continues (Halbert 1993). Under an adaptive management process, management actions are treated as a series of experiments, and the results of those "experiments" are scientifically analyzed and used to guide future management.

Effectiveness monitoring measures are used to evaluate whether conservation measures have achieved the specified resource objective. The end result of effectiveness monitoring is to facilitate adaptations if the original measure proves inadequate. Effectiveness monitoring for this HCP includes only those management activities for which uncertainty exists regarding the outcome, and for which Tacoma has complete responsibility. Effectiveness monitoring of conservation measures undertaken as part of the Additional Water Storage (AWS) project will be addressed by the USACE and the Services during Section 7 consultation. Tacoma's participation as local sponsor and via this HCP is limited to providing partial funding to support necessary monitoring and adaptive management. Adherence to funding commitments will be documented as part of compliance monitoring.

Criteria for effectiveness monitoring measures included as part of this HCP will be developed in coordination with the Services. The results of effectiveness monitoring activities will be reviewed in coordination with the Services at 5-year intervals and, if necessary, conservation measures that are judged to be ineffective will be modified. Effectiveness monitoring activities will continue until the Services are satisfied that the measures are achieving the desired resource objective.

Funds required to implement effectiveness monitoring for this HCP will be provided solely by Tacoma. Cost reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma.

Research

Conservation measures for which there is currently little biological uncertainty (e.g., screening criteria at the Tacoma Water Supply Intake at River Mile [RM] 61.0 [Headworks]) will be implemented as described in this HCP, with compliance monitoring to ensure implementation of the measure. Where Tacoma is responsible for ensuring effectiveness of a measure (e.g., snag creation), effectiveness monitoring and adaptive management will be implemented. Research is a third category under Tacoma's Green River monitoring and research program and represents the majority of the funding commitment.

Tacoma has committed to several conservation measures associated with facilities operated by other parties (e.g., USACE operation of Howard Hanson Dam [HHD]). Tacoma has also committed to conservation measures where resource agencies and the MIT have been provided the opportunity to identify and recommend adaptive management options with the approval of the NMFS and USFWS (e.g., springtime refill at HHD). For conservation measures where agencies and the MIT are responsible for adaptively managing a resource, Tacoma has committed to funding research to provide them with feedback on the results of their actions.

Tacoma may modify implementation of the HCP, if requested by the NMFS and USFWS, based on the results of the research measures. Tacoma may also modify implementation of the HCP, if requested by the NMFS and USFWS, based on the consensus of the USACE and the Green River Flow Management Committee (GRFMC). However, any modifications to the conservation measures identified in the HCP shall not represent additional commitments of money, water, or other resources without the consent of Tacoma. Recommendations by the USACE and the GRFMC regarding implementation of the HCP or the USACE's operation of HHD cannot preclude or restrict Tacoma's ability to withdraw water to an extent greater than that agreed to as part of HCMs 1-01 and 1-02 in Chapter 5 of the HCP.

Within the financial limitations described in Chapter 8, Tacoma agrees to fund all or part of the various research activities. A research fund will be established by Tacoma as part of this HCP to allow research activities to continue through the 50-year term of the HCP (see Chapter 8). The research fund will allow flexibility in the apportionment of funds between research efforts as new information becomes available and research priorities change. Cost savings identified through increased efficiencies, competitive bids, or coordinated efforts with other monitoring programs (e.g., King County restoration efforts) will accrue to the research fund. Should funds in excess of the financial commitments identified in Chapter 8 be required to evaluate project impacts or potential restoration measures, the funds must come from sources other than the City of Tacoma.

Annual funding of the research efforts will begin immediately following construction of the HHD AWS project. During the first 10 years of the AWS project, the research fund will be managed by the USACE. During this initial period, the GRFMC will recommend the design and implementation of research activities to the USACE. The USACE will distribute funds or implement the research studies pending approval of the NMFS and the USFWS. During or following this initial 10-year period, the USACE and the City of Tacoma may designate an alternate agency to manage the research fund pending approval of the NMFS and the USFWS. An independent scientific panel could also be formed to guide research activities pending approval of the NMFS and the USFWS.

The intent of the research fund is to allow the NMFS and the USFWS, and with their approval the GRFMC, the opportunity to design and implement an annual Green River research program. In the absence of recommendations of the GRFMC, Tacoma is committed to implementing the monitoring and research program described in this HCP. Details of the research program have been identified in the following section. Additional details will be developed in coordination with the NMFS and USFWS, the USACE, and the GRFMC during the pre-construction engineering and design (PED) phase of the AWS project. The USACE and Tacoma may modify the research program, in coordination with the GRFMC, provided the NMFS and USFWS concur. Any modification to the research program shall not represent additional commitments of money, water, or other resources without the consent of Tacoma. Tacoma's monetary commitment is identified in Chapter 8 of this HCP.

Based on the results of the research, the GRFMC can recommend adaptations in the USACE's water storage and release schedule for HHD. However, responsibility for operation of HHD, including the reservoir storage and release schedule, lies with the USACE. The USACE, in turn, must comply with project purposes as identified by congressional authorization and must abide by NMFS and USFWS direction through Section 7 consultation under the ESA.

Research will address three primary areas of uncertainty:

- downstream fish passage at HHD (including reservoir and dam passage);
- flow management in the middle and lower Green River; and
- sediment and woody debris transport in the mainstem Green River.

Downstream Fish Passage at Howard Hanson Dam

Potential restoration of anadromous fish production above the USACE's HHD is one of the primary conservation measures of this HCP. While restoration of anadromous fish production to the upper Green River watershed offers great promise, achieving the full benefit of fish passage restoration measures will require close monitoring and evaluation of the downstream passage of salmonids as they enter and pass through the reservoir and dam. Achieving successful downstream passage will require research and evaluation to balance successful passage of outmigrating salmonids through HHD and the reservoir with potentially conflicting requirements to protect downstream fish and wildlife resources.

A variety of measures has been proposed as part of the AWS project to evaluate and monitor outmigrating salmonids. Monitoring measures proposed as part of the AWS project include using nets to sample juvenile salmonids as they enter the reservoir, hydroacoustic surveys to identify fish distribution as they pass through the reservoir and dam, and operation of fish sampling facilities to recapture marked fish to assess passage survival. Tacoma's commitment under this HCP is to provide funding support for downstream fish passage research as local sponsor of the AWS project. Some details of the proposed downstream fish passage monitoring plan have been identified, but additional details will be developed during the pre-construction engineering and design phase of the AWS project. The results of research and evaluation measures will be used by the resource agencies and MIT to recommend modifications to the proposed storage and refill rules governing operation of HHD. Viable contingencies include changes to storage timing, refill rate, duration of refill and route of water released from HHD.

Both the USACE and Tacoma have committed to funding downstream fish passage research measures as part of the AWS project. Tacoma's commitment under this HCP will be to fund a portion of the research effort as the local project sponsor. Through the first 10 years following construction of the AWS project, Tacoma will provide funding support for downstream fish passage research measures at the level identified in Chapter 8 of this HCP. Funding support for downstream fish passage research during years 11 through 50 of the AWS project must be provided by other funding entities. Should funds in excess of those identified in Chapter 8 be necessary to fully examine downstream fish passage issues during the first 10 years of the AWS project, funds must be acquired from cost savings or reapportionment from other monitoring measures or by conducting monitoring on a less frequent schedule.

Flow Management

Tacoma is seeking a permit under the ESA to cover water withdrawals associated with supplying municipal water to regional customers. One effect of these water withdrawals is to alter streamflow in the mainstem Green River below Tacoma's Headworks. To provide resource agencies and the MIT with information to better manage instream resources, Tacoma has committed to funding a series of flow management research measures. Flow management research measures identified in this HCP include identifying the physical and biological relationships between mainstem, lateral and side-channel habitats in the middle Green River, identifying the timing and location of spawning salmon and steelhead, and sampling outmigrating juvenile salmonids to identify their outmigration timing, distribution, and survival.

Flow management research measures will provide the NMFS and USFWS and other members of the GRFMC with the knowledge and opportunity to better manage flows and fisheries in the Green River. Using the results of the research measures, they can adaptively manage the Green River flow regime and recommend changes in the storage and release of water from HHD to benefit instream resources. Potential flow management opportunities include maintenance of alternate base flows, capture or release of freshets, and flow augmentation to protect steelhead redds or side-channel rearing areas. Many details of the proposed flow management research program are described in this HCP. Additional details will be developed in coordination with the USACE, Services, MIT, Washington State Department of Fish and Wildlife (WDFW), and King County during the PED phase of the AWS project.

Some of the flow management research measures contained in this HCP represent joint funding efforts by the USACE and Tacoma as part of the AWS project. Other measures represent commitments by Tacoma as part of prior agreements with the MIT. As described in Chapter 8 of this HCP, Tacoma's commitment to flow management research is to fund a portion of the research effort through the first 10 years following construction of the AWS project. Within the funding limits identified in Chapter 8, Tacoma will also provide complete funding for flow management research measures during years 11 through 50 of the AWS project. Should funds in excess of those identified in Chapter 8 be necessary to fully examine specific aspects of flow management issues, funds must be acquired from cost savings or reapportionment from other research measures, or by conducting research on a less frequent schedule.

Flow management research activities identified in this HCP will be complementary to ongoing salmon and steelhead spawning surveys and other monitoring activities conducted by state and Tribal fisheries managers. Streamflow, channel configuration, biotic indices, and water quality parameters are also monitored by various federal, state and local jurisdictions responsible for flood control, public health, and the environment. Coordination with other entities will be critical to maximizing the benefits of conservation measures identified in this HCP (see following section on Basin-Wide Coordination).

Sediment and Woody Debris Transport

The original construction and continued operation of the USACE's HHD interrupts the delivery of gravel-sized and larger sediments and woody debris to the middle and lower Green River. Tacoma and the USACE, as part of the AWS project, have committed to placing quantities of gravel-sized sediments and woody debris below Tacoma's Headworks. The intent is to restore a measure of the natural transport function lost by construction and operation of HHD. Tacoma's commitment, as identified in Chapter 5 of this HCP, is limited to transport and placement of specified quantities of material. Tacoma's gravel and woody debris conservation measures do not commit to a specified level of conservation performance. For instance, Tacoma's gravel nourishment conservation measure stipulates that the addition of 3,900 cubic yards of gravel may be insufficient to fully restore sediment transport functions in the Green River. Tacoma's commitment for sediment and woody debris research is also limited to a specified contribution of funds.

Sediment and woody debris research will identify the amount and composition of sediment and woody debris materials stored in the middle Green River downstream of the input sites. Assuming approval of the Services, information gathered through research efforts will be made available to the GRFMC to allow resource managers to evaluate sediment and woody debris transport alternatives. Potential changes to the sediment and woody debris measures include adaptations to the timing, location, and method of placement of sediments and woody materials. Through the first 10 years following construction of the AWS project, Tacoma will provide funding support for sediment and debris transport research as identified in Chapter 8 of this HCP. Funding support for sediment and woody debris transport efforts during years 11 through 50 of the AWS project must be provided by other funding entities. Should additional funds be necessary to examine sediment or woody debris transport on a basin-wide scale, or if additional funds are needed to expand the evaluation of biological effectiveness, funds must be acquired from cost savings or reapportionment from other research measures or by conducting research on a less frequent schedule.

Basin-Wide Coordination

Tacoma currently owns lands that make up about 10 percent of the upper Green River watershed, or about 5 percent of the entire Green River basin (Ryan 1996; Wiggins et al. 1995). Plum Creek Timber Company, U.S. Forest Service (USFS), Washington State, King County, Weyerhaeuser, Boeing, and the cities of Auburn, Kent, and Tukwila also own or have jurisdiction over large portions of the Green River basin. In response to the listing of Puget Sound chinook under the ESA, many of these entities are committing to increased monitoring efforts to evaluate the effect of their activities on listed species. The widespread interest in monitoring Green River natural resources offers the opportunity to optimize efforts through coordination. Coordination also helps avoid duplication of effort and may provide the opportunity to combine funds to address basin-wide issues or to shift monitoring funds to areas of greatest need.

Collaboration and coordination of monitoring efforts is especially important when addressing issues that extend beyond the immediate effects of a single agency or landowner. Rehabilitation of natural stream processes may involve solutions with potentially significant ramifications. For instance, the sediment transport regime in the Green River is affected by almost all landowners in the basin. The original construction and operation of the HHD was a combined effort of the USACE and King County. Howard Hanson Dam currently blocks the downstream transport of gravel-sized and larger sediments. While HHD serves to trap sediment, historic forestry practices in the upper watershed have changed the rate of sediment delivery into the Howard Hanson Reservoir. Efforts to reinitiate gravel transport below HHD must not only consider the historic and future rate of sediment movement from the upper watershed, but must also consider the existing and future rate of sediment contributions from downstream tributaries. Land use practices in sub-basins such as Newaukum, Soos, Springbrook, and Mill creeks have changed the rate and size distribution of sediments supplied to the mainstem Green River downstream of HHD. While individual landowners and jurisdictional agencies may affect only a small portion of the basin, each contributes to a basin-wide problem.

Increasing the rate of sediment supply to the Green River below HHD may affect the channel capacity in the lower river. Downstream landowners will want assurances that their needs for flood protection are addressed. The effect of placing sediment below HHD may also change depending on the change in sediment contribution from lower basin tributaries. Rehabilitation of the Green River sediment transport regime is but one example of the benefits of basin-wide coordination in developing solutions to natural resource issues.

In addition to enhancing the cost effectiveness and efficiency of monitoring efforts, coordination among various parties in the Green River basin would help ensure that management actions support complementary restoration goals. Tacoma's conservation measures identified in Chapter 5 provide the opportunity to protect ecosystem functions in the middle and lower watershed, and to restore anadromous fish production to the upper watershed. As described in Chapter 4, flood control, urbanization, timber harvest, hatchery practices, fisheries harvest, and land use changes will all influence the effectiveness of measures implemented by Tacoma to protect and restore ecosystem functions. The relative success of conservation measures will be determined not only by Tacoma's implementation of those measures, but by water control, land use, and natural resource management decisions outside the control of the City. Recovery of Green River ecosystem functions to the extent practicable within the present land uses of the basin will require coordination with Tribal, federal, state and local jurisdictions with resource management responsibilities.

While decisions regarding the operation of HHD are ultimately the responsibility of the USACE and the Services (through Section 7 consultation), Tacoma believes that establishment of a Green River basin coordinating committee would enhance the synergistic benefits of conservation measures identified in Chapter 5. However, the establishment of such a committee is not the responsibility of Tacoma, and is therefore beyond the scope of this HCP. An ad hoc committee of Tribal, state, and federal agency representatives currently coordinates fish harvest and hatchery management decisions. An informal GRFMC also exists to review and coordinate flow management decisions with the USACE. A basin-wide coordinating committee could address the interaction of instream flow, habitat, harvest, and hatchery issues in the Green River, and be instrumental in maximizing the resource benefits of the conservation measures provided in this HCP. Such a committee could be set up as part of the Water Resource Inventory Area (WRIA) 9 planning process or similar mechanisms.

One objective of a Green River basin coordinating committee might be to manage basin-wide monitoring and evaluation programs. Tacoma has structured the monitoring and research program to complement a central committee should one be developed at a later date. The research program is expressly designed so that, with the approval of the NMFS and USFWS, a basin-wide committee can direct annual research funds. In the absence of a formal basin-wide coordinating committee, Tacoma will implement the monitoring and research program as specified in the HCP.

The following sections contain descriptions of individual compliance, effectiveness, and research measures. Each measure has been given an identification number consisting of letters designating the type of monitoring (e.g., CMM for compliance monitoring measure) followed by a two-digit number (e.g., CMM-01). In some cases, there are multiple components for a given monitoring measure; these are given a separate letter code and individually described.

Tacoma recognizes that the sampling and collection of any fish species within the Green River watershed is predicated upon having a valid scientific collection permit issued by the WDFW. Furthermore, the collection of any federally listed fish species will require acquisition of a federal recovery permit as specified under section 10(a)(1)(A) of the ESA. Prior to initiating any of the monitoring measures that involve fish sampling, Tacoma will obtain all necessary collection permits and authorizations from state and federal resource agencies and Tribes, and will report findings of such samplings in accordance with permit requirements.

Reporting

Reports describing the results of all compliance, effectiveness, and research monitoring efforts will be submitted to the Services. To minimize repetition, the following text identifies only the Services as primary recipients of monitoring data and reports. However, it is expected that Tacoma or the Services will provide copies of specific reports to other federal, state, and local governments and Indian Tribes who will participate in coordination activities or who could provide meaningful comments and review. Copies of relevant reports will also be submitted to all state or local agencies with regulatory control over actions undertaken as part of monitoring (e.g., WDFW, as the agency in charge of issuing Hydraulic Project Approvals [HPA], will receive copies of all reports describing proposed or completed instream habitat restoration activities).

The reporting format and schedule for each monitoring or research measure is listed in the summary tables for Chapters 6.1, 6.2, and 6.3 and a summary implementation schedule is contained in Chapter 8, Table 8-4 of the HCP. Unless otherwise indicated, the results of all monitoring will be summarized and presented to the Services during meetings convened at 5-year intervals (5-year reviews). Again, to avoid repetition, the text and tables identify only the Services as participants in 5-year reviews. However, contingent upon approval by the Services, Tacoma expects to invite participation in the 5-year reviews by the USACE, WDFW, Washington Department of Ecology (Ecology), Washington Department of Natural Resources (WDNR), MIT, King County, and the GRFMC (or a comparable group if one is established). It is expected that the Services will provide copies of monitoring reports and materials distributed at the 5-year reviews to those organizations and to other interested parties.

6.1 Compliance Monitoring

A brief description of compliance monitoring measures (CMMs) as well as monitoring criteria, measurement frequency, reporting requirements, and contingencies is supplied in Table 6-1. Tacoma's specific commitments associated with each measure are contained within the outlined textboxes following the table. The supporting rationale for each monitoring measure follows the individual textboxes. All monitoring activities will be summarized in writing and presented to the Services during reviews at 5-year intervals. Individual monitoring measures may require more frequent reporting. Monitoring data will be maintained by Tacoma and will be made available to the Services upon request. Provided that Tacoma has implemented the measures as specified, no further action will be necessary beyond reporting requirements specified in individual measures. Funds required to implement compliance monitoring will be provided by Tacoma solely or in conjunction with the USACE. Cost reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-01	Minimum Instream Flow Monitoring	• Green River discharge at Palmer and Auburn available	• Daily	• Post on web page or equivalent public access database within 1 year after ITP issuance	
		• Water supply information available (water diversions and well withdrawal)	• Daily	• Post on web page or equivalent public access database within 1 year after ITP issuance	
		• Document that use restrictions have been implemented if minimum flows in the Green River are lowered to 225 cfs during drought conditions	• As needed	• Written notification to the Services beginning at initial exercise of SDWR	
		• No water withdrawn under SDWR when flows are < 200 cfs at Palmer or < 400 cfs at Auburn between 15 July and 15 September	• Daily	• Post on web page or equivalent public access database beginning at initial exercise of SDWR • Summary plots and tables at 5-year reviews	
		• No water withdrawn under SDWR when flows are < 300 cfs at Palmer between 16 September and 14 July	• Daily	• Post on web page or equivalent public access database beginning at initial exercise of SDWR • Summary plots and tables at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-01	Minimum Instream Flow Monitoring (cont.)	• Pumping rates are less than the rate required to prevent stage declines in an identified adult salmonid holding area in the North Fork Green River of more than 1 inch per hour between 1 July and 31 October	• Hourly when pumping occurs	• Post on web page or equivalent public access database beginning 2 years after ITP issuance • Summary plots and tables at 5-year reviews	
		• Pumping occurs only when turbidity approaches or exceeds 5 nephelometric turbidity units at the Tacoma Headworks	• Daily	• Post on web page or equivalent public access database beginning at initial exercise of SDWR • Summary plots and tables at 5-year reviews	
CMM-02	HHD Non-Dedicated Water Storage and Flow Management Monitoring	• Data on quantity of water available for non-dedicated storage, water dedicated to municipal supply, and water dedicated to flow augmentation for instream resources available on public access database	• Daily	• Post on web page or equivalent public access database beginning 15 February of initial year of exercise of SDWR storage • Summary plots and tables provided to GRFMC monthly from 1 February to 1 July • Report to the Services at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-03	Tacoma Headworks Rehabilitation Monitoring	**SITE NO. 1**			
		Number of pieces of LWD placed: 48 (including at least 6 but no more than 18 rootwads) LWD species: fir, hemlock, cedar, or spruce LWD length ≥ 20 ft LWD diameter (minimum) ≥12 inches Rootwad: diameter at base of bole ≥18 inches Rootwad: stem length ≥ 3ft Boulder size: b-axis ≥ 4 ft	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	
		• Stability Alignment has changed < 20º Location has shifted < 5 meters = 16.4 ft (LWD) or < 2x diameter for boulders Anchor materials intact LWD sound; limited rot or decay Material size similar to installed; no fragmentation	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement during years 6-50
		SITE NO. 2			
		Number of pieces of LWD placed: 5 LWD species: fir, hemlock, cedar or spruce LWD length ≥ 20 ft LWD diameter (minimum) ≥ 12 inches Rootwad: diameter at base of bole ≥18 inches Rootwad: stem length ≥ 3 ft Boulder size: b-axis ≥ 4 ft	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-03	Tacoma Headworks Rehabilitation Monitoring (cont.)	• Stability Alignment has changed < 20º Location has shifted < 5 meters = 16.4 ft (LWD) or < 2x diameter for boulders Anchor materials intact LWD sound; limited rot or decay Material size similar to installed; no fragmentation	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement during years 6-50
CMM-04	Tacoma Headworks Upstream Fish Passage Facility Monitoring	• Meets facility design criteria developed in cooperation with NMFS, USFWS,WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services within 2 years following construction	
		• Documentation of daily number and species transported, release locations, and mortality	• Annual	• Results reported at 5-year reviews	• Modify hauling operations or timing in the event of mortality
		• Confirm adults find and enter ladder by identifying presence/absence of adult anadromous salmonids below the Headworks during trap and transport operations	• Years 1 and 2, survey every 7 days during mid-September to mid-November, and April-May	• Results reviewed annually for ladder entrance modifications; reported at 5-year review	• Modify ladder entrance
		• Confirm that reintroduction of anadromous fish does not pose a risk to public health through degradation of drinking water quality	• Daily at the Headworks and weekly at select locations in the upper watershed	• Results reviewed annually following introduction of adult salmon; increased frequency if public health issues are identified	• Contract with independent expert to coordinate with the Services to evaluate options before reducing upstream passage of adult fish

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-05	Tacoma Headworks Downstream Fish Bypass Facility Monitoring	• Meets facility design criteria developed in cooperation with NMFS, USFWS,WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services within 1 year following construction	• Install baffles or otherwise modify facility to meet design criteria
		• Confirm that debris that collects on trash rack and fish screen are passed downstream	• Volume of debris manually removed from the trash racks and screens will be recorded as part of maintenance operations as site conditions require	• Results will be reported to the Services annually and summarized at the first two 5-year reviews	
		• Confirm that modified Headworks spillway is configured to minimize risk of injury to downstream migrants	• Spillway passage tests will be conducted within 2 years of completion of Headworks modifications	• Results will be reported to the Services within 6 months of completed tests	• Modify Headworks spillway and/or plunge pool conditions
CMM-06	Monitor the Transport of Juvenile Fish to be Released Upstream of HHD	• Documentation of funding or implementation of transport and release (if measure is implemented) Map of release sites Record of number, species, and size of fish released per site	• Record of release process provided to MIT within 1 week of fish transport	• Financial records available to the Services on request • Results will be reported to the Services annually and summarized at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-07	Side Channel Restoration Signani Slough Monitoring	• Meets facility design criteria developed in cooperation with NMFS, USFWS,USACE, WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	
		• Stability for anchored pieces Alignment has changed < 20° Location has shifted < 5 meters is 16.4 ft (LWD) or < 2x diameter for boulders Anchor material, if used, intact LWD sound; limited rot or decay Material size similar to installed Inlet capacity reduced < 20%	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement years 6-50
CMM-08	Mainstem Woody Debris Management Monitoring	**LWD ACCOUNTING** Maintain database of: No. of pieces removed from reservoir No. of pieces for downstream passage No. of pieces for other HCP restoration No. of pieces available for other projects • Copy of LWD availability notification (if applicable)	• Complete within 1 year of ITP issuance with annual updates thereafter	• Data available to the Services on request; summarize at 5-year reviews	
		UNANCHORED LWD PLACEMENT • Annual downstream LWD allocation: At least 5 pieces (if available) or 50% of total collected, whichever is greater Location of wood placement sites Number of truckloads of small woody debris (up to 5) Number of pieces of LWD placed Diameter of LWD: ≥ 1 ft Length of LWD: ≥ 12 ft	• Annual inspection after LWD is transported	• Placement data available to the Services on request • Results reported at 5-year review	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-08	Mainstem Woody Debris Management Monitoring (cont.)	**ANCHORED LWD PLACEMENT (if applicable)** • Location of wood placement sites • Individual piece or collective volume > 11 yd^3 • Stability Alignment has changed < 20° Location has shifted < 16 ft Anchor material intact LWD sound; limited rot or decay Material size similar to installed	• One-time post-construction • Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Project completion report provided to the Services 1 year after placement • Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	
CMM-09	Mainstem Gravel Nourishment Monitoring	• Location of gravel placement Volume of gravel placed: ≤ 3,900 yd^3	• Annual inspection of placement sites following high flows	• Purchase records and placement data available to the Services on request • Results reported at 5-year review	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-10	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring	**HABITAT REHABILITATION (various locations)**			
		• LWD species: fir, hemlock, cedar • LWD (side channels and tribs): Length ≥ 20 ft Diameter ≥ 12 in. Diameter of rootball ≥ 3 ft Frequency (site average) ≥ 2 pieces/channel width • LWD large channels (> 65 ft wide) Volume of piece or group ≥11 yd^3 • Meets design criteria developed in cooperation with NMFS, USFWS, USACE, WDFW, and MIT prior to construction	• One-time within 1 year after placement	• Project completion report provided to the Services within 6 months of completion	
		• Stability (all locations) Alignment of LWD structures changed < 20° Location has shifted < 16 ft (LWD) or < 2x diameter for boulders Anchor material intact LWD sound; limited rot or decay Material size similar to installed; no fragmentation	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement during years 6-50
		VEGETATION IN INUNDATION POOL			
		• Year 1: ≤ 10% mortality of all plantings • Year 5: ≤ 20% mortality of all plantings • Year 10: ≤ 50% mortality of all plantings • No increase in the percent cover of invasive non-native species in any year	• Inspect in years 1, 3, 5, 7, 10	• Inspection data available on request • Results summarized for 5-year reviews in years 5 and 10	• Replant as needed • Implement weed control treatment

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-10	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring (cont.)	**FISH PASSAGE BARRIERS**			
		• Location of barrier culverts	• Year 1	• Map provided to the Services within 6 months following completion of inventory	
		• Treatment prioritization	• Year 2	• List provided to the Services by end of year 2	
		• Culvert design criteria from WDFW (1999)	• As needed	• Records of design calculations, culvert specifications, and post-construction inspection will be maintained and provided to the Services on request • Culvert replacement activities will be reported 5-year review	• Repair or replace as needed
CMM-11	Snowpack and Precipitation Monitoring	• Data on Green River snowpack and precipitation available on public access database	• Daily November through June	• Post on web page or equivalent public access database before storage of SDWR behind HHD • Summary plots provided at GRFMC meetings • Report to the Services at 5-year reviews	• Adopt improved measurement technology if it becomes available at a comparable cost

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-12	Upland Forest Management Monitoring	**ALL HARVEST UNITS**			
		Current copy of standard written notification provided to contractors and loggers	• Update as needed following ITP issuance	• Presented at first 5-year review and subsequent reviews if modified	
		Douglas-fir 50-year site index > 80	• Annual summary following ITP issuance	• Documentation to the Services on request	
		• At least four green recruitment trees retained per acre (including at least 2 conifer if present) including: 1 ≥ 20" dbh (if present) 1 ≥ 16" dbh (if present) 2 ≥ 12" dbh (if present)	• Inspect and map 1 year after harvest	• Results summarized at 5-year reviews	
		• At least 6 snags per acre are retained	• Inspect and map following harvest and at 10-year intervals	• Documentation provided to the Services annually on request • Results summarized at 5-year reviews	• Adjust rate of snag recruitment in coordination with the Services
		UNEVEN-AGED HARVESTING			
		• No harvest of conifer stands > 100 years old in Conservation Zone	• Annual summary following ITP issuance	• Documentation provided to the Services annually on request	
		• Unit size ≤ 120 acres	• Annual summary	• Results summarized at 5-year reviews	
		• On average, area harvested annually accounts for < 1% of total area in conifer-dominated stands in Conservation Zone/year	• Calculated at end of each 5-year reporting period		
		• Planted with 50 to 100 shade-tolerant conifers per acre	• Single inspection 1 year after harvest		• Replant

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-12	Upland Forest Management Monitoring (cont.)	**EVEN-AGED HARVESTING**			
		• Units located only in Commercial Zone	• Annual summary following ITP issuance	• Documentation provided to the Services annually on request	
		• On average, affects ≤ 1.5% of the conifer-dominated stands in Commercial Zone per year	• Calculated at end of each 5-year reporting period	• Results summarized at 5-year reviews	
		• Minimum age of conifer-dominated stand at harvest = 70 years	• Annual summary	• Documentation provided to the Services annually on request	
		• Unit size ≤ 40 acres	• Annual summary	• Documentation provided to the Services annually on request	
		• Planted with 300 to 400 Douglas-fir, western hemlock, western redcedar, or true fir seedlings per acre	• Single inspection 1 year after harvest	• Documentation provided to the Services annually on request • Results summarized at 5-year reviews	• Replant
		SALVAGE HARVEST			
		• Unit size ≤ 120 acres	• Annual summary following ITP issuance	• Documentation provided to the Services annually on request	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-12	Upland Forest Management Monitoring (cont.)	**HARDWOOD CONVERSION**			
		• Conducted only in Commercial or Conservation zone	• Annual summary following ITP issuance	• Documentation provided to the Services annually on request	
		• Planted with 300 to 400 Douglas-fir, western hemlock, western redcedar, or true fir seedlings per acre	• Single inspection 1 year after harvest	• Results summarized at 5-year reviews	• Replant
CMM-13	Riparian Buffer Monitoring	• Average no-harvest buffer width (based on at least 10 measurements at intervals ≤100 ft) Type 1 and 2 waters = 200 ft Type 3 waters = 150 ft Type 4 waters = 50 ft up to 100 ft Type 5 waters = 25 ft	• Single inspection within 1 year of harvest	• Raw data provided to the Services annually on request • Results reported at 5-year reviews	
		• Average partial-harvest buffer width (based on at least 10 measurements at intervals ≤100 ft; start at outer edge of no-harvest zone) Type 3 waters = 50 ft Type 5 waters = 25 ft	• Single inspection within 1 year of harvest	• Raw data provided to the Services annually on request • Results reported at 5-year reviews	
CMM-14	Road Construction and Maintenance Monitoring	• No net increase in permanent road miles in the Natural Zone over term of HCP **OR** if increase has occurred over reporting period, Tacoma will identify roads to be abandoned in the future to ensure compliance	• Calculated at end of each 5-year reporting period	• Results reported at 5-year reviews	
		• Location and configuration of new roads as specified by Watershed Analysis prescriptions	• Single inspection at time of construction	• Documentation provided to the Services annually on request	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-15	Species-Specific Habitat Management Monitoring	• No new roads in berry fields, meadows, avalanche chutes and wetlands	• Annual	• Maps available on request; results reported at 5-year reviews	
		• Buffer and protect occupied Larch Mountain salamander habitat	• Annual	• Maps available on request; results reported at 5-year reviews	
		• Record of grizzly bear sitings, gray wolf dens, Pacific fisher, California wolverine, Canada lynx provided by watershed inspectors	• Record sightings as they occur; immediate notification of the Services	• Sightings data sheets available on request	• Implement species-specific habitat conservation measures
		• Annual check with USFWS area biologist and WDFW Priority Habitats database	• Annual	• Results reported at 5-year reviews	• Implement species-specific habitat conservation measures

6.1.1 Compliance Monitoring Measure CMM-01 Minimum Instream Flow Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-01

MEASURE: Minimum Instream Flow Monitoring

CMM-01A - Mainstem Green River

Before water can be withdrawn or stored under the Second Diversion Water Right (SDWR), Tacoma shall ensure that the MIT and federal and state resource agencies have access to the U.S. Geological Survey (USGS) streamflow database, or equivalent source, for the purpose of monitoring streamflow conditions at the Palmer, Washington (USGS # 12106700), and Auburn, Washington (USGS # 12113000), gage stations (Tacoma 1995). Tacoma shall ensure instream flow levels are measured on a daily basis, as noted under the conditions specified in the Muckleshoot Indian Tribe/Tacoma Public Utilities Agreement (MIT/TPU Agreement), and at both the Palmer and Auburn, Washington, gages. The results of such monitoring shall document that Tacoma has taken all steps necessary to comply with seasonal restrictions on the SDWR and the instream flow requirements stipulated in the MIT/TPU agreement. Should Tacoma exercise the option to lower minimum flows to 225 cubic feet per second (cfs) at the Auburn gage during drought conditions, written documentation that water use restrictions have been implemented will be provided to the Services.

Tacoma will make the results of the above monitoring available to the MIT and interested federal and state resource agencies. Furthermore, Tacoma shall also update its system of flow monitoring, as mutually agreed upon by the MIT and federal and state resource agencies, consistent with advances in data transfer technology. As part of this monitoring, Tacoma shall also provide system water supply information (e.g., well and municipal reservoir levels), as requested by MIT and federal and state resource agencies (Tacoma 1995). Access to these data will be provided through an Internet web page or equivalent public access database with daily updates on reservoir and river conditions. The web page will be available within 1 year following signing of the ITP.

CMM-01B – North Fork Well Field

Tacoma shall maintain records of withdrawals from the North Fork well field, including the rate of withdrawal on an hourly basis. In addition, daily turbidity values measured at the RM 61.5 Headworks will be maintained. Records of well withdrawals and turbidity readings will be made available to the Services upon request to document compliance.

The results of a study to identify the physical effect of the rate of well field pumping on stage changes in the lower North Fork channel will be provided to the NMFS and USFWS within 2 years following signing of the ITP. The study must be designed and

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completed in cooperation with the NMFS and USFWS and submitted to the MIT and local, state, and other federal resource agencies for review and comment. The results of the study will be used to assess the maximum rate of pumping that maintains a pumping-related stage reduction of no greater than 1 inch per hour in an area of potential adult salmonid holding refugia in the lower North Fork channel. Following completion of the study, documentation of compliance with the 1 July through 31 October ramp rate restrictions will be provided through maintenance of hourly pumping records.

Surveys of adult salmonids holding in the North Fork Green River downstream of the North Fork well field will be conducted during the late summer and fall to quantify the resource potentially at risk. The presence of adult fish in the North Fork Green River downstream of the North Fork well field will be evaluated by pedestrian surveys conducted every 10 days between 1 September and 31 October. Surveys will be conducted for the first 5 years following completion of the Tacoma Headworks upstream passage facility. The results of these surveys will be reported at the first 5 year review, and will be made available to the Services on request.

Objective

The objective of this monitoring measure is to document compliance with minimum flows, water withdrawal restrictions, and pumping rates by making streamflow data and system water supply information available on an Internet web page or other public access database.

Rationale

Mainstem Green River. Tacoma has diverted water from the Green River since 1913, under the First Diversion Water Right claim (FDWRC). Tacoma's FDWRC is not subject to the state of Washington's 1980 minimum instream flow (Caldwell and Hirschey 1989). In 1986, Tacoma was granted an additional water right, the SDWR from Ecology, for up to 100 cfs. In 1995, Tacoma entered into an instream flow agreement with the MIT that conditioned the use of its water rights on minimum flows set forth in the MIT/TPU Agreement (Tacoma 1995). In order to meet this agreement, Tacoma must provide access to USGS streamflow data in the Green River on a daily basis during periods of water withdrawal.

This compliance monitoring measure will be implemented to document that Tacoma is taking all necessary steps to ensure the flow requirements of the MIT/TPU Agreement as described in Table 6-1 and Chapter 5 are met. Information will be available on demand from an Internet web-site or other public access database that is updated daily. Summary plots and tables describing water withdrawals and instream flows will be presented at 5-year reviews.

North Fork Well Field. In general, pumping from the North Fork well field occurs during the late fall, winter and spring when streamflow and turbidity are highest. However, periods when well withdrawals would be required to meet drinking water standards have been documented to occur during September (Noble 1969), at a time when well withdrawals have the potential to impact cool water refugia in the lower North Fork Green River. As part of CMM-01, records of well field use and turbidity readings from the mainstem Green River will ensure that the well field is only used when needed to maintain water quality and protect public health. Documentation of stage changes in response to pumping and information on use of the affected reach by adult salmonids will be used to quantify the resource at risk and assess the magnitude of that potential risk.

6.1.2 Compliance Monitoring Measure CMM-02 Howard Hanson Dam Non-Dedicated Water Storage and Flow Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-02

MEASURE: Howard Hanson Dam Non-Dedicated Water Storage and Flow Management Monitoring

Tacoma has agreed to provide funding support to distribute data for development of an enhanced springtime operating strategy for HHD. Tacoma will post data on the amount of water available for non-dedicated storage, water dedicated to municipal supply, and water dedicated to flow augmentation for instream resources on the web page. A summary of this data will be provided to the GRFMC on a monthly basis from 1 February through 1 July, and will be presented to the Services during regularly scheduled 5-year reviews.

Objective

The objective of this monitoring measure is to provide data on the amount of water available in the dedicated and non-dedicated blocks of water stored in Howard Hanson Reservoir storage to facilitate flow management by the GRFMC.

Rationale

Tacoma is the local sponsor of the HHD AWS project, and will support the USACE and GRFMC in developing an enhanced springtime operating strategy for HHD. The springtime storage and release strategy will involve management of dedicated and non-dedicated blocks of water that will be used to benefit fisheries resources, as described in HCM 2-02 (Section 5.2.2). To that end, Tacoma has committed to ensuring that data on the quantity of water in non-dedicated, dedicated water supply and dedicated flow augmentation blocks are available to the GRFMC. Providing data on the amount of water in the various storage allocations will assist the GRFMC to evaluate management decisions and recommend in-season adjustments.

6.1.3 Compliance Monitoring Measure CMM-03 Tacoma Headworks Rehabilitation Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-03

MEASURE: Tacoma Headworks Rehabilitation Monitoring

A number of rehabilitation structures (consisting primarily of large woody debris [LWD] and rootwads) will be placed in the Headworks inundation pool to improve habitat conditions in the reach inundated by the raise in the pool inundation zone. These structures will be monitored to determine their longevity and ability to withstand high flows. The stability of the structures will be assessed using criteria based on the alignment, location, extent of fragmentation or decay, and condition of anchoring materials. Structures that are deemed non-functional as a result of high flows will be modified or replaced by Tacoma as needed within the first 5 years following construction. Tacoma will also fund one complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary. The physical stability of the structures will be evaluated in years 1, 3, and 5 following construction, and after all flows that have a return interval of ∃20 years as measured at HHD.

Objective

The objective of this monitoring measure is to evaluate the physical condition and stability of rehabilitation structures installed in the Headworks inundation pool to confirm that they meet design criteria and remain stable.

Rationale

The benefits of using LWD to rehabilitate salmonid habitat are well documented (House and Boehne 1986; Murphy 1995). For this reason, habitat conservation measures that involve placement of LWD are assumed to be effective provided they remain stable and function as intended. Therefore, monitoring for this HCP will be limited to documentation that the structures comply with design and performance criteria.

Design criteria for CMM-03 are described in detail in the Final Second Supply Project Comprehensive On-Site and Off-Site Fish Mitigation report (CH2M Hill et al. 1996). Large woody debris specifications call for a total of 48 pieces of LWD to be placed at two sites within the Headworks reach. The number of pieces required is based on achieving a desired frequency of two pieces per channel width within the Headworks reach. Large woody debris must be fir, hemlock, cedar or spruce. Logs will have a minimum diameter of 12 inches and be at least 20 feet long. Rootwads will have a diameter of at least 18 inches at the base of the bole, and a stem that is at least 3 feet long. These pieces are less than the minimum size or volume that qualifies as a "key" piece in the mainstem Green River channel, which is greater than 100 feet wide in the Headworks reach. However, to enhance stability, the LWD will be placed in groups of three to five logs, and attached to each other and to a placed boulder that has a minimum diameter of 4 feet. At Site 1, which consists of a large point bar, approximately 10 boulders (minimum diameter 4 ft) will be placed at the upstream end to dissipate the energy of high flows sweeping across the bar. At Site 2, five single logs will be placed at the outside of a meander bend, and attached to each other and to boulders that have been placed on the bank.

Compliance with the design criteria will be documented by a one-time inspection of each rehabilitation site immediately following construction. The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Structures will be judged stable if they remain within 16.4 feet (5 meters) of their original location, their alignment has changed less than 20 degrees, anchor materials and connections are intact, and the LWD is sound with little rot, decay, or fragmentation. The stability of each rehabilitation structure will be evaluated through field inspections conducted 1, 3, and 5 years after construction. Performance criteria established in the HPA require that all structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at HHD. If the structures fail to meet the stability criteria during the first 5 years, Tacoma will repair or replace them, modifying the design criteria as necessary in cooperation with NMFS and USFWS. After the first 5 years, Tacoma will provide funding for one additional replacement of the structures, should they decay or fail following large floods.

A post-project completion report, describing any deviations from the original design, will be presented to the Services within 6 months after the project has been completed. The results of the initial stability inspections will be summarized in a report presented at the first 5-year review. Additional inspection reports will be submitted at review periods during which a 20-year flow event has occurred.

6.1.4 Compliance Monitoring Measure CMM-04 Tacoma Headworks Upstream Fish Passage Facility Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-04

MEASURE: Tacoma Headworks Upstream Fish Passage Facility Monitoring

Following construction of the new fish ladder and trap-and-haul facility at the Headworks, the structure will be evaluated to ensure that project design criteria are met. Specific facility design criteria, performance standards, and a detailed evaluation approach will be developed in cooperation with the Services, WDFW, and the MIT during engineering and design of the Headworks modifications associated with the Second Supply Project (SSP).

Observations of fish behavior at the entrance to the fishway will be used to ensure the passage facility complies with the requirement to facilitate safe upstream passage of adult fish. The presence of adult fish in the vicinity of the Headworks will be evaluated by snorkel surveys conducted every 7 days from mid-September to mid-November, and in April and May for the first 2 years of the project, or until satisfactory results are observed, whichever is longer. Successful capture of adult fish in the trap when adults are holding in the immediate vicinity of the Headworks will indicate that the facility is accessible. Congregations of adult anadromous salmonids below the Headworks, in combination with a low capture rate, will indicate that design modifications are required. The results of these surveys will be reported to the Services on an annual basis.

Release records, visual observation of fish condition, and a low rate of mortality will be considered evidence that fish are being successfully transported upstream. These data will be summarized annually and reported to the Services at regularly scheduled 5-year reviews.

Tacoma will monitor the effects of upstream fish passage on drinking water quality as part of its surface water treatment operations. If continued monitoring confirms that reintroduction of anadromous fish does not pose a risk to public health, no further action will be taken. If, to adequately protect drinking water quality, it becomes necessary to limit the biomass of adult fish transported into the upper watershed, Tacoma will coordinate with the NMFS, USFWS, and the fisheries managers before instituting measures to decrease fish passage.

Objective

The objective of this monitoring measure is to evaluate the upstream Headworks facility following construction to confirm that it meets project design criteria and that passage of adult fish does not pose a risk to public health.

Rationale

Construction of a new fish ladder and trap-and-haul facility at the Headworks is instrumental to the successful restoration of anadromous fish runs into the upper Green River. Evaluation of hydraulic conditions over the expected range of flows following construction is required to demonstrate that the facility complies with design criteria. A post-project completion report, describing any deviations from the original design and the results of the hydraulic evaluation, will be presented to the Services within 1 year after the project has been completed. Adjustments of the fishway may be required if fish do not enter the ladder or fail to ascend into the trap. Monitoring the number, behavior, and physical condition of adult salmonids below the Headworks and in the trap will provide evidence that the project design is appropriate and will verify the adequacy of the facility.

Tacoma does not believe reintroduction of anadromous fish to the upper watershed poses a risk to drinking water quality and public health at the numbers that have been described in the Draft Environmental Impact Statement (DEIS) for the AWS project (up to 6,500 adult coho and 2,300 adult chinook). This level would be reached over a period of years, allowing adequate opportunities to assess water quality on an ongoing basis. Tacoma will monitor the effects of fish passage on drinking water quality as part of its surface water treatment operations. Measurements will be taken daily at the Headworks and weekly at select locations within the upper watershed. If continued monitoring confirms that reintroduction of anadromous fish does not pose a risk to public health, no further action will be taken. If, to adequately protect drinking water quality, it becomes necessary to limit the biomass of adult fish transported into the upper watershed, Tacoma will coordinate with the NMFS, USFWS, and the fisheries managers before instituting measures to decrease fish passage. As part of the coordination effort, Tacoma will select one or more independent experts to evaluate available options. The independent expert will submit a report to the City, fisheries managers, and public health officials with recommendations as to the level of fish passage that can occur without posing a risk to drinking water quality and public health.

6.1.5 Compliance Monitoring Measure CMM-05
Tacoma Headworks Downstream Fish Bypass Facility Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-05

MEASURE: Tacoma Headworks Downstream Fish Bypass Facility Monitoring

The fish screen and bypass facility will be designed based on specifications for fish protection associated with downstream passage facilities developed by the NMFS

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and WDFW, and will meet the maximum design approach velocity requirement of 0.4 feet per second (fps). The configuration and hydraulic performance of the facility under the normal range of flows expected during the period when juvenile salmonids are migrating downstream will be evaluated following construction to confirm that the facility meets design criteria. Specific design criteria, performance standards, and a detailed evaluation approach will be developed during engineering and design of the Headworks modifications associated with the SSP. A post-project completion report describing the results of the performance evaluation will be submitted to the Services within 1 year of project completion.

Wood debris and drift that collects on the trash racks and fish screens must be periodically removed to maintain satisfactory screen operations. Debris that collects on the fish screens will be removed through mechanical or manual maintenance operations and passed downstream. If wood debris or drift are removed or dislodged via manual methods, the volume will be recorded. The number and approximate size of wood pieces dislodged will be totaled on a monthly basis and reported to the Services as part of an annual review. The volume of wood debris and drift manually removed or dislodged will be summarized and reported to the Services during the first two 5-year reviews. This monitoring measure will continue through the first 10 years following completion of the Headworks SSP modifications.

As part of the SSP Headworks modifications, Tacoma will rebuild its Headworks facility and reconfigure the Green River channel below the Headworks. Headworks modifications will be designed to minimize potential injury to salmonids associated with downstream passage over the Headworks spillway. Within 2 years following completion of the Headworks modifications, Tacoma will conduct a biological test of the modified spillway to demonstrate that the risk of injury to salmonids passing downstream over the spillway has been minimized.

Objective

The objective of this monitoring measure is to evaluate the screen and bypass facility following construction to confirm that it meets design specifications.

Rationale

Screen bypass facilities such as the one that will be constructed at the Headworks are based on a standard design that has been developed and approved by the NMFS and WDFW. Design specifications for the Headworks bypass facility will be developed based on the NMFS criteria. An evaluation of the hydraulic conditions at the completed project will be made over the range of flows expected during downstream migration following construction. A post-project completion report, describing the results of the performance evaluation and any deviations from the original design, will be presented to the Services within 1 year after the project has been completed. If the completed facility meets the design specifications, no additional monitoring will be conducted.

Woody debris and organic drift materials are an important link between the aquatic and terrestrial environment (see Chapter 5.2.8). Water withdrawn at Tacoma's Headworks is intentionally screened to prevent the intake of adult and juvenile salmonids and wood debris and organic drift. Past maintenance practices at similar water withdrawal facilities have included the collection and disposal of water-borne debris that collect on trash racks and screens. Disposal of this debris interrupts natural stream processes and presents maintenance cost. Tacoma will ensure that wood debris and drift that collect on trash racks and screens at the Headworks will be passed downstream to continue to be transported to downstream habitats.

Although fish passing downstream over Tacoma's Headworks are believed to incur little injury or mortality during their transit over the existing spillway, some potential for injury does exist. The existing concrete gravity diversion dam is 17 feet high. Reconstruction of the Headworks as part of the SSP will raise the diversion by 6.5 feet to a total height of 23.5 feet. Although there are no site-specific data on hydraulic conditions, fish injury, or fish mortality at the existing Tacoma Headworks diversion dam, information from studies at other projects suggests that the rate of mortality experienced by juvenile fish passing over a 23.5-foot spillway is probably low. Tacoma will rebuild its Headworks facility and reconfigure the channel below the Headworks. Design modifications will consider alternative strategies to minimize potential injury associated with downstream passage of salmonids over the Headworks spillway. Within 2 years following completion of the Headworks modifications, Tacoma will conduct a biological test of the modified spillway to demonstrate that the risk of injury to juvenile salmonids passing downstream over the spillway has been minimized. Before implementing the study, Tacoma will develop a study design in coordination with the Services. The results of the study will be provided to the Services within 6 months of completing the field portion of the test.

6.1.6 Compliance Monitoring Measure CMM-06
Monitor the Transport of Juvenile Fish to be Released Upstream of HHD

COMPLIANCE MONITORING MEASURE NUMBER: CMM-06

MEASURE: Monitor the Transport of Juvenile Fish to be Released Upstream of HHD

If the Services and the MIT determine that supplementation of juvenile salmonids upstream of HHD is beneficial, Tacoma will provide funds to record the number, size, and the release site of juvenile fish transported by Tacoma and released above HHD.

Objective

The objective of this monitoring measure is to confirm that juvenile salmonids are successfully released upstream of HHD.

Rationale

Reporting the release sites and dates, and the number and size of juvenile salmonids released into the upper watershed, will be necessary to document Tacoma's compliance with the measure. Documentation of juvenile salmonid transportation and release is also needed to provide the Services with information that is critical to monitoring and managing salmon production in the upper watershed. These data will complement monitoring the HHD downstream fish passage facility and evaluating overall watershed production. A map of the release sites, record of the number and species of fish released at each site, and copies of the completed follow-up survey forms will be provided to the Services annually, and the results of the surveys will be summarized and presented for each 5-year review following a period when fish are released.

6.1.7 Compliance Monitoring Measure CMM-07
Side Channel Restoration Signani Slough Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-07

MEASURE: Side Channel Restoration Signani Slough Monitoring

Tacoma will contribute funds to monitor the reconnection of Signani Slough in the middle Green River. The restored channel will be evaluated for 1 year immediately following construction to document that the site meets the design criteria developed in cooperation with the Services, USACE, WDFW, and MIT. The stability of the

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structures will be assessed on the basis of: 1) inlet capacity; 2) alignment, location, extent of fragmentation, or decay of LWD structures; and 3) condition of anchoring materials. Structures that are deemed non-functional will be modified or replaced by Tacoma as needed within the first 5 years following construction. Tacoma will also fund one additional complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary. The physical stability of the structures will be evaluated in years 1, 3, and 5 following construction, and after all flows that have a return interval of ∃20 years as measured at HHD.

Objective

The objective of this monitoring measure is to assess the physical condition and stability of rehabilitation structures to confirm that they meet design criteria, remain in place, and produce the desired hydraulic conditions.

Rationale

Levees, channel degradation, and controlled flows from HHD have all combined to reduce the Green River's interaction with its former side-channel habitats. In 1854, fish could access approximately 1,900 linear miles of stream in the Green River; however, by 1985 only 125 linear miles were still accessible (Fuerstenberg et al. 1996). Off-channel habitat is one obvious source of lost habitat since the turn of the century, and is the focus of the Signani Slough Habitat Conservation Measure.

The biological benefits of off-channel habitats are well documented (Brown and Hartman 1988; Peterson 1982; Cederholm and Scarlett 1982). For this reason, habitat conservation measures that involve reconnection of off-channel habitat and placement of LWD are assumed to be effective provided they remain stable and function as intended. Monitoring for the purposes of this HCP will document that the structures comply with design and performance criteria. However, monitoring of fish use and population surveys may be conducted by Tacoma or other entities as part of the research efforts described in Chapter 6.3. Conceptually, restoration will require breaching the Headworks road in two places and installing two 24- to 48-inch inlet culverts; diverting up to 35 cfs from the mainstem through the side channel; replacing the existing outlet culvert; adding gravels and vegetation; and adding LWD at a frequency of approximately two pieces per channel width. Large woody debris placed within Signani Slough will be at least 12 inches in diameter and 20 feet long. Final project design criteria will be developed in cooperation with the Services, USACE, MIT, and state and local agencies prior to construction.

The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Large woody debris placed within the side channel will be judged stable if it remains within 16.4 feet (5 meters) of the original location, the alignment has changed less than 20 degrees, anchor cables and connections are intact, and the LWD is sound with little rot, decay or fragmentation. The stability of each enhancement structure will be evaluated through field inspections conducted 1, 3 and 5 years after construction.

Performance criteria established in the HPA are expected to require that all rehabilitation structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at HHD. If the structures fail to meet the performance and stability criteria during the first 5 years, Tacoma will repair or replace them, modifying the design criteria as necessary. After the first 5 years, Tacoma will provide funding for one additional replacement of the structures, should they decay or fail following large floods.

6.1.8 Compliance Monitoring Measure CMM-08 Mainstem Woody Debris Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-08

MEASURE: Mainstem Woody Debris Management Monitoring

The amount of LWD collected from the HHD reservoir each year will be recorded, and a LWD accounting spreadsheet will be developed to track the distribution of LWD. The number of pieces of LWD obtained from the reservoir and allocated to: 1) the mainstem Green River woody debris management program; 2) other HCP-related conservation measures; 3) non-HCP-related habitat restoration projects or MIT cultural use within the Green River basin; 4) ecosystem restoration projects outside of the Green River basin; or 5) disposal will be recorded annually. This spreadsheet and documentation of annual communications with other basin stakeholders regarding the availability of LWD for non-HCP-related projects will be provided to the Services on request beginning 1 year after issuance of the ITP.

Woody debris allocated to unanchored downstream transport will be placed adjacent to the stream within the active channel and allowed to naturally distribute downstream during high flows in the fall. Tacoma will record the initial placement locations, total volume of small woody debris, and the number and size of pieces of LWD placed at each input site. Each input site will be revisited the following spring to document the number of unanchored pieces of LWD remaining following high flows.

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> In addition to or instead of unanchored wood placement, LWD may be anchored at specific locations. If LWD is anchored in the river rather than allowing flows to distribute the pieces naturally, the locations and design criteria applied to each placement site will be recorded.
>
> The location and amounts of small woody debris and unanchored LWD placed and successfully recruited each year will be summarized at each 5-year review. If anchored placement is implemented, a post-project completion report describing the location and design of LWD anchoring projects will be presented to the Services within 6 months after each project has been completed, and the results of stability evaluations will be summarized at 5-year reviews.

Objective

The objective of this monitoring measure is to document the annual allocation of LWD collected from the reservoir. Confirm that unanchored LWD placement is transported downstream by high flow events by documenting the volume remaining at placement site location(s) the following spring. Confirm that anchored LWD meets design criteria and remains stable at each anchored placement site.

Rationale

The goal of the mainstem woody debris management program is to pass at least 50 percent of the wood collected from behind HHD to downstream reaches. The LWD accounting spreadsheet and communications records will confirm that Tacoma is distributing LWD collected from behind HHD to the mainstem LWD management program or other approved uses in compliance with the ITP. Annual site visits will verify whether unanchored LWD is successfully recruited to the river.

If LWD anchoring is determined to be a preferable means of reintroducing LWD to the middle Green River, post-project completion reports will document that anchored LWD placement projects have complied with design criteria developed in cooperation with the Services, USACE, MIT, and state and local agencies. Compliance with the design criteria will be documented by a one-time inspection of each placement site immediately following construction. The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Structures will be judged stable if they remain within 16.4 feet (5 meters) of their original location, if their alignment has changed less than 20 degrees, if the anchor materials and connections are intact, and if the LWD is sound with little rot, decay or fragmentation. The stability of each rehabilitation structure will be evaluated through field inspections conducted 1, 3, and 5 years after construction. Performance criteria established in the HPA require that all structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at HHD.

Monitoring the total volume of LWD in the mainstem Green River and evaluating the effectiveness of LWD placement is beyond the scope of this compliance monitoring measure. Research funds are allocated to evaluate the effectiveness of woody debris placement as described in Chapter 6.3.

6.1.9 Compliance Monitoring Measure CMM-09 Mainstem Gravel Nourishment Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-09

MEASURE: Mainstem Gravel Nourishment Monitoring

Tacoma will annually record the volume, type, location, and method of placement of gravel added to the Green River channel below the Headworks. Records will be maintained and made available to the Services on request. Tacoma's commitment under this conservation measure is limited to the contribution of funds necessary to annually place up to 3,900 cubic yards of gravel appropriately sized for use by spawning salmonids. Input sites will be inspected annually following high flows to identify the volume of gravel that has been redistributed downstream within the river channel.

Objective

The objective of this monitoring measure is to document that the required volume of gravel has been input to the Green River.

Rationale

The goal of the gravel nourishment conservation measure is to replace an increment of the bedload that was formerly delivered to the middle Green River but is now trapped behind HHD. Records of the amount and composition of gravel input each year will be maintained to document that Tacoma is complying with the ITP. Monitoring of the effectiveness of gravel nourishment is beyond the scope of this compliance monitoring measure, but will occur under research measure (RFM-03B), as described in Chapter 6.3.

6.1.10 Compliance Monitoring Measure CMM-10 Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-10

MEASURE: Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring

Habitat Rehabilitation

Structures installed as part of the upper watershed stream, wetland and reservoir shoreline rehabilitation measure (HCM 2-03) will be monitored to ensure that they meet design criteria and remain stable. Final design criteria will be developed in cooperation with the Services, USACE, WDFW, and MIT during the PED phase of the AWS project. The goal of the criterion will be to achieve habitat indices equivalent to “good” ratings applied during Watershed Analysis (WFPB 1997), if applicable to the stream type, or to comparable criteria approved by the Services. The stability of the structures will be assessed using criteria based on the alignment, location, extent of fragmentation or decay, and condition of anchoring materials. The physical stability of the structures will be evaluated in years 1, 3, and 5 following construction, and thereafter following all flows that have a return interval of $\geq$ 20 years as measured at HHD.

Structures that are deemed non-functional will be modified or replaced by Tacoma as needed within the first 5 years following construction. Tacoma will also fund one additional complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary.

Vegetation in the Inundation Pool

Vegetation monitoring will occur through the use of randomly selected permanent transects and/or sample plots to identify vegetation cover and vigor. Vegetation sampling will be conducted in years 1, 3, 5, 7, and 10 following implementation of the AWS project. If the percent cover of planted vegetation does not meet the criteria summarized in Table 6-1 in any given year, Tacoma will replant as needed. If the percent cover of invasive non-native species increases over the existing conditions, Tacoma will implement a weed control treatment.

Fish Passage Barriers

The results of the culvert inventory will be presented to the Services within 1 year of issuance of the ITP, and a prioritized plan to eliminate artificial blockages in the Upper HCP Area will be developed in cooperation with the Services, WDFW, MIT, and other landowners with property accessed by the affected roads within 2 years of issuance of the ITP. Stream crossings modified as part of the culvert improvements habitat conservation measure will be sized to pass a 100-year flood flow and will meet culvert

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> design criteria specified by the WDFW (WDFW 1999) or meet comparable methodologies approved by the Services. Tacoma will provide documentation of the treatment date, hydrologic analysis, and design criteria used to treat each artificial blockage at the first 5-year review. Should the new structures or existing passable structures become impassable during the term of the HCP, Tacoma will replace those structures within 1 year of identification, modifying the design criteria as necessary to reduce the risk of future blockages. Additional passage barriers treated after the initial reporting period will be summarized at the first 5-year review following treatment. Identification of passage barriers that may form following the initial systematic inventory will be accomplished during the post-storm inspection program implemented under the Road Sediment Reduction Plan (RSRP).

Objective

The objective of this monitoring measure is to evaluate the physical condition and stability of rehabilitation structures to confirm that they meet design criteria, remain in place, and produce the desired hydraulic conditions. Survey planted areas to confirm that the vegetative stocking and cover requirements are met. Confirm that management-related fish passage barriers have been corrected and that new passage structures meet design criteria.

Rationale

Habitat Rehabilitation. Design criteria for the upper watershed stream rehabilitation projects will be developed in cooperation with the Services, USACE, WDFW, and MIT during the PED phase. Compliance with the design criteria will be documented by a one-time inspection of each rehabilitation site immediately following construction. The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Structures will be judged stable if they remain within 16.4 feet (5 meters) of their original location, if their alignment has changed less than 20 degrees, if the anchor materials and connections are intact, and if the LWD is sound with little rot, decay or fragmentation. The stability of each rehabilitation structure will be evaluated through field inspections conducted 1, 3 and 5 years after construction. Performance criteria established in the HPA require that all rehabilitation structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at HHD. If the structures fail to meet the stability criteria during the first 5 years, Tacoma will repair or replace them, modifying the design criteria as necessary in coordination with the Services. After the first 5 years, Tacoma will provide funding for one additional replacement of the structures, should they decay or fail following large floods.

A post-project completion report, describing any deviations from the original design, will be presented to the Services within 6 months after the project has been completed. The results of the initial stability inspections will be summarized in a report presented at the first 5-year review. Additional inspection reports will be submitted at review periods during which a 20-year flow event has occurred.

Vegetation in the Inundation Pool. Monitoring of measures designed to establish inundation-tolerant vegetation communities within the expanded inundation pool are intended to assess the rate and degree to which the desired plant community develops in newly submerged portions of the inundation pool. The upper watershed rehabilitation habitat conservation measure will be assumed to have effectively created the desired mix of floodplain forest and wetland communities if vegetation cover meets or exceeds the criteria summarized in Table 6-1. If mortality exceeds the allowable percentages, the areas will be replanted after the reason for failure has been identified (e.g., poor planting stock, herbivory, hydrologic conditions). Following the establishment of plant materials, manual control, or herbicidal treatment for control of non-native invasive species appropriate for the individual species will be developed as necessary.

Fish Passage Barriers. The goal of the culvert improvements habitat conservation measure is to remove artificial barriers that prevent one or more lifestages of the covered species from moving up or downstream. The initial culvert inventory will be used to prioritize treatment of barriers; inventory results will be provided to the Services within 1 year. Culverts that require replacement will be identified and prioritized in coordination with the Services, WDFW, MIT, and other landowners with property accessed by the affected roads within 2 years. Records of the treatments applied at each site, including the location, date of treatment, results of hydrologic analysis and physical specifications of the new structure (length, diameter, grade etc.) will be provided to the Services on request, and summarized for the first 5-year review.

Watershed Analysis stipulates that a RSRP be developed for each Watershed Administrative Unit (WAU) within 2 years of final approval by the WDNR. The RSRP requires landowners in the upper Green River to develop a program to inspect stream-crossing sites with a high risk of failure, blockage or diversion following major storm events. Implementation of this post-storm monitoring will facilitate early identification of stream-crossing sites where storm-related impacts that preclude fish passage may have occurred. If a previously passable culvert on Tacoma's land becomes impassable as a result of such impacts, Tacoma will replace the structure within 1 year of the initial identification. The results of ongoing culvert replacement or repair activities will be summarized for each 5-year review.

6.1.11 Compliance Monitoring Measure CMM-11 Snowpack and Precipitation Monitoring

> **COMPLIANCE MONITORING MEASURE NUMBER: CMM-11**
>
> **MEASURE: Snowpack and Precipitation Monitoring**
>
> To document that snowpack and precipitation monitoring stations have been installed and remain operational, Tacoma will ensure that the Services have access to the data on an Internet web site or an equivalent source consistent with advances in data transfer technology. Financial records documenting funds transfer will be provided to the Services on request.

Objective

The objective of this monitoring measure is to document compliance by making snowpack and precipitation monitoring data available to the Services and other interested parties.

Rationale

In order to improve the accuracy of water supply forecasting for the Green River, Tacoma is committing to provide funds for installation and annual maintenance of up to three snow pillows with rain gages in the upper Green River basin. Snowpack data are downloaded from the Snowpack Telemetry (SNOTEL) sites by the National Resource Conservation Service on a daily basis between 1 November and 1 July and made available for use in water supply forecasting. Ensuring that snowpack and precipitation monitoring data from the new monitoring sites are available on an Internet web site or comparable public access database, will document that Tacoma has complied with the requirements of the snowpack monitoring habitat conservation measure. Tacoma will also provide financial records associated with implementing this measure upon request.

6.1.12 Compliance Monitoring Measure CMM-12 Upland Forest Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-12

MEASURE: Upland Forest Management Monitoring

In coordination with the Services, Tacoma will place newly acquired forestlands in the upper watershed that it wishes to add to the HCP area, into one of the three forest management zones prior to initiating any management activities. At each scheduled reporting period, Tacoma will provide the Services with an updated map of the forest management zones and a table of current acreage totals (by zone). The map will show Tacoma ownership in the Upper HCP Area (above the Headworks) and distinguish between the three forest management zones.

A copy of the standard written notification provided to contractors and loggers notifying them of pertinent HCP measures and ensuring that they are aware of all relevant terms and conditions of the HCP will be provided to the Services at the first review in year 2. Updated copies will be provided at subsequent reporting periods if any changes are made to the notification.

At each scheduled reporting period, Tacoma will provide the Services with a current map of the three forest management zones showing the age of all forest stands in the Upper HCP Area and all stands that have been affected by timber harvest activities since the previous reporting period. The map will also depict the locations of sensitive habitats such as moderate to high hazard Mass Wasting Map Units (MWMUs), berry fields, meadows, and sites known to be occupied by covered species.

Tacoma will provide a list of all forest management activities that have occurred in each forest management zone since the previous reporting period. The list will include the location (section, township, range), acreage, site index, type of harvest, active dates of harvest, method(s) of slash disposal and state Forest Practices Application number (if available) for all harvest activities, to document that the requirements of HCM 3-01 have been met. The results of any slope stability analysis required by watershed analysis prescriptions will also be included. Tacoma will report the results of post-harvest sampling to verify that leave-tree retention standards have been met. Regular reporting to the Services will include listings of all hardwood conversion and salvage timber harvest activities. A database for tracking forest management activities will be developed by Tacoma within 1 year of ITP issuance.

A summary list of all reforestation activities will be provided to the Services at each scheduled review. The list will include the state Forest Practices Application number, date of planting, planting density and species of trees planted for all reforestation activities that have occurred since the previous reporting period.

Objective

The objective of this monitoring measure is to document additions to the Upper HCP Area; verify that forestry activities conducted in each of the three forest management zones comply with management restrictions; and verify snag, green recruitment tree, and log retention requirements have been met in the Upper HCP Area.

Rationale

Lands owned by Tacoma in the Upper HCP Area are managed to meet three objectives: to protect water quality, to provide habitat for fish and wildlife, and to generate revenues through the harvest of timber to fund the overall land management program and finance the acquisition of additional lands in the watershed (Ryan 1996). The protection of water quality is the primary management objective throughout the watershed, but varying amounts of active management can occur to meet the other two objectives without compromising water quality. The amount of management that can occur in a given area is specified in the upland forest management habitat conservation measures. This compliance monitoring measure will document that the harvest and reforestation activities conducted in each of the three forest management zones comply with harvest restrictions; meet snag, green recruitment tree, and log retention requirements; and protect specialized habitats as required under the HCP.

6.1.13 Compliance Monitoring Measure CMM-13 Riparian Buffer Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-13

MEASURE: Riparian Buffer Monitoring

Maps of riparian buffers will be updated every 5 years. Riparian buffers will be measured and marked in the field prior to harvest to ensure that they meet the requirements of HCM 3-02. Marking will be accomplished by measuring the width of each buffer in at least 10 locations spaced more than 100 feet apart. Tacoma will monitor each riparian buffer immediately following harvest to ensure that buffers have been left as marked. The results of this monitoring will be provided to the Services at each 5-year review.

Objective

The objective of this monitoring measure is to verify compliance with the riparian buffer requirements in the Upper HCP Area.

Rationale

Buffer strips are a common method for maintaining riparian system connection and function in the Pacific Northwest. Belt et al. (1992) reviewed over 100 documents that related riparian buffer strips to forest practices, water quality, and fish habitat. The provision of riparian buffer strips was correlated with stream water temperature, cover, large organic debris, and sediment production, all vital ingredients in the life history of salmonids. Johnson and Ryba (1992) found that the riparian zone stabilizes streambanks and prevents erosion, filters suspended sediment, moderates the microclimate, and supports and protects fish species. Riparian buffer areas also provide habitat conditions that are critical to many wildlife species (O'Connell et al. 1993). Thus, compliance with riparian buffer requirements in the Upper HCP Area becomes a critical element of both fish and wildlife management under this HCP.

In most cases, the width of the natural zone adjacent to the channel meets or exceeds minimum riparian buffer requirements. However, in some cases roads or powerline corridors are located within the buffer, and define the outer limit of the Natural Zone. In addition, some of the smaller Type 3, 4, and 5 streams are located wholly or partially within the Conservation or Commercial zones. On streams where the width of the adjacent natural zone is less than the minimum riparian buffer requirements, no-harvest and partial-harvest buffers will extend into the Conservation or Commercial zones. In harvest units where riparian buffers are located wholly or partially within the Commercial or Conservation zones, Tacoma will mark the total width of no-harvest and partial-harvest riparian buffers prior to harvest to ensure they meet criteria specified in this HCP. At least 10 measurements will be obtained at intervals less than or equal to 100 feet to delineate the buffer widths. If the buffer zone is more than 1,000 feet long, measurements will be taken every 100 feet for the entire length of the buffer. Tacoma will recheck buffers in the field following harvest to document that buffers have been left as marked. Riparian monitoring data will be summarized by stream type, and presented to the Services at each 5-year review to document compliance.

6.1.14 Compliance Monitoring Measure CMM-14 Road Construction and Maintenance Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-14

MEASURE: Road Construction and Maintenance Monitoring

Tacoma will document compliance with road-management measures by regular reporting of road-management activities. Maps depicting the location of all new roads, recently abandoned roads, active roads, and locked gates will be prepared, and updated at each scheduled reporting period. A table will be provided summarizing the characteristics of newly constructed roads, including the road length, prism and drainage design, and surfacing. The total length of road abandoned within each reporting period, and a description of actions taken to abandon each road, will also be provided. A map depicting the location of roads, relative to MWMUs with a moderate or high mass-wasting potential identified during field inspections or through watershed analysis will be updated as necessary and presented at each 5-year review. Maps, tables, and the results of any slope stability analyses conducted on new or existing roads as a requirement of watershed analysis will be presented to the Services at each 5-year review.

A copy of the RSRP (completed within 2 years of ITP issuance), annual updates (if needed), and results of any evaluation of the success in meeting sediment reduction targets required under watershed analysis prescriptions will be provided to the Services on request and summarized at 5-year reviews.

Objective

The objective of this monitoring measure is to verify that road-management measures have been implemented as specified.

Rationale

Impacts to both fish and wildlife species have been attributed to the construction of roads (WDNR 1997). Roads have been responsible for triggering the majority of management-related landslides in the upper Green River basin (Reynolds 1996; Reynolds and Krogstad in prep). A positive correlation has been observed between the area of logging roads in a basin and levels of fine sediment in downstream spawning gravel (Cederholm et al. 1981). As the level of fine sediment in spawning gravel increases, survival of salmonid eggs and fry declines (Tappel and Bjornn 1983; Reiser and White 1988; Young et al. 1991). Both elk and deer habitat use increases with increasing distance from open roads (WDNR 1997). Thus, Tacoma will monitor roads within the Upper HCP Area to verify that road-management measures have been implemented as specified in the HCP.

Periodic evaluation of road surface sediment contributions will be conducted as part of the 5-year watershed analysis review process required by the WDNR. Completion of the 5-year review is a cooperative effort between upper Green River watershed landowners. Documentation of Tacoma's participation in this process and copies of the RSRP, annual updates and 5-year reviews will serve as evidence that Tacoma has complied with road-management measures contained in this HCP.

6.1.15 Compliance Monitoring Measure CMM-15 Species-Specific Habitat Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-15

MEASURE: Species-Specific Habitat Management Monitoring

Tacoma employees will receive instruction in the identification of covered species, and employees and contractors will be provided with a data sheet to be completed in the event that a covered species is sighted. Sightings by Tacoma employees or contractors will be reported to the Services and WDFW in a timely manner. Tacoma will also obtain updated information from the WDFW Priority Habitats and Species database and will provide written documentation that the WDFW and USFWS have been contacted to request information on recent sightings in the vicinity of the HCP Area on an annual basis.

At each scheduled reporting period, Tacoma will provide the USFWS with maps depicting the locations of newly constructed roads in relation to preferred grizzly bear habitats (berry fields, meadows, avalanche chutes, and wetlands) to verify that no new roads have been constructed through those habitats within the Upper HCP Area. If grizzly bear sightings are confirmed within the Green River watershed, Tacoma will summarize actions taken to comply with management restrictions listed in the species-specific habitat conservation measures at the next scheduled reporting period.

If gray wolf den sites are confirmed within the Green River watershed, Tacoma will summarize actions taken to limit activities within specified protection areas surrounding the den and rendezvous sites at each subsequent reporting period until the den site is confirmed to be no longer active. Similar summaries will be provided to the USFWS if Pacific fisher, California wolverine, or Canada lynx den sites are confirmed within the Upper HCP Area.

Seasonal and long-term protection measures will be implemented if peregrine falcon, bald eagle, spotted owl or northern goshawk nest sites are confirmed within the Upper HCP Area. Spotted owls are currently known to be present within the Green River watershed. Tacoma will maintain records documenting that annual updates on the status of activity centers have been obtained, and will summarize actions taken to limit activity around nest sites at each scheduled 5-year review. Similar documentation will

CMM-15 (continued on next page)

CMM-15 (continued)

be provided to the Services and WDFW if bald eagle, peregrine falcon, or northern goshawk nest sites are confirmed to be present within the Upper HCP Area.

Compliance with protection of trees and snags used by pileated woodpeckers or Vaux's swift will be reported as part of upland forest management monitoring. Compliance with the requirements for limiting ground disturbance and timber harvesting near Larch Mountain salamander habitat will also be demonstrated as part of upland forest management monitoring.

Objective

The objective of this monitoring measure is to verify compliance with species-specific management measures.

Rationale

Numerous threatened, endangered, or sensitive species may periodically use the Upper HCP Area. Among these, the following will receive special interest in this HCP: grizzly bear, Pacific fisher, California wolverine, Canada lynx, peregrine falcon, bald eagle, spotted owl, northern goshawk, pileated woodpecker, Vaux's swift, and Larch Mountain salamander. Compliance monitoring will demonstrate that Tacoma has taken steps to identify the status of the covered species in and near the HCP Area, and has implemented species-specific habitat conservation measures as required.

Many of the conservation measures described in Chapter 5 have been developed to protect or enhance aquatic, wetland, or upland habitats or to address ecosystem functions such as sediment transport. These measures often benefit many of the species for which Tacoma is seeking coverage under the ITP. For example, upland forest management measures in the upper Green River basin will benefit fish and wildlife, and riparian plant communities. Where a species was not addressed by a specific conservation measure, general habitat conservation measures were considered to provide adequate protection. Monitoring measures developed for general conservation measures are described elsewhere in this document.

6.2 Effectiveness Monitoring

A brief description of effectiveness monitoring measures (EMMs), monitoring criteria, measurement frequency, reporting requirements, and adaptive management processes are presented in Table 6-2. Tacoma's specific commitments associated with each measure are contained within the outlined textboxes following the table. The supporting rationale for each monitoring measure follows the individual textboxes. All monitoring activities will be summarized in writing and presented to the Services during reviews at 5-year intervals. Individual monitoring measures may involve more frequent reporting. Monitoring data will be maintained by Tacoma and will be made available to the Services upon request.

The end result of effectiveness monitoring is to facilitate adaptations if the original measure proves inadequate. Detailed effectiveness monitoring criteria will be developed in cooperation with the Services. The results of effectiveness monitoring activities will be reviewed in coordination with the Services at 5-year intervals and, if necessary, conservation measures judged to be ineffective will be modified. Effectiveness monitoring activities will continue until the Services are satisfied that the measures are achieving the desired resource objective. Funds required to implement effectiveness monitoring will be provided solely by Tacoma. Cost reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma.

Table 6-2. Effectiveness Monitoring to be Implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement frequency	Reporting	Adaptive Management
EMM-01	Snag and Green Recruitment Tree Monitoring	• Rate of snag creation/retention meets the needs of the species covered by the ITP (see Chapter 2)	• Immediately following harvest after ITP issuance and at 10-year intervals thereafter	• Data available to the Services on request • Cumulative results reported at 5-year reviews	• After year 10, adjust rate or method of intentional leave-tree mortality in coordination with the Services
EMM-02	Species-Specific Habitat Management Validation	• Document response of covered species to species-specific management measures	• As necessary after ITP issuance, if species are present and specific management plans are implemented	• Summarize use of HCP Area by covered species at 5-year reviews	• Modify measures as necessary in coordination with the Services
		• Review of response indicates that continuing management activities as prescribed in the species-specific management measure will not prevent continued use of the HCP area by the species	• Annually after ITP issuance, as necessary, depending on presence of species	• Annual reporting to the Services until measure is determined to be effective	
EMM-03	Uneven-Aged Harvest Monitoring and Adaptive Management	• Document if windthrow has resulted in individual stands containing an average of less than 25 healthy dominant or codominant conifers per acre 5 years after uneven-aged harvesting	• Five years after uneven-aged harvest operation	• The results of uneven-aged harvest monitoring conducted in the previous year will be reported as part of annual reviews	• Adjust the rate and/or method of harvesting

6.2.1 Effectiveness Monitoring Measure EMM-01 Snag and Green Recruitment Tree Monitoring

MONITORING AND EVALUATION MEASURE: EMM-01

MEASURE: Snag and Green Recruitment Tree Monitoring

At 10-year intervals, Tacoma will revisit harvested areas (and adjacent riparian buffers and Upland Management Areas [UMAs]) to record the number, size, species, condition, and apparent wildlife use of snags and green recruitment trees left in compliance with HCM 3-01G. These data will be used to determine trends in snag retention, recruitment and use. If it is determined through review of Tacoma's data, or through reference to research conducted elsewhere in the Pacific Northwest, that the rate at which Tacoma is killing green recruitment trees needs to be adjusted (up or down) or the selection of trees to be killed needs to be modified to better meet the needs of the covered species, the Services and Tacoma will develop mutually acceptable adjustments to the specified rate and selection process. However, in no case will there be changes to the rate within the first 10 years of HCP implementation, as at least that much time is necessary to obtain a sample of sufficient size. The results of this monitoring will be reported at each 5-year review.

Objective

The objective of this monitoring measure is to verify success of efforts to retain and recruit snags.

Rationale

Snags are important features of wildlife habitat that are frequently lacking or in short supply in intensively managed commercial forestlands. Given the overall management history of the Upper HCP Area, it is assumed that snag abundance is low. Snags will be allowed to develop through natural processes in the Natural Zone, in stands over 100 years old in the Conservation Zone, and in no-harvest riparian buffers and UMAs. However, in the Commercial Zone, and in stands less than 100 years old in the Conservation Zone, Tacoma may need to actively recruit snags at the time of harvesting by killing a portion of the green recruitment trees, as described in the upland forest management habitat conservation measures. Snag creation is a relatively novel management tool, and monitoring is warranted to ensure that the overall objective of providing usable habitat for the covered species is met. Data will therefore be collected from harvested areas 10 years after the harvest activities are completed and reviewed by the Services at regularly scheduled reporting periods. Given the low rate of harvest anticipated under the HCP, a minimum of 10 years will be necessary to collect sufficient data for a meaningful analysis. This amount of time will also be necessary to observe any meaningful changes in the number and condition of snags, since snag recruitment and decay are relatively slow processes. For these reasons, there will be no revisions to the snag recruitment program for at least the first 10 years of HCP implementation.

6.2.2 Effectiveness Monitoring Measure EMM-02 Species-Specific Habitat Management Validation

MONITORING AND EVALUATION MEASURE NUMBER: EMM-02

MEASURE: Species-Specific Habitat Management Validation

If the presence of a covered species is confirmed within the HCP Area, Tacoma will implement species-specific management measures as described in Chapter 5, and will work with the Services to develop a monitoring program designed to assess the effectiveness of those measures. At each scheduled reporting period, Tacoma will provide available information on the responses of covered species to any of the species-specific management measures that have been implemented during the preceding period (e.g., nest or den site protection buffers or seasonal harvest activity restrictions).

In determining the need to adapt the species-specific conservation measures, it must be recognized that the measures are not intended to completely avoid impacts to covered species, nor are they intended to provide optimal habitat conditions for covered species in the HCP Area. If continued management activities conducted in accordance with the prescribed species-specific measures are resulting in few direct impacts to the targeted covered species and do not prevent continued use of the overall HCP Area by the species, the measures will not be adjusted. Conversely, if it is determined that continued management activities conducted in accordance with the prescribed measure are preventing use of the HCP Area by a covered species, the measure will be adjusted. Adjustments to the species-specific management measures will be developed in coordination with the Services. The results of those adjustments will be evaluated and reported at subsequent 5-year reviews until the Services are satisfied with the effectiveness of the conservation measures.

Objective

The objective of this monitoring measure is to determine effectiveness of species-specific protection measures.

Rationale

The overall objective of the species-specific management measures in this HCP is to minimize the impacts of Tacoma’s activities on various life stages of covered species. To that end, it is appropriate for Tacoma to review the effectiveness of these measures, and make adjustments that may be necessary to accomplish the overall objective. It is equally appropriate, however, to limit adjustments to those necessary to meet the overall objectives of the HCP, and not necessarily to accommodate changes in public opinion or resource management policy.

6.2.3 Effectiveness Monitoring Measure EMM-03 Uneven-Aged Harvest Monitoring and Adaptive Management

MONITORING AND EVALUATION MEASURE NUMBER: EMM-03

MEASURE: Uneven-Aged Harvest Monitoring and Adaptive Management

Tacoma will evaluate the success of uneven-aged harvesting in the Conservation Zone by revisiting harvested stands 5 years after each uneven-aged harvest operation. Tacoma will determine the number of standing live overstory trees after 5 years, the conditions of the standing live trees, the number and size of standing snags, and (if possible) the mechanism responsible for the falling of overstory trees and snags left at the time of uneven-aged harvesting. Tacoma will also make qualitative assessments of understory shrub and forb development 5 years after harvesting.

If windthrow has resulted in individual stands containing an average of less than 25 healthy dominant or codominant conifers per acre 5 years after uneven-aged harvesting, Tacoma will consider that cause to adjust the rate and/or method of harvesting. Before adjustments are made, however, factors such as aspect, slope, position on slope, soil moisture, and overstory species composition will be evaluated. Adjustments to the rate and/or method of harvesting will only be made in those locations where comparable high rates of windthrow can be expected.

Tacoma and the Services will also keep abreast of research elsewhere in the region on the methods and effects of uneven-aged harvesting, particularly such harvesting with the intention of producing late-seral forest habitat for wildlife. The rate and/or method of uneven-aged harvesting on the covered lands will be modified if Tacoma and the Services agree that research suggests the need for a change. Research can suggest a change if it is found that the method and/or rate in the HCP is counter to the objective of accelerating the development of late-seral forest conditions and that it is detrimental to the maintenance of habitat for one or more of the covered species, or that it conflicts with the protection of individuals of a covered species.

Objective

The objective of this monitoring measure is to evaluate the success of uneven-aged harvesting, and adjust the method and/or rate of harvesting, when necessary, to accelerate the development of late-seral coniferous forest conditions.

Rationale

Uneven-aged management through selection harvest and commercial thinning has been suggested as a means of accelerating the development of late-seral coniferous forest conditions in young managed forests (Carey 1994). Thinning can be problematic; however, because it can lead to increased windthrow among the remaining overstory trees (Stathers et al. 1994) and can retard stand development. Wind is a prevalent problem on the west slopes of the Cascade Mountains, but the effects of wind on overstory trees tend to be somewhat correlated with site-specific conditions (Tang 1995). Most damaging winds come from the south and southwest, making trees on slopes facing those directions most vulnerable. Trees on exposed upper slopes and ridge tops are more vulnerable than trees in protected valley bottoms. Soil moisture can affect susceptibility; wetter soils result in trees with shallower roots that are less stable and more vulnerable to being blown over. The species of tree is also a factor, since some species are characteristically more shallow-rooted than others. Lastly, the history of an individual tree affects its vulnerability to wind. Trees that grow in the open are exposed to wind throughout their lives and develop more extensive root systems to support their larger boles and crowns. Conversely, trees that develop in dense stands typically have narrower stems and less extensive root systems. When these trees are suddenly exposed to increased winds as a result of thinning or selection harvest, they experience increased rates of windthrow.

Tacoma will consider all site-specific conditions when planning commercial thinning operations, and thinning will not occur on sites considered particularly susceptible to windthrow. As an additional precaution, thinned stands will be visited 5 years after thinning to assess windthrow.

While a certain level of windthrow is natural and desirable for creating late-seral forest conditions, excessive windthrow is not. A threshold of 25 dominant or codominant surviving conifers is considered appropriate for the HCP, since stands of this density still have sufficient live trees to develop late-seral forest characteristics (Franklin et al. 1981). An analysis period of 5 years was chosen because it is believed that if windthrow is going to be excessive, it will appear within the first 5 years after harvesting. After that time, the combination of increased canopy density (from growth of individual crowns) and increased wind firmness of individual trees (from root and stem development) will decrease the potential for windthrow.

Tacoma and the Services will also review pertinent research in the region on the effects of commercial thinning. If such research suggests the need to change the thinning program in the HCP, Tacoma and the Services will consider such changes. Changes will be made primarily where they will assist in achieving the overall objective for the Conservation Zone (developing and protecting late-seral coniferous forest), but changes may also be considered to accomplish other objectives that do not conflict with the primary objective (e.g., reducing HCP implementation costs).

6.3 Research

The research funding measures (RFMs), measurement frequency, reporting requirements, objectives, and contingencies are summarized in Table 6-3. Tacoma's specific commitments associated with each measure are contained within the textboxes following the table. The supporting rationale for each measure follows the individual textboxes. Additional details of the research program will be developed in coordination with the NMFS and USFWS, the USACE and the GRFMC during PED phase of the AWS project. The USACE and Tacoma may modify the research program, in coordination with the GRFMC, provided the NMFS and USFWS concur.

Based on the results of the research, Tacoma may modify implementation of the HCP, if requested by the NMFS and USFWS. Tacoma may also modify implementation of the HCP, if requested by the NMFS and USFWS, based on the consensus of the USACE and the GRFMC. Any such modifications made by Tacoma shall not represent additional commitments of money, water, or other resources without the consent of Tacoma. All research activities will be summarized in writing and presented to the Services during reviews at 5-year intervals. Individual measures may require more frequent reporting. Research data will be maintained by Tacoma, and will be made available to the Services upon request.

Funding of the research measures is described in Chapter 8 of this HCP. As described in Chapter 8, Tacoma will provide funds solely or in conjunction with other entities. Cost savings identified through increased efficiencies, competitive bids, or coordinated efforts with other monitoring programs (e.g., King County restoration efforts) will accrue to the Green River research fund. Increased funding of specific research measures must be provided through cost-savings from other research funding measures or must come from sources other than the City of Tacoma.

Table 6-3. Tacoma's Green River HCP commitments in support of research.

Measure	Description	Measurement frequency	AWSP[2] Project Years	Reporting	Objective	Contingency
RFM-01 HHD Downstream Fish Passage Facility	**A. Monitor movement of juvenile fish into reservoir**					
	Seasonal installation of fyke net in upper mainstem	2 days per week	1-9 years between years 6 and 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Identify species, timing, size and age distribution of fish migrating downstream into Howard Hanson Reservoir	GRFMC to recommend changes to timing and rate of storage/release regime
	B. Monitor reservoir passage of juvenile fish					
	Conduct mobile hydroacoustics surveys of Howard Hanson Reservoir (e.g., Dilley 1994)	Weekly	2, 3, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Determine fish distribution throughout the reservoir during the peak downstream migration period	GRFMC to recommend changes to timing and rate of storage/release regime
	C. Monitor fish passage facility survival and fish collection efficiency					
	Paired passive-integrated transponder tag releases and detection	Sample size and replications to be determined during PED phase	1, 2, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Provide data on reservoir and project passage efficiency and survival	USACE changes to modular-inclined screen facility, GRFMC to recommend changes to timing and rate of storage/release

2 Additional Water Storage Project (AWS project) is assumed to begin when water available to Tacoma under its Second Diversion Water Right is stored behind Howard Hanson Dam.

Table 6-3. Tacoma's Green River HCP commitments in support of research.

Measure	Description	Measurement frequency	AWSP[2] Project Years	Reporting	Objective	Contingency
Downstream Fish Passage Facility (cont.)	Seasonal operation of screw trap at the outlet of HHD but upstream of fish bypass outfall	Sampling protocol to be determined during PED phase	3, 4, 5, 10	Results will be reviewed annually and reported at the 5-year reviews	Provide data on project passage efficiency and survival	GRFMC to recommend changes in modular-inclined screen operation and changes to timing and rate of storage/release regime
	D. Monitor condition of fish passing through fish passage facility					
	Sampling station upstream of the outfall will allow assessment of fish condition, and supplemental tagging. Fish assessment will include: • species, number and age; • injury and/or mortality; • length, weight; and • smoltification	Sampling protocol to be determined during PED phase	Annually in years 1-10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Provide data on reservoir and project passage efficiency and survival	USACE changes to modular-inclined screen facility, fisheries agencies to recommend changes to restoration strategy
	E. Marked Fry					
	Mark and recapture juvenile salmonids to quantify capture efficiency of sampling station	Sampling protocol to be determined during PED phase	1,2,3	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Quantify efficiency of modular-inclined screen and fish bypass facility	USACE changes to modular-inclined screen facility, GRFMC changes to timing/rate of storage/release

Table 6-3. Tacoma's Green River HCP commitments in support of research.

Measure	Description	Measurement frequency	AWSP[2] Project Years	Reporting	Objective	Contingency
Downstream Fish Passage Facility (cont.)	**F. Hydroacoustic surveys**					
	Fixed hydroacoustics deployed in HHD forebay, fish passage facility horn, and wetwell. Mobile hydroacoustic monitoring and gillnetting in reservoir. Placement of transducers in the passage facility	Sampling protocol to be determined during PED phase	1, 2, 3, 4, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Determine whether juvenile fish can find and use the bypass system	USACE changes to modular-inclined screen facility, GRFMC changes to timing and rate of storage/release
	G. Monitor water quality and zooplankton in the reservoir					
	Spring and summer surveys in upper and lower portions of the reservoir	Sampling protocol to be determined during PED phase	1, 5, 10	Results will be reported at the 5-year reviews	Identify gross changes in reservoir productivity and salmonid feeding habitats that occur as a result of implementing the AWS project	Fisheries agencies to recommend changes to restoration strategy
	H. Monitor Predator Abundance in the Reservoir					
	Snorkel surveys to identify concentrations of predatory fish at migratory transition areas (reservoir confluences, outfalls), hook and line or nets to collect stomach samples	Sampling protocol to be determined during PED phase	3, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Compare the effects of the AWS project on predator populations and consumption rates	Fisheries agencies to recommend predator control program

Table 6-3. Tacoma's Green River HCP commitments in support of research.

Measure	Description	Measurement frequency	AWSP[2] Project Years	Reporting	Objective	Contingency
RFM-02 Flow Management	**A. Monitor effects of flow management strategies on side-channel habitats**					
	Physical habitat					
	Quantify inlet/outlet elevations and LWD; map habitat at various flows	Survey every 2 weeks February-June	1, 4, 10 and every 5 years (11-50)	Results reviewed annually for minor flow changes and reported at first 5-year review	Provide data on side-channel connectivity and the quality and quantity of habitat provided by various flow release schedules	GRFMC to recommend changes to timing and rate of storage/release regime
	Biological					
	Conduct snorkel and electrofishing surveys to identify timing of emergence, distribution, growth, and response to flow changes	Survey every 2 weeks February-June	2, 5, 10 and every 5 years (11-50)	Results reviewed annually for minor flow changes and reported at first 5-year review	Evaluate the biological response to flow management to guide development of a flow management strategy	GRFMC to recommend changes to timing and rate of storage/release regime
	B. Monitor steelhead spawning and incubation					
	Contribute funding to the MIT and WDFW to conduct steelhead spawner surveys	Every 7-10 days April-July	Annually years 1-50	Results reviewed annually for minor flow changes and reported at first 5-year review	Evaluate the effects of the released flows on steelhead spawning and egg incubation	GRFMC to recommend changes to timing and rate of storage/release regime

Table 6-3. Tacoma's Green River HCP commitments in support of research.

Measure	Description	Measurement frequency	AWSP[2] Project Years	Reporting	Objective	Contingency
Flow Management (cont.)	**C. Monitor downstream migration of juvenile salmonids**					
	Install and operate rotary screw trap near RM 34 to monitor mainstem juvenile movement	Four evenings and one 24-hour sample per week from February-June	1, 2, 3, 4, 5, 10 2 years out of every 10 (11-50)	Results will be reviewed annually to suggest minor modifications and reported at the first 5-year review	Identify changes in juvenile salmonid downstream migration patterns resulting from implementation of the AWS project	GRFMC to recommend changes to timing and rate of storage/release regime
	D. Monitor salmon spawning and Incubation (WDFW/MIT)					
	Provide financial support to WDFW/MIT to expand spawning surveys to lateral habitats and restoration sites	Every 10 days September-November	1, 2, 3, 4, 5 and reduced annual effort years 6-50	Results will be reviewed annually to suggest minor modifications and reported at the 5-year review	Identify off-channel habitats used by salmonids that are affected by an early refill schedule	GRFMC to recommend changes to timing and rate of storage/release regime
	E. Monitor salmon redds and emergence (MIT/WDFW)					
	Identify salmon redds during spawning season and monitor impacts of early refill using fry emergence traps	Install traps January-February	1, 2, 3,	Results will be reviewed annually to suggest minor modifications and reported at the 5-year review	Evaluate the impact of early refill on salmon emergence and incubation	GRFMC to recommend changes to timing and rate of storage/release regime

Table 6-3. Tacoma's Green River HCP commitments in support of research.

Measure	Description	Measurement frequency	AWSP[2] Project Years	Reporting	Objective	Contingency
RFM-03 Mainstem Sediment and Woody Debris	**A. Monitor distribution of woody debris**					
	Survey Green River from Headworks to Highway 18 to identify distribution and abundance of woody debris	One survey during early spring to identify woody debris abundance and distribution	1, 2, 3, 4, 5, and 10	Distribution of woody debris to be provided to GRFMC following surveys. Results will be reviewed annually; reported to the Services at year 5 and 10 reviews	Provide data to the NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of the wood debris management program to restore woody debris recruitment and function in the Green River without compromising public health and safety or the viability of downstream flood control measures	Change location and method of placement; remain within specified costs of transporting and dumping LWD and five trucks of SWD
	B. Monitor distribution of sediments below Tacoma Headworks					
	• Areal extent of gravel bars exposed at flow < 300 cfs at Auburn gage • Changes in bed elevation and channel capacity at selected cross-sections	One measurement during low flow conditions each year	1, 2, 5, 10	Results will be reviewed after annual surveys to suggest changes in placement method and location; reported to the Services at 5-year reviews	Provide data to NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of gravel nourishment activities in the middle Green River	Change location and method of placement; remain within specified costs of 3,900 cubic yards at Flaming Geyser

6.3.1 Research Funding Measure RFM-01 (A-H) HHD Downstream Fish Passage Facility

RESEARCH FUNDING MEASURE NUMBER: RFM-01(A-H)

MEASURE: HHD Downstream Fish Passage Facility

Because of the size and the complexity of the fish passage facility, monitoring and evaluation of the HHD downstream fish passage facility will be segregated into the following categories: fish migration into the reservoir (RFM-01A), reservoir passage of juvenile fish (RFM-01B); reservoir passage survival, fish passage facility survival and fish collection efficiency (RFM-01C); condition of fish passing through collector passage (RFM-01D); marked fry (RFM-01E), hydroacoustic surveys (RFM-01F); reservoir water quality monitoring (RFM-06G), and reservoir predator abundance monitoring (RFM-01H). Data from these studies will be provided to the GRFMC as needed to make decisions regarding minor annual modifications to the storage and release schedule. The results of the studies will be presented at regularly scheduled 5-year reviews to facilitate an evaluation of the effectiveness of the HHD downstream passage facility and to aid in making adaptive management decisions.

RFM-01A: Monitor Movement of Juvenile Fish into Reservoir

Tacoma will contribute funding to operate a fish trap (i.e., fyke net) at the confluence of the North Fork and mainstem Green River to characterize the immigration of juvenile salmonids into the reservoir. This activity will include a weekly evaluation (of 2 days per week) of immigration timing of juvenile fish entering the reservoir. The species, size, and age of each fish trapped will be recorded. Stomach contents will also be collected from a sub-sample of the fish. In addition to planned weekly evaluations, sampled fish will be marked and evaluated at the outfall sampling station in conjunction with other study components, such as paired passive-integrated transponder tag release and recapture, assessment of the modular-inclined screen and fish passage facility efficiency, and hydroacoustic monitoring of the forebay and wetwell. Monitoring will be conducted in project years 1, 2, 3, 4, 5 and every 2 years between years 6 through 10. It is recommended that monitoring continue 2 years out of every 10 years between years 11 and year 50; however, funding for monitoring past year 10 will not be part of Tacoma's obligations under this HCP.

RFM-01B: Monitor Reservoir Passage of Juvenile Fish

Tacoma will contribute funding to passive-integrated transponder tag, release, and monitor coho, chinook, and steelhead smolts in project years 2, 3, 5, and 10.

Final numbers of tagged fish of each species will be determined through agency coordination and discussion with a statistician. Tagged fish will be supplied from a mutually agreed-to hatchery/smolt rearing facility or capture process as determined by MIT, WDFW, and NMFS. Two or more release locations will be situated upstream of the fish bypass facility, to include releases at the forebay and 0 to 0.5 miles upstream

RFM-01 (A-H) (continued on next page)

RFM-01 (A-H) (continued)

of the reservoir at various pool levels. Release groups will include simultaneous (at both release locations), systematic releases of each species, and will be spread out over a 3- to 4-week period. Release times will bracket the peak outmigration period for steelhead, coho, and chinook. Tagged fish will be monitored downstream of the modular-inclined screen near the bypass outfall. Information gained during reservoir passage monitoring will be provided to the GRFMC annually for use in making minor modifications to reservoir refill strategies. The results of the study will be evaluated and presented at the 5-year reviews to determine whether major changes to the storage/release regime are warranted.

RFM-01C: Monitor Fish Passage Facility Survival and Fish Collection Efficiency

Tacoma will contribute funding to monitor the efficiency of the modular-inclined screen and the fish bypass facility during normal juvenile outmigration times in project years 1 through 10. Three groups of coho salmon, chinook salmon, or steelhead fry will be released to test the efficiency (injury rate and survival) of the modular-inclined screen and fish bypass facility. The final number of replications, and number of marked fish required for each replication, will be determined through agency coordination and discussion with a statistician. Marked fish will come from a mutually agreed-to hatchery/supplementation facility as determined by MIT, WDFW, and NMFS. Three release locations will be used including: upstream of the fish passage facility (either above the trashrack or at the entrance to the facility); below the modular-inclined screen in the bypass flume; and at or below the wetwell exit. One test group will be used to evaluate modular-inclined screen efficiency; another test group will be used to evaluate the bypass system; and a third test group will be used to evaluate the wetwell exit and bypass flume. Test fish will be recovered at the sampling station located approximately 100 feet upstream of the bypass outfall.

In addition, the bypass and screen are currently proposed to have viewing portals so an observer can look directly at the screen. The modular-inclined screen surface will be periodically monitored at various flow rates and velocities to assess impingement of smolts against the modular-inclined screen. Information collected through this monitoring activity will be presented to the USACE to guide development of modifications to the fish passage facility collection system if such actions are deemed necessary by the Services.

Salmonids moving downstream from the upper Green River watershed and encountering the HHD project will pass downstream through either the new intake tower and modular-inclined screen, or through the existing radial gates. Monitoring the number, species and condition of fish passing through the existing radial gates will be addressed through operation of a screw trap in the mainstem Green River channel immediately below HHD. A screw trap will be operated during the spring outmigration season below the HHD outlet but upstream of the fish bypass outfall. The results of the screw trap will be used to identify the number, species, and conditions of fish passing through the radial gates during periods of reservoir storage. Operation

RFM-01 (A-H) (continued on next page)

RFM-01 (A-H) (continued)

of the screw trap will also enable researchers to identify project operations that may allow juvenile salmonids to bypass the modular-inclined screen and counting station and egress through the radial gates. A screw trap will be operated during years 3, 4, 5, and 10 following completion of the AWS project. Results will be reviewed annually and at the 5-year reviews.

RFM-01D: Monitor Condition of Fish Passing Through Fish Passage Facility

Tacoma will contribute funding in project years 1 through 10 to monitor the condition (injury, mortality, length, weight, smoltification, and stress) of test and natural outmigrants after the fish pass through the bypass system, are locked through the wetwell, and released through the discharge flume of the HHD fish passage facility. A sampling station will be built near the fish bypass outfall. The sampling station will be used for assessment of marked (fin-clipped and passive-integrated transponder tagged) and unmarked separate outmigrants. The sampling station will include a separation system that includes passive-integrated transponder tag monitors, adjustable slide gate, and double read firmware to keep marked from unmarked fish. Sampling station facilities located next to the bypass outfall will include: flume from juvenile bypass to the sampling station; water supply separate from diverted bypass flume; holding tanks or troughs for diverted fish; and a secondary flume to return sampled fish to the Green River.

Marked juveniles and smolts will be analyzed to determine travel time, reservoir survival, and fish passage efficiency at HHD. Unmarked smolts, in conjunction with hydroacoustic monitoring, will be used to determine species composition of outmigrating fish.

Species, growth characteristics, and injury rates will be recorded for each fish. The sampling protocol will consist of a weekly evaluation (2 to 3 hours per day, every other day) during the juvenile salmonid outmigration period. In addition to the planned weekly evaluations of fish condition and species composition, the sampling station will support other study components such as reservoir passage, assessment of the fish passage facility efficiency, and hydroacoustic surveys.

RFM-01E: Marked Fry

Tacoma will contribute funding to test the efficiency of the modular-inclined screen and fish bypass facility using controlled releases of marked groups of juvenile salmonids. A series of releases of marked chinook, coho, and steelhead juveniles will be conducted during the juvenile salmonid outmigration period. The sample size and number of test releases will be identified during discussions with an experienced biometrician, resource agencies, and the MIT. Tests will be conducted in years 1, 2, and 3.

RFM-01 (A-H) (continued on next page)

RFM-01 (A-H) (continued)

RFM-01F: Hydroacoustic Surveys

Tacoma will contribute funding to monitor the number and location of juvenile and adult salmonids in the forebay, the number and behavior of fish entering the fish lock, and the diel and seasonal distribution (horizontal and vertical) of juvenile and adult salmonids in the reservoir in years 1 through 5 and year 10. These study elements shall be monitored using hydroacoustic surveys. A scanning system for the tracking of fish in the forebay will include a hydroacoustic system with one or two split-beam transducers. Forebay hydroacoustic monitoring will be used to assess the utility of flow management (i.e., ramp-up and ramp-down events) to attract juvenile fish to the fish passage facility. The information gained from mobile hydroacoustic surveys will be used to evaluate total project survival of juvenile migrants, predator build-up at tributary confluences, and congregations of juvenile outmigrants upstream of the passage facility.

Transducers will also be placed at various locations within the passage facility. Transducers placed downstream of the trashracks will provide entrainment estimates for the fish collector and radial gates. Additional transducers will be placed near the wetwell exit and lock chamber. The facility, as now planned, would have an automatic control that regularly cycles lock events at pre-programmed times. The linked control to the hydroacoustics would be biologically based, giving estimates of fish density in the lock chamber before a lock event occurs.

RFM-01G: Monitor Water Quality and Zooplankton in the Reservoir

Tacoma will contribute funding to establish three permanent water quality stations to monitor the water temperature, dissolved oxygen (DO), and conductivity in Howard Hanson Reservoir. In addition, surveys will be conducted in years 1, 5, and 10 to collect zooplankton data in the upper and lower sections of the reservoir for analysis. This data will be analyzed in conjunction with stomach contents collected during the juvenile salmonid reservoir migration study. Data from the zooplankton surveys will be used to assess changes in the overall composition of the invertebrate community (distribution and densities). Used in combination with other sampling data and mobile-hydroacoustic surveys, water quality surveys will further the knowledge of juvenile salmonid ecology in the reservoir and will be provided to the NMFS, USFWS, WDFW, and MIT in part to assess the influence of water management procedures on prey abundance.

RFM-01H: Monitor Predator Abundance in the Reservoir

Tacoma will contribute funding to monitor the distribution and abundance of trout and other predators of juvenile anadromous salmonids in Howard Hanson Reservoir and in the vicinity of the HHD and Headworks bypass outfalls in order to compare the effects of the AWS project on predator populations and consumption rates. Two years of monitoring of resident trout and/or avian predator abundance in the reservoir will be conducted prior to initial operation of the HHD downstream fish passage facility,

RFM-01 (A-H) (continued on next page)

RFM-01 (A-H) (continued)

followed by post-construction monitoring in project years 3, 5, and 10. It is recommended that additional monitoring be conducted every 5 years during project years 11 through 50; however, funding in years 11 through 50 will not be part of Tacoma's obligations under this HCP. Specific details of the monitoring methodology will be developed during the PED phase, and submitted to the Services for approval prior to implementation. If an increase in overall predator abundance in response to juvenile migratory presence is detected, a selective predator removal program may be initiated. However, such a program would only be initiated if recommended by the NMFS, USFWS, WDFS, and MIT.

Objective

The objectives of this research funding measure are as follows:

RFM-01A - Identify species, timing, size and age distribution of fish migrating downstream into Howard Hanson Reservoir.

RFM-01B - Determine fish distribution throughout the reservoir during the peak downstream migration period.

RFM-01C - Provide data on reservoir and project passage efficiency and survival.

RFM-01D - Provide data on reservoir and project passage efficiency and survival.

RFM-01E - Quantify efficiency of modular-inclined screen and fish bypass facility.

RFM-01F - Determine whether juvenile fish can find and use the bypass system.

RFM-01G - Identify gross changes in reservoir productivity and salmonid feeding habitats that occur as a result of implementing the AWS project.

RFM-01H - Compare the effects of the AWS project on predator populations and consumption rates.

Rationale

The use of state-of-the-art fish passage technology and the complexity of the HHD project operations will require an extensive, long-term research program to provide feedback to maximize benefits to outmigrating juvenile salmonids. Such a program is needed to identify optimal facility and reservoir operations that will likely need to be adjusted based on water year type (i.e., wet, normal, or dry), and as the composition of fish stocks changes upstream of HHD. Information gathered as part of this research program will be provided to the GRFMC, agencies responsible for making decisions regarding fisheries management, and to the USACE as necessary to guide adaptive management of the downstream passage facility.

Monitor Movement of Juvenile Fish into Reservoir. Like other HHD downstream fish passage monitoring activities, monitoring the migration of fish into the reservoir is a critical step in evaluating the success of reintroducing anadromous salmonid populations above HHD. Dilley and Wunderlich (1992, 1993) successfully trapped juvenile salmonids in both the North Fork and mainstem of the Green River upstream of the full-pool mark. They determined trends, rather than quantitative estimates of fish movement, that, when compared to hydroacoustics, helped them (or will help others) to understand fish passage through the reservoir. Monitoring fish migration into the reservoir is important to determine if juvenile fish migrations are delayed and if that delay is attributable to the AWS project.

Monitor Reservoir Passage of Juvenile Fish. Beginning in 1991, the USFWS performed a series of studies to evaluate the downstream passage of fish at HHD (Dilley and Wunderlich 1992, 1993; Dilley 1993, 1994; Aitkin et al. 1996). Outmigration study results indicated that increasing outflow from HHD during periods of high inflow will increase the number of smolts that can safely exit the project during the smolt migration period (Dilley and Wunderlich 1992, 1993). In addition to the USFWS studies, in 1984 WDFW trapped smolts at the existing radial gate outlet (Seiler and Neuhauser 1985). The results of these studies were incorporated into the design process and used by the HHD Fish Passage Technical Committee (FPTC) for evaluating alternative designs of HHD outlet facilities (e.g., modular-inclined screen, fish bypass, and fish lock), and spring refill rule curves.

Passive-integrated transponder tags can be used for the large-scale marking of fry to smolt-sized fish (2.0 to 2.5 inches and larger). Tags can be used to assess reservoir survival, overall fish passage efficiency and timing of entrance into the HHD fish passage facility during refill and high pool (Prentice et al. 1990; Peterson et al. 1994). Passive-integrated transponder tags provide an individual tag number of each marked fish and, when passed through the excitation field of the antennae, provide an immediate return on arrival time of that marked fish at the fish passage facility. Passive-integrated transponder tags can be used to activate fish separation facilities so that marked fish can be automatically diverted to a sampling station. Passive-integrated transponder tags may also be used in combination with coded-wire tags (CWT) during outplants of fry in the upper Green River so that fry-to-smolt survival can be assessed and used for evaluation of overall success of the HHD fish bypass project (Peterson et al. 1994; Achord et al. 1996).

Monitor Reservoir Passage and Survival, Fish Passage Facility Survival, and Fish Collection Efficiency. Although the modular-inclined screen is considered state-of-the-art technology, a test of the modular-inclined screen installed at the fish passage facility will be necessary to ensure that the modular-inclined screen meets design criteria (Smith 1993; Taft et al. 1993; Winchell et al. 1993; Taft et al. 1997). As with the monitoring measure intended to track movement of juvenile fish through the reservoir, passive-integrated transponder tags are considered the best tool for evaluating passage of fish through the fish passage facility. Passage of juvenile fish through the collector and fish passage facility will be evaluated using the following methodology, or comparable methodologies approved by the Services.

The passive-integrated transponder tag monitoring system will include:

- One portable passive-integrated transponder tagging station for tagging fry and/or smolts in the hatchery or field: electronic balance, digitizer, tag detector, automatic tag injector, multi-port controller, laptop, or other portable computer.
- Two or three passive-integrated transponder tag extended range fish monitors. One monitor will be located at the beginning of the juvenile bypass system while the second will be located near the bypass outfall.

Tagged fish will be monitored by a two- or three-coil system (24 in, 134.2 KHz tunnel monitor with estimated 90-95 percent detection probability, or best available technology) located downstream of the modular-inclined screen near the bypass outfall.

A separation system for passive-integrated transponder tagged fish within the bypass flowline will be installed. Once a fish monitor detects a passive-integrated transponder tag, a controller will activate a trigger mechanism that opens a slide gate to separate the tagged fish from the juvenile bypass flume, into a secondary flume, and into holding tanks in the sampling station (described below). Components will include an adjustable slide gate and double-read firmware.

Monitor Condition of Fish Passing Through Fish Passage Facility. Monitoring of the condition of fish passing through the fish passage facility is needed to fully evaluate its overall efficacy. Data will be provided to the USACE, NMFS, USFWS, and WDFW for review, and they will recommend changes to the modular-inclined screen facility or restoration strategy if necessary. This measure will also help determine the composition of fish that exit the facility and ensure that the fish bypass facility meets the desired biological criteria.

Marked Fry. Although laboratory tests and tests at other sites in the Pacific Northwest have shown juvenile salmonid survival rates exceeding 95 percent, the modular-inclined screen is considered experimental technology (Smith 1993; Taft et al. 1993; Hilgert et al. 1997). Marked groups of juvenile salmonids will be released to test the efficiency of the modular-inclined screen and fish bypass facility. Data will be provided to the USACE, NMFS, USFWS, and WDFW for review, and they will recommend changes to the modular-inclined screen facility or restoration strategy if necessary.

Hydroacoustic Surveys. Hydroacoustic surveys are needed in order to evaluate fish distributions at the dam, forebay, and near the fish passage facility under varying flow and reservoir elevation conditions. Fish densities and trajectories can be quickly mapped over relatively large areas using a combination of target tracking and stepped-scanning hydroacoustic techniques (Thorne 1992). A split-beam transducer on a dual-axis rotator can continuously sample the forebay area and near the intake horn for the presence of downstream-migrating juveniles and larger fish (potential predators). Dilley and Wunderlich (1992, 1993) conducted hydroacoustic monitoring (single beam) of smolt outmigration through the existing bypass and radial gate outlets at HHD. Hydroacoustic monitoring was successfully used in conjunction with scoop-trapping below the outlet to determine the daily passage rates of downstream-migrating coho and chinook salmon juveniles and smolts through the dam. Dilley (1994) was able to characterize the diel and seasonal horizontal and vertical distribution of juvenile and adult anadromous and resident salmonids in the reservoir using mobile hydroacoustic equipment and gill net surveys. Hydroacoustic monitoring is important to determine if juvenile salmonids can find and use the fish bypass entrance.

The monitoring program will include a scanning system for the tracking of fish in the forebay, including a hydroacoustic system with one or two 6-by-10° elliptical split-beam transducers with rotators. Transducers and rotators may be mounted on the trashrack and will require power and data transmission cable connections. System components for the evaluation for outmigrant juvenile anadromous salmonids through HHD include:

- two 6-by-10° split-beam transducers placed downstream of the trashracks;
- one 6° conical transducer with rotator placed in the wetwell exit;
- two 6-by-10° transducers placed in the lock chamber;
- two spare transducers and cable for replacement/back-ups; and

- one mobile hydroacoustic unit to monitor and evaluate outmigrant juvenile anadromous salmonids and larger salmonids at various locations around the facility.

Transducers placed downstream of the trashracks will provide entrainment estimates for the fish collector and radial gates. Additional transducers will be placed near the wetwell exit and lock chamber. The facility, as now planned, would have an automatic control that regularly cycles lock events at pre-programmed times. The linked control to the hydroacoustics would be biologically based, giving estimates of fish density in the lock chamber required before a lock event occurs. Modifications and refinements to the hydroacoustic-monitoring program will occur during the PED phase of the AWS project. Modifications will be reviewed with the Services prior to implementation to ensure the monitoring objectives are met by the design of the program.

Monitor Water Quality and Zooplankton in the Reservoir. Currently, the USACE conducts semi-monthly water quality surveys within the reservoir, concentrating on temperature, DO, and conductivity at specific depths. This monitoring measure will provide supplemental data on important water quality characteristics at selected locations in the reservoir. The reservoir will be undergoing dynamic changes during the initial years of the AWS project. Changes that may result from the AWS project include: a large influx of nutrients from inundation of surrounding vegetation; an increase in heat budget and development of a more pronounced thermocline; reintroduction of salmon carcasses and resulting increase in nutrients; and increased densities of juvenile salmonids. Any of the aforementioned events may result in changes to the migration pattern of juvenile salmonids moving through HHD. This measure will track any changes in water quality that may affect juvenile salmonid migrations through the reservoir and past HHD. The results of the monitoring will be presented to the NMFS, USFWS, and WDFW at regularly scheduled 5-year reviews. These agencies may recommend changes in reservoir level management if deleterious impacts to migration from water quality parameters are documented.

Monitor Predator Abundance in the Reservoir. Based on past experience at other Pacific Northwest reservoir systems, there is concern regarding the potential for predation on downstream-migrating juvenile salmonids. Populations of predators (e.g., northern pikeminnow [*Ptychocheilus oregonensis*]) have been listed as a cause of lower survival of juvenile salmonids in many Northwest systems (Cada et al. 1994; Ledgerwood et al. 1994). Rieman et al. (1991) estimated that 14 percent of all juvenile salmonids that enter the John Day Reservoir on the Columbia River are consumed by a combination of northern pikeminnow, walleye (*Stizostedion vitreum*), and/or smallmouth bass

(*Micropterus dolomieui*). While existing surveys of the HHD reservoir area do not suggest the likely presence of warmwater gamefish or large populations of northern pikeminnow, large resident trout or residualized salmon may present a predation risk under future project operations. This monitoring measure will track predator populations and indicate if a predator build-up is occurring as a result of the AWS project. If such a build-up does occur, the population of large predatory fish may be cropped to pre-AWS project levels based on recommendations by NMFS and USFWS. If bull trout are observed during any of the surveys, they will not be targeted for removal.

6.3.2 Research Funding Measure RFM-02 (A-E) Flow Management

RESEARCH FUNDING MEASURE NUMBER: RFM-02(A-E)

MEASURE: Flow Management

RFM-02A: Monitor Effect of Flow Management Strategies on Side-Channel Habitats

Tacoma will contribute funds for a 3-year pre-construction monitoring study to determine the habitat quality, quantity, and juvenile salmonid use of off-channel habitats in the middle Green River, and how that habitat may be enhanced through water management strategies. An initial survey of physical habitat characteristics of side channels in the middle Green River was conducted in the fall of 1996, and an initial survey of juvenile salmonid use conducted in the spring of 1998. Follow-up surveys to document both the physical conditions and biological use of the middle Green River side channels will be conducted prior to initial operation of the HHD downstream fish passage facility.

Following initial operation of the HHD fish passage facility, 4 years of post-construction monitoring will be conducted. Two years of post-construction monitoring (conducted in project years 1 and 4) will target physical habitat conditions in side channels. Two additional years of monitoring (in project years 2 and 5) will target observed biological responses to flow management. One additional year of physical habitat monitoring and 1 additional year of biological monitoring will be funded in each 10-year interval thereafter for the duration of the ITP. Information collected from side-channel surveys will be provided to the GRFMC annually to help guide yearly flow release decisions. The results of these studies will be presented to the GRFMC and representatives of agencies responsible for fisheries management to help them determine whether adaptations of the water management strategy on the Green River are required, and to provide valuable information for habitat restoration programs.

RFM-02 (A-E) (continued on next page)

RFM-02 (A-E) (continued)

RFM-02B: Monitor Steelhead Spawning and Incubation

Tacoma shall provide funding to the MIT and the WDFW to conduct an annual monitoring program aimed at evaluating steelhead spawning and incubation success during the spring and early summer. Surveys will be conducted every 7 to 10 days in index reaches of the middle Green River extending from just below the Headworks (RM 61.0) to the confluence with Big Soos Creek near Auburn (RM 33.8). The locations of steelhead redds shall be made available to Tacoma and fisheries resource agencies on a real-time basis.

Information collected through the steelhead monitoring surveys will be used, along with an existing flow model, to evaluate the effects of the released flows on steelhead spawning and egg incubation. These data will be used to identify habitats that are affected by refill, and will provide information to the GRFMC that can be used to refine refill operations to minimize the effects of project operations on steelhead embryonic development. Evaluation of water surface elevations necessary to maintain wetted substrates will be used as the basis to refine flows released during refill periods.

RFM-02C: Monitor Downstream Migration of Juvenile Salmonids

Tacoma shall contribute funds to a pre-AWS project monitoring study (i.e., baseline) to document existing characteristics of downstream-migrating juvenile salmonids. Two years of baseline monitoring will be conducted prior to initial operation of the HHD downstream fish passage facility. Annual post-construction monitoring activities shall be conducted in years 1 through 5 of the AWS project and in 2 of every 10 years thereafter for the duration of the ITP. Monitoring within each year will be adjusted for the planned refill strategy, including study of natural and planned freshet releases. This measure will provide information to the GRFMC that can be used to define an adaptive refill and release schedule for the AWS project that will minimize impacts on downstream-migrating juvenile salmonids.

RFM-02D: Monitor Salmon Spawning and Incubation

Tacoma shall provide funding to the MIT and the WDFW to conduct annual surveys to identify the timing of spawning and distribution of salmon redds within the middle Green River during the fall and winter. Salmon redd surveys will be conducted to identify off-channel (e.g., side channels and sloughs) and lateral mainstem habitats that are used by spawning salmonids and may be affected by an early refill schedule. In the event that the data suggest that AWS project operations appear to be conflicting with salmon incubation conditions, the GRFMC will recommend management adaptations.

RFM-02E: Monitor Salmon Redds and Emergence

Tacoma shall provide funding to the MIT and the WDFW to install fry emergence traps at selected salmon redds identified during the index reach surveys. Traps will be

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RFM-02 (A-E) (continued)

installed in January and February, and visited daily until emergence is complete. Surveys will be conducted annually in years 1, 2 and 3. Results will be reviewed by fisheries agencies annually to suggest minor modifications to the flow regime, and will be synthesized and reported at the first 5-year review to provide data that will allow the GRFMC to develop management adaptations to the flow strategy if necessary.

Objective

The objectives of this research funding measure are as follows:

RFM-02A - Provide data on side-channel connectivity and the quality and quantity of habitat provided by various flow release schedules, and evaluate the biological response to flow management to guide development of a flow management strategy.
RFM-02B - Evaluate the effects of the released flows on steelhead spawning and egg incubation.
RFM-02C - Identify changes in juvenile salmonid downstream migration patterns resulting from implementation of the AWS project.
RFM-02D - Identify off-channel habitats used by salmonids that are affected by an early refill schedule.
RFM-02E - Evaluate the impact of early refill on salmon emergence and incubation.

Rationale

Monitor Effect of Flow Management Strategies on Side-Channel Habitats. In the fall of 1996, Tacoma conducted physical habitat surveys of side channels occurring between the Headworks (RM 61.0) and RM 35.0. A total of 59 side-channel areas comprising approximately 15 river miles was identified during the survey. Monitoring side-channel habitats under varying flow conditions will be an important tool in guiding future water management strategies, while attempting to increase production of juvenile salmonids in the middle Green River. The proposed methodology for evaluating physical habitat will consist of measuring the stage at side-channel inlet and outlet locations, and collecting data on LWD and habitat within each side channel at various flows. A final study plan will be presented to the Services for approval prior to initiating surveys.

Monitor Steelhead Spawning. The majority of the steelhead spawning in the middle Green River occurs from 15 March through 15 June (USACE 1998). Egg incubation continues into July. The WDFW currently monitors steelhead spawning and incubation on the Green River for fisheries management purposes. A flow model was developed to predict how the AWS project would operate using 1996 reservoir refill rules applied to the historic flow records from 1964 through 1995. The effects of the AWS project on wild winter steelhead spawning and incubation were modeled to quantify how frequently potential steelhead spawning areas would be dewatered under baseline and proposed conditions. The analysis indicated that for the period of record, 1964 through 1995, the most critical time during baseline encompassed the period when steelhead redds are constructed during 1 June through 15 June.

The MIT and WDFW conduct steelhead-spawning surveys in various sections of the Green River. Research monitoring will be conducted to evaluate the effectiveness of flow releases for providing suitable steelhead spawning and incubation conditions in the mainstem. The research results will be reviewed annually at GRFMC meetings and a summary report presented at the first 5-year review.

Monitor Downstream Migration of Juvenile Salmonids. Pre-and post-construction monitoring of juvenile salmonid downstream migrations will provide important information regarding migration characteristics and species response to changes in flow management (e.g., early refill, baseline, freshets). In addition, assuming restoration of anadromous salmonids in the upper Green River watershed, such monitoring will provide an index of the success of downstream passage of juveniles, both at HHD and the Headworks. Parameters such as seasonal and diel timing of migration, migrational response to environmental changes (i.e., flow, turbidity, day length, water temperature) by species and by life stage, and observed responses during HHD refill and release will also be evaluated through this monitoring activity. The research results will be reviewed annually at GRFMC meetings and a summary report presented at the first 5-year review.

The proposed methodology utilizes a rotary-screw-trap as the primary method of sampling migrating fish (Thedinga et al. 1994). The trap will be located near RM 34.0 and will be operated from early February through June. Sampling will be conducted during evening hours 5 days per week with one 24-hour sample randomly selected each week.

Monitor Salmon Spawning and Incubation. Chinook salmon spawning in the Green River starts in late August to early September, while coho and chum salmon usually begin spawning in November (Grette and Salo 1986). The MIT conducts salmon spawning surveys in various sections of the Green River. Research monitoring will be conducted to evaluate the effectiveness of flow releases for maintaining suitable salmon spawning and incubation conditions in the mainstem. The research results will be reviewed annually at GRFMC meetings and summary report presented at the first 5-year review.

Monitor Salmon Redds and Emergence. Chinook salmon spawning in the Green River starts in late August to early September and the eggs and alevins remain within the gravels throughout the winter, emerging February and March. Coho and chum salmon usually begin spawning in November (Grette and Salo 1986), with emergence occurring in the late winter and spring. Chum salmon frequently spawn in side channels that are connected to the river at high flows. Chum salmon generally migrate downstream within a few weeks of emerging from the gravel, and juvenile fish have been known to become trapped in the side channels that become disconnected in the spring (Coccoli 1996). Surveys of salmon emergence will be conducted to evaluate the effectiveness of flow releases for maintaining suitable incubation conditions and side-channel connectivity in the mainstem. The research results will be reviewed at GRFMC meetings and a summary report presented at the first 5-year review.

6.3.3 Research Funding Measure RFM-03 (A-B) Mainstem Sediment and Woody Debris

RESEARCH FUNDING MEASURE NUMBER: RFM-03 (A-B)

MEASURE: Mainstem Sediment and Woody Debris

RFM-03A: Monitor Distribution of Woody Debris

The LWD management program provides a means of increasing instream LWD throughout the mainstem middle Green River downstream of the Headworks. However, the program must be monitored to ensure that unanchored wood inputs do not detrimentally impact channel stability, public health and safety, or flood control, and that anchored LWD remains stable and functions as intended. Tacoma will fund LWD surveys of the reach between RM 61.0 and RM 32.0 in years 1 through 5 and year 10 following completion of the PED phase of the AWS project. The amount and distribution of LWD between RM 61.5 and RM 32.0 will be assessed using a modified version of the TFW Level 1 Survey Protocol and Large Woody Debris Jam Methodology. Additional monitoring at 5-year intervals is recommended, but funding for further monitoring will not be part of Tacoma’s obligations under this HCP.

If safety or flood control concerns are found to preclude unanchored placement, or if the Services determine continued inputs of unanchored LWD will not effectively contribute to natural stream processes, LWD may be anchored at specific locations. The stability of anchored placements will be conducted as part of compliance monitoring activities described in Chapter 6.1.

A report summarizing data gathered during periodic LWD loading surveys and anchored LWD stability evaluations will be provided to the Services during the 5-year

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RFM-03 (A-B) (continued)

reviews. It is anticipated that the Services, USACE, and the GRFMC will use the monitoring data to adapt the LWD input strategy as needed.

RFM-03B: Monitor Distribution of Sediments below Tacoma Headworks

The amount and composition of sediment stored in the active channel downstream of the input sites will be evaluated by periodic mapping of active in-channel storage sites and surveying cross-sections. Gravel bars will be mapped on low-level aerial photographs taken when flows are less than 300 cfs at the Auburn gage in years 1, 2, 5, and 10 following completion of the PED phase of the AWS project. Permanent cross-sections will be installed downstream of the input site near the inlets of major side channels, or in sites where sediment transport calculations suggest that deposition is likely. The cross-sections will be resurveyed in years 1, 2, 5, and 10 following completion of the PED phase of the AWS project. Additional monitoring at 5-year intervals is recommended, but funding for monitoring beyond year 10 will not be part of Tacoma's obligations under this HCP.

The results of gravel nourishment monitoring will be reported to the Services following each survey. It is anticipated that the monitoring data will be used by the NMFS, USFWS, USACE, and the GRFMC to refine the placement strategy if needed.

Objective

The objectives of this research funding measure are as follows:

RFM-03A - Provide data to the NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of the effectiveness of the mainstem LWD management program at restoring LWD recruitment and function in the middle Green River without compromising public health and safety or the viability of downstream flood control measures.

RFM-03B - Provide data to NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of the effectiveness of gravel nourishment activities in the middle Green River at maintaining spawning habitat and side-channel connectivity.

Rationale

Monitor Distribution of Woody Debris. Restoring recruitment of wood to the middle Green River requires passing small woody debris, large logs, and rootwads that are trapped behind HHD downstream to the middle Green River. Placing small woody debris and LWD within the active channel at low flows and allowing it to be naturally redistributed by high flows is the most cost-effective means of getting wood back into the system. It is assumed that wood that is deposited within the channel or floodplain during high flows will benefit fish habitat regardless of its final location or configuration.

However, if LWD jams are too frequent or block the entire channel, they may jeopardize or detrimentally impact flood control measures or public health and safety. Monitoring is necessary to make sure that the input process effectively delivers LWD to the river system and that increased LWD loadings in the middle Green River do not pose unacceptable risks to other beneficial uses of the river.

A survey of LWD loading and distribution in the middle Green River will be conducted after successful LWD recruitment is documented each year for the first 5 years of the ITP, and in year 10. The amount and distribution of LWD between the Tacoma Headworks and RM 32.0 will be assessed using a modified version of the Tacoma Level 1 Survey Protocol and Large Woody Debris Jam Methodology, except that logs wholly in Zone 3 or 4 need not be counted. Large woody debris surveys will be conducted primarily by boat. The minimum size criteria will be modified to reflect a reasonable size for large rivers such as the Green River. A new minimum size criteria will be developed based on a literature review and interviews with practitioners and research scientists currently conducting LWD studies on large rivers. In addition, the minimum piece count of wood required for a wood accumulation to be considered a jam will be modified as appropriate for larger rivers. Debris jams will be further stratified into three categories (small, moderate and large). Information on the LWD loading and distribution will be summarized and presented to the Services at each 5-year review. The location of large new LWD jams will be reported to the GRFMC immediately following each survey. If the GRMC concludes that the frequency and size of LWD jams has increased as a result of LWD placement, and that the risk to other beneficial uses has become unacceptable, unrestricted LWD inputs will be halted, and mainstem LWD management will be limited to anchored placement. Alternatively, if the Services determine, based on data presented at the 5-year reviews, that continued inputs of unanchored LWD will not effectively contribute to natural stream processes, all or a portion of the LWD allocated to the mainstem LWD management program may be anchored at specific locations within the middle Green mainstem, or redistributed to other approved uses. If the mainstem LWD management program is curtailed at the direction of the Services or GRFMC, funding for this conservation measure will be transferred to other research monitoring measures.

Monitor Distribution of Sediments below Tacoma Headworks. Construction and operation of HHD has blocked the natural downstream transport of gravel-sized sediments in the

Green River since 1962. A recent study conducted for the USACE indicated that HHD prevented the delivery of an estimated 6,500 to 19,600 tons (3,900 to 11,800 cubic yards) of coarse bedload per year from the upper Green River basin to depositional reaches in the middle Green River (USACE 1998). The upper watershed previously contributed more than 90 percent of the alluvial materials deposited by the middle Green River (Mullineaux 1970). Thus, the decreased sediment inputs are believed to have reduced the amount of available spawning gravels downstream of HHD, and could result in disconnection of side-channel habitats as the mainstem incises to form an armor layer. Tacoma has agreed to help fund and monitor gravel nourishment activities for years 1 through 10 as part of the AWS project.

The results of gravel nourishment monitoring will be reported to the GRFMC prior to subsequent gravel placement following each resurvey. Monitoring data will facilitate adaptation of the placement strategy if gravels are not mobilized as efficiently as anticipated, or if alternate placement locations are deemed to be more beneficial biologically. The decision to change the gravel nourishment strategy will be made by the GRFMC with the approval of the NMFS and USFWS.

Initiating gravel placement activities using the most conservative estimate of pre-HHD bedload transport (i.e., 3,900 cubic yards/year), and monitoring active storage and channel capacity downstream of the placement site will ensure that aggradation that could compromise flood control measures is identified in a timely manner. If the NMFS, USFWS, USACE, and the GRFMC conclude that continued gravel placement would compromise downstream flood control measures, gravel nourishment will be reduced or halted, and the funds for gravel nourishment monitoring will be redirected to other research monitoring efforts. Conversely, monitoring may also indicate that increasing the amount of gravel input annually would be beneficial. Tacoma will not be obligated to provide additional funding for increased gravel nourishment as a part of this HCP, but funding could be obtained from alternative sources and implemented under the GRFMC's adaptive management program.

Literature Cited

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7. Effects of Tacoma Water Withdrawal and Conservation Measures

Impact Analysis Procedures

Tacoma Water (Tacoma) has prepared this Habitat Conservation Plan (HCP) and is requesting coverage under an Incidental Take Permit (ITP) for two distinct sets of activities associated with procurement of water from the Green River: 1) the withdrawal of water under the First Diversion Water Right Claim (FDWRC), the Second Diversion Water Right (SDWR), and effects of springtime storage of the SDWR on downstream resources; and 2) the management of the upper watershed above the Tacoma Water Supply Intake at River Mile (RM) 61.0 (Headworks). These sets of activities are interrelated, but they are not interdependent. The water withdrawal facilities could be operated with or without incidental take coverage for the upper watershed, and management of the upper watershed could continue regardless of the manner in which water is withdrawn. For this reason, the effects of these activities are discussed separately.

Water Withdrawal

Tacoma receives a majority of its water supply from the Green River. Water is diverted from the Green River for municipal and industrial (M&I) use at the Headworks or at the North Fork well field in the upper watershed. Water withdrawals reduce flows in the reaches downstream of these locations, affecting the availability and quality of habitat for a variety of aquatic and terrestrial species. The Headworks diversion structure also presents a barrier to the upstream migration of anadromous fish, which directly affects adult salmon and steelhead returning to spawn in the river above RM 61.0. Blocking the upstream migration of anadromous fish indirectly affects a variety of fish and wildlife species due to the loss of marine-derived nutrients. Most adult anadromous fish die after spawning, and their carcasses play an important role in the nutrient cycle of Pacific Northwest watersheds.

Tacoma is proposing a number of flow-related conservation measures, non-flow-related measures and habitat-rehabilitation measures to mitigate these impacts. Some of these measures were developed in cooperation with the U.S. Army Corps of Engineers (USACE) in response to a letter identifying six principles of operation and design regarding the Howard Hanson Dam (HHD), Additional Water Storage project (AWS project) (see Appendix E). Tacoma is also providing additional funding support[1] for measures to improve fish and wildlife resources in areas of the Green River watershed where habitat conditions have been degraded by the management activities of others (e.g., diking of lower river for flood control, reduction in gravel transport HHD). The conservation measures summarized here are described in more detail in Chapter 5.

Tacoma's flow-related conservation measures include the following (see Chapter 5 for a complete listing):

Minimum Flow Requirements. The minimum instream flows provided under the Muckleshoot Indian Tribe/Tacoma Public Utilities Agreement (MIT/TPU Agreement) address habitat conditions for fish and wildlife habitat resources in the lower and middle Green River during the summer and fall. The lowest flows allowed in the Green River at Auburn under the provisions of the MIT/TPU Agreement are 225 to 250 cubic feet per second (cfs) during drought years, 250 cfs during average to dry years, 300 cfs during wet to average years, and 350 cfs during wet years. Tacoma's SDWR on the Green River was originally limited only by state of Washington-imposed instream flows at the Palmer U.S. Geological Survey (USGS) river gage. Constraints on use of the water, including higher minimum instream flows, were expanded by the MIT/TPU Agreement. The Agreement settles Muckleshoot claims against Tacoma arising out of Tacoma's municipal water supply operations on the Green River, including the first and second water diversions. The MIT/TPU Agreement did not address Tacoma's involvement in the joint USACE/Tacoma AWS project. Under the MIT/TPU Agreement, Tacoma agreed to constrain diversion of the FDWRC during certain drought conditions (see Chapter 5.1). Tacoma also agreed to higher minimum instream flow levels than identified by state statute for the SDWR. Under terms of the MIT/TPU Agreement, water from the SDWR will not be available during much of the summer during average water years and will be severely limited during drought years. In addition, criteria are established under which Tacoma will contribute certain amounts of water to supporting streamflows in the Green River during low flow conditions.

Provision for Optional Storage of 5,000 Acre-Feet (Ac-Ft) for Low Flow Augmentation. This measure provides for optional storage of up to an additional 5,000 ac-ft of water within HHD reservoir on an annual basis. This water can be used for low flow augmentation to improve fish and wildlife habitat conditions in the Green River.

[1] The cost-share percentages referenced in this document between Tacoma and USACE are subject to changes in the Water Resource Development Act or other congressional funding initiatives that may adjust the cost-share formula between the parties.

AWS Project. Tacoma is the local sponsor for the USACE's AWS project. The preferred alternative for the AWS project is a dual-purpose water supply and ecosystem restoration project with implementation of early spring refill of 20,000 ac-ft for Tacoma's SDWR water supply (i.e., Phase I). Flow-related benefits of the AWS project include a flow-management strategy that provides a block of water to be used to augment springtime flows for fishery benefits, including higher sustained baseflows during May and June and the potential release of freshets during the spring to improve outmigrant survival of juvenile salmon and steelhead.

Operation of HHD, including the storage and release of water, is the responsibility of the USACE. The impacts of HHD water control activities on listed species will be assessed via Section 7 consultation between the USACE, the U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS) (USFWS and NMFS are collectively referred to as the Services).

Habitat and ecosystem rehabilitation measures to be implemented as part of this HCP solely by Tacoma, or in cooperation with other parties include:

Upstream Fish Collection and Transport Facility at the Headworks. This facility will be used to capture upstream migrating adult anadromous salmonids, including chinook salmon, at Tacoma's Headworks diversion structure. These fish will be relocated above HHD to spawn in the upper Green River watershed. This measure will provide anadromous fish access to the upper watershed, which represents 45 percent of the Green River basin. The trap-and-haul approach to upstream fish passage at HHD due to the difficulty of laddering that 235-foot-high structure.

Downstream Fish Passage Facility at HHD. A downstream passage facility will be partially funded by Tacoma (USACE 1998) to provide for downstream passage of juvenile salmonids and steelhead kelts (spawned steelhead adults that survive to potentially spawn again) through HHD.

Downstream Fish Bypass Facility at Headworks. A downstream fish bypass facility will be installed at Tacoma's Headworks to increase the survival of outmigrating juvenile salmonids.

Large Woody Debris (LWD) Placements. Woody debris, including rootwads, will be placed in the free-flowing reaches of the upper Green River and the Headworks inundation pool. Woody debris (including both small and large woody debris) will also be collected in the HHD reservoir, transported downstream around HHD, and placed in the mainstem channel below the Headworks. Standing timber will be left in the newly inundated portion of Howard Hanson Reservoir to provide habitat complexity as well as a source of future LWD for other rehabilitation measures.

Gravel Nourishment. Gravel will be introduced into the Green River below the Headworks to augment the supply of gravels in the middle Green River. Gravel may be placed between HHD and the Headworks if deemed beneficial by the Services.

Side-Channel Reconnection and Restoration. A large side channel (Signani Slough), which was separated from the Green River by the realignment of Burlington Northern Railroad tracks, will be reconnected to the main river channel to provide up to 3.4 acres of side-channel habitat. Conservation measures designed to address target baseflows during the spring and instream flow requirements during the summer will also provide for side-channel connectivity with the mainstem Green River.

Defining Impacts and Benefits

The effects of Tacoma's water withdrawals and conservation measures described in this document will vary month to month and from species to species depending on the distribution of fish and wildlife species within the Green River basin. Anadromous fish species have been blocked from accessing the watershed above Tacoma's Headworks since the early 1900s, and several of the conservation measures included in this HCP address the reintroduction of anadromous fish to the upper watershed. Determining which stocks and which species should be considered for reintroduction to the upper watershed is a fish management decision that is beyond the responsibility of Tacoma. The Washington State Department of Fish and Wildlife (WDFW) and Muckleshoot Indian Tribe (MIT) are co-managers of Green River fish and wildlife resources and together with the Services will evaluate reintroduction of anadromous fish into the upper watershed. However, in order to evaluate potential effects of the HCP, assumptions regarding the distribution and potential for reintroduction above HHD were defined for each species to be covered by the ITP.

The Green River basin, like other watersheds in the Pacific Northwest, is a highly dynamic ecosystem where aquatic habitat conditions vary over both space and time. Under natural conditions, climate, landform, and wildfire help drive these variations. In the Green River, however, many of the geomorphic processes responsible for maintaining aquatic habitats have been forced out of the normal range of variability by anthropogenic activities such as flood control, urban development, flow diversion and forest harvest

(Chapter 4.5.3). Both the analysis of impacts that may result from activities such as Tacoma's HCP, and long-term recovery planning, must consider current processes as they exist under the modified geomorphic regime as well as the ability to restore natural processes given existing social, economic and scientific limitations. For example, diversion of the White and Cedar/Black rivers, operation of HHD, and construction of flood control works such as levees and revetments have allowed extensive development to occur in the lower watershed. It is unlikely that the extensive urban development can or will be completely reversed, or that the natural channel morphology of the lower river can be completely restored.

Changes in the channel morphology of the Green River affect the quality and distribution of aquatic habitat conditions in the Green River. Habitat conditions are also influenced by the effect of operation of Howard Hanson Dam, Tacoma's withdrawals and changes to the tributary flow regimes resulting from forestry activities, urban development and groundwater withdrawals. In order to isolate and identify the effects of Tacoma's withdrawals on the availability of aquatic habitat, analyses conducted under this HCP used the Physical Habitat Simulation (PHABSIM) component of the Instream Flow Incremental Methodology (IFIM). The IFIM was developed by the USFWS (Bovee 1982) and uses measurements of physical and hydraulic channel conditions, linked to descriptions of fish behavior, to quantify changes in an index of fish habitat resulting from changes in flow. Analyses conducted for this HCP used the results of a PHABSIM analysis conducted by the Washington State Department of Ecology (Ecology) on the Green River (Caldwell and Hirschey 1989).

It has recently been proposed that the analysis of the effects of water control projects be assessed based on changes in the flow regime using a suite of hydrological statistics. The Index of Hydrologic Alteration (IHA) methodology, developed by Richter et al. (1996), allows for a comparison of the natural or unregulated flow regime versus a flow regime under land use changes and water control operations. The IHA analysis provides a mechanism for assessing changes in hydrologic parameters, but the method is not well suited for isolating the biological effects resulting from a specific water control activity (Richter et al. 1996). It is anticipated that following implementation of the HCP and AWS project, federal, state and local agencies and the MIT will have increased input regarding flow management on the Green River (as described in HCM 2-02). Future flow management decisions may be guided, in part, by comparing the unregulated flow regime to various potential operational scenarios using the IHA analysis method developed by Richter et al. (1996) or similar research.

Analyses of the effects of Tacoma's withdrawals under this HCP were conducted using three different Green River flow regimes. For the purpose of defining and quantifying the effects of Tacoma's water withdrawals and flow-related conservation measures, HHD was assumed to be in place and operating for all three regimes. The three regimes analyzed are:

1) HCP FLOW CONDITIONS: GREEN RIVER FLOWS **WITH** AWS PROJECT AND **WITH** TACOMA WATER WITHDRAWALS AND WITH HHD IN PLACE

   This flow regime describes conditions for which Tacoma is seeking coverage under the ITP. The flow regime was developed assuming all facilities of the AWS project were constructed and operating. The AWS project provides limited restoration of ecosystem functions and provides storage of water for M&I use. Water for both low flow augmentation and M&I use is stored behind HHD during the spring when the demand for municipal water is comparatively low. Municipal water is released from HHD for diversion at the Headworks during the summer when M&I water demands are higher. Under Phase I of the AWS project, the rate of water storage can be designed to maximize water storage during periods of less environmental impact (i.e., prior to peak chinook emergence) and reduce the rate of water storage during periods of greater environmental impact (i.e., during the peak of chinook downstream migration) (see Chapter 5). The AWS project provides maximum use of a large reservoir volume to store dedicated and non-dedicated blocks of water that can be managed to provide higher springtime baseflows, higher sustained flows during the steelhead spawning and incubation period, and freshets to improve downstream passage of outmigrating juvenile chinook salmon. Flow conditions resulting from Tacoma's withdrawals were modeled assuming:

   - operation of HHD by USACE to provide flood control;
   - storage and release of 24,200 ac-ft of water by USACE to provide low flow augmentation;
   - storage of up to 5,000 ac-ft of water by the USACE on an annual basis; (Note: the modeling runs for this HCP assume that up to 5,000 ac-ft of water will be stored every year. During drought years, the stored water is gradually released to augment low summer flows. The model runs assume that water stored during average and wet years is quickly released over a two-week period in June consistent with USACE debris removal operations. Under the AWS project, water stored during average and wet years is available for fisheries benefits such as augmenting flows during late June and July to protect steelhead incubation.)

- operation of HHD by USACE using management of dedicated and non-dedicated blocks of water as described in Chapter 5;
- FDWRC withdrawals of up to 113 cfs on a daily basis (as constrained by MIT/TPU Agreement);
- storage of up to 20,000 ac-ft of SDWR water behind HHD by USACE between 15 February and 30 June at a rate of up to 100 cfs a day when flows permit;
- withdrawals of up to 100 cfs a day when stored M&I water available under the SDWR is released from HHD; and
- withdrawals of up to 100 cfs of SDWR water at the Headworks when flows permit (as constrained by MIT/TPU Agreement) and SDWR water is not being stored or released at HHD.

2) GREEN RIVER FLOW CONDITIONS **WITHOUT** AWS PROJECT AND **WITHOUT** TACOMA WATER WITHDRAWALS BUT WITH HHD IN PLACE

This flow regime was used for the purpose of identifying the effects of Tacoma's water withdrawals. The "without Tacoma withdrawal" flow regime assumes that neither the FDWRC or SDWR are exercised; no water is diverted by Tacoma at its Headworks and no municipal water is stored behind HHD. This flow regime was also developed assuming the AWS project does not proceed and the HHD downstream fish passage facility is not constructed. Construction of a new downstream fish passage facility at HHD will not be available under alternate federal development acts such as Section 1135, the Water Resource Development Act of 1986 or Section 206, the Water Resource Development Act of 1996. Under those Acts, a non-federal sponsor is required to provide 25 to 35 percent of planning, design and construction costs, and 100 percent of all operation and maintenance costs. Not more than $5 million may be spent at a single locality.

Investigation of a new Section 216 General Investigation Project to provide downstream fish passage at HHD would require a new local sponsor. The local sponsor would be required to pay up to 35 percent of the planning and design costs; up to 35 percent of construction costs; and up to 100 percent of post-construction operation, maintenance, and monitoring. A local sponsor for a single-purpose restoration project providing the downstream fish passage facility proposed under the HHD AWS project has not been identified. In addition, the USACE has indicated that if Tacoma did not proceed as local sponsor, it will probably not invest further planning resources in a downstream fish passage facility at HHD. Without the AWS project, it is unlikely that the storage of up to 5,000 ac-ft of additional flow augmentation water will be implemented by the

USACE (USACE 1998, response to comments on the DEIS/DFR). However, storage of up to 5,000 ac-ft of water on an annual basis was assumed for this scenario.

Flows in the middle and lower Green River under this flow regime are between 113 cfs (except when constrained under HCM 1-01) and up to 213 cfs greater than those occurring under "with Tacoma withdrawal" conditions. The Green River flow conditions without Tacoma withdrawals assumes:

- operation of HHD by USACE to provide flood control;
- storage and release of 24,200 ac-ft of water by USACE to provide low flow augmentation;
- storage of up to 5,000 ac-ft of water by the USACE on an annual basis; (Note: the modeling runs for this HCP assume that up to 5,000 ac-ft of water will be stored every year. During drought years, the stored water is gradually released to augment low summer flows. The model runs assume that water stored during average and wet years is quickly released over a two-week period in June consistent with USACE debris removal operations. Under the AWS project, water stored during average and wet years is available for fisheries benefits such as augmenting flows during late June and July to protect steelhead incubation.)
- operation of HHD by USACE using management of dedicated and non-dedicated blocks of water as described in Chapter 5 (Note: without the AWS project, it is uncertain whether the benefits of flow management could be realized, since reservoir storage will be constrained by the maximum summer conservation pool of elevation 1,141; however, flow management using blocks of water dedicated to low flow augmentation and non-dedicated water storage was assumed for modeling purposes.); and
- no active diversion of water through Tacoma's Headworks structure on the North Fork well field.

For the purposes of this HCP, the flow-related impacts to fish and wildlife in the Green River attributable to Tacoma are defined as those resulting from flow reductions occurring in the lower and middle river (i.e., below RM 61.0) as a result of the FDWRC and SDWR diversions. Water withdrawn at Tacoma's Headworks North Fork well field or stored behind HHD for M&I use reduces flow in the Green River below RM 61.0 and is considered a flow-related impact. The effects of Tacoma's water withdrawals were determined by subtracting daily flow values under the Green River flow conditions **with** AWS project and **with**

Tacoma withdrawals from those occurring under Green River flow conditions **without** AWS project and **without** Tacoma withdrawals.

Tacoma's impacts are those resulting from the reduction of flows in the lower and middle Green River by the amount of the diversion up to 213 cfs (i.e., withdrawal of FDWRC and SDWR), and occur throughout the year except when the flow requirements provided under the MIT/TPU Agreement cannot be met at Auburn and Palmer control points. When flows in the river drop below the minimum instream flow requirements, then SDWR diversions are reduced to comply with the flow requirement until the second supply diversion is shut down completely. At this point, Tacoma's diversions are up to 113 cfs for the FDWRC, which continue except under drought conditions when the diversion is reduced by Tacoma as provided under the MIT/TPU Agreement. The effects of Tacoma's water withdrawals for average year, dry year, and wet year conditions are illustrated in Figures 7-1, 7-2, and 7-3, respectively.

The hydrograph of the Green River remains stable throughout most of the summer and early fall under all the year types modeled. This is a result of the sustained release of low flow augmentation water stored behind HHD. Inflows from the upper Green River watershed into the reservoir are generally low compared to outflows during the summer and early fall period. The hydrology model employed in the HCP analysis assumes that USACE will continue to store 24,200 ac-ft for low flow augmentation even without Tacoma withdrawals, which is consistent with current congressionally authorized operating requirements for HHD. Consequently, flow releases from HHD tend to be very stable during the summer, with the exception of periodic fluctuations in flow associated with storm runoff.

The hydrology model assumes that a minimum flow of 110 cfs is met on a year-round basis at Palmer, which is the USACE target minimum flow for HHD operations. The hydrology model also assumes that the USACE will follow the minimum flow targets established at Auburn under the MIT/TPU Agreement in releasing low flow augmentation water stored in HHD. The amount of flow released from HHD to meet these minimum flow targets depends upon reservoir levels and climactic conditions (i.e., wet, average, dry, critically dry). Climactic conditions are assessed and minimum flow targets are set every two weeks during the summer, resulting in a slightly "stepped" hydrograph during this period in some years (Figures 7-1 and 7-2). The USACE could conceivably release a variable flow regime from HHD during the summer with the additional water available without Tacoma water withdrawals; the pattern of summer flow releases would be handled through Section 7 consultation between the USACE and the Services.

3) GREEN RIVER FLOWS **WITHOUT** AWS PROJECT BUT **WITH** TACOMA WATER WITHDRAWALS AND WITH HHD IN PLACE

For the purpose of this HCP, a third flow condition was used to identify the benefits of flow-related mitigation measures associated with Tacoma's local sponsorship and financial support of the AWS project.

Flow-related benefits of the AWS project were determined by subtracting daily flows occurring under "**without** AWS project but **with** Tacoma water withdrawals" from those occurring under HCP flow conditions: "Green River flows **with** the AWS project and **with** Tacoma water withdrawals." As mentioned previously, Tacoma is the local sponsor and is contributing funds to the AWS project. Green River flows under the "**without** AWS project but **with** Tacoma water withdrawals" were modeled assuming:

- ▷ operation of HHD by USACE to provide flood control;
- ▷ storage and release of 24,200 ac-ft of water by USACE to provide low flow augmentation;
- ▷ storage of up to 5,000 ac-ft of water by the USACE on an annual basis; (Note: the modeling runs for this HCP assume that up to 5,000 ac-ft of water will be stored every year. During drought years, the stored water is gradually released to augment low summer flows. The model runs assume that water stored during average and wet years is quickly released over a two-week period in June consistent with USACE debris removal operations. Under the AWS project, water stored during average and wet years is available for fisheries benefits such as augmenting flows during late June and July to protect steelhead incubation.)
- ▷ operation of HHD by USACE using a 1996 refill scenario; reservoir refill starting on 15 March, a constant refill rate of 200 cfs 15 March to 15 April and a 400 cfs refill rate from 16 April to 31 May as described in "Section 9: Modeling parameters for Baseline, Phase I and Phase II reservoir operations" included in Appendix F1 of the DFR/DEIS for the AWS project (USACE 1998);
- ▷ withdrawals of up to 113 cfs under the FDWRC on a daily basis (as constrained by MIT/TPU Agreement); and
- ▷ withdrawals of up to 100 cfs under the SDWR when flows permit (as constrained by MIT/TPU Agreement).

> The scenario of "**without** the AWS project but **with** Tacoma water withdrawals" means that any water stored behind HHD is used for low flow augmentation and no water is stored for municipal use. Tacoma will withdraw 113 cfs under the FDWRC on a daily basis and up to 100 cfs under the SDWR at the Headworks. Water available under the SDWR will have to satisfy minimum flow levels specified in the MIT/TPU Agreement. The effects of the AWS project early refill and spring flow augmentation measures on flows in the Green River are illustrated for average year, dry year, and wet year conditions in Figures 7-4, 7-5, and 7-6, respectively.

The impacts of Tacoma's exercise of its FDWRC and SDWR, as well as the flow-related benefits provided by the AWS project, were analyzed using Ecology's instream flow model and a reservoir operations and water supply model developed for HHD by CH2M Hill (USACE 1998, Appendix F, Section 9) (see Chapter 4 for a general description of project operations). The output from this model was used to simulate daily flows in the Green River at the Palmer and Auburn gages under three Green River flow conditions from 1964 to 1995 (i.e., 32-year period of record). Median and 90 percent exceedance flows predicted under Green River flow conditions **with** the AWS project and **with** Tacoma water withdrawals, Green River flow conditions **without** the AWS project and **without** Tacoma water withdrawals, and Green River flow conditions **without** the AWS project and **with** Tacoma water withdrawals are summarized on a monthly basis for the 1964-1995 period of record in Figure 7-7. The lowest median and 90 percent exceedance flows under all three conditions are observed from July through October.

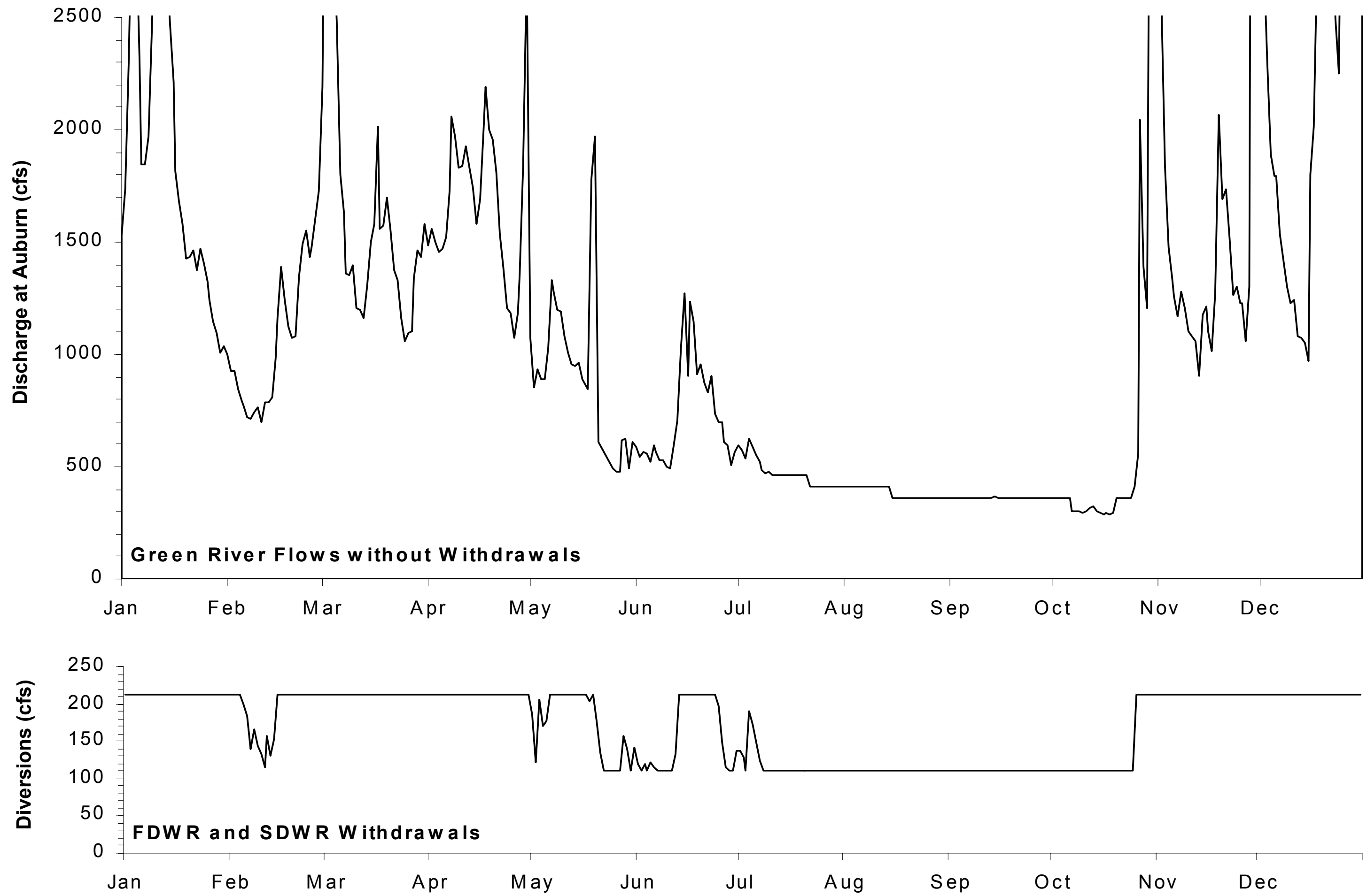


Figure 7-1. Annual hydrograph of Green River at Auburn gage under Green River flow conditions **without** AWS project and **without** Tacoma water withdrawals during average year (1994). For comparison purposes, water available to Tacoma under the FDWRC and SDWR during 1994 are shown in the bottom graph.

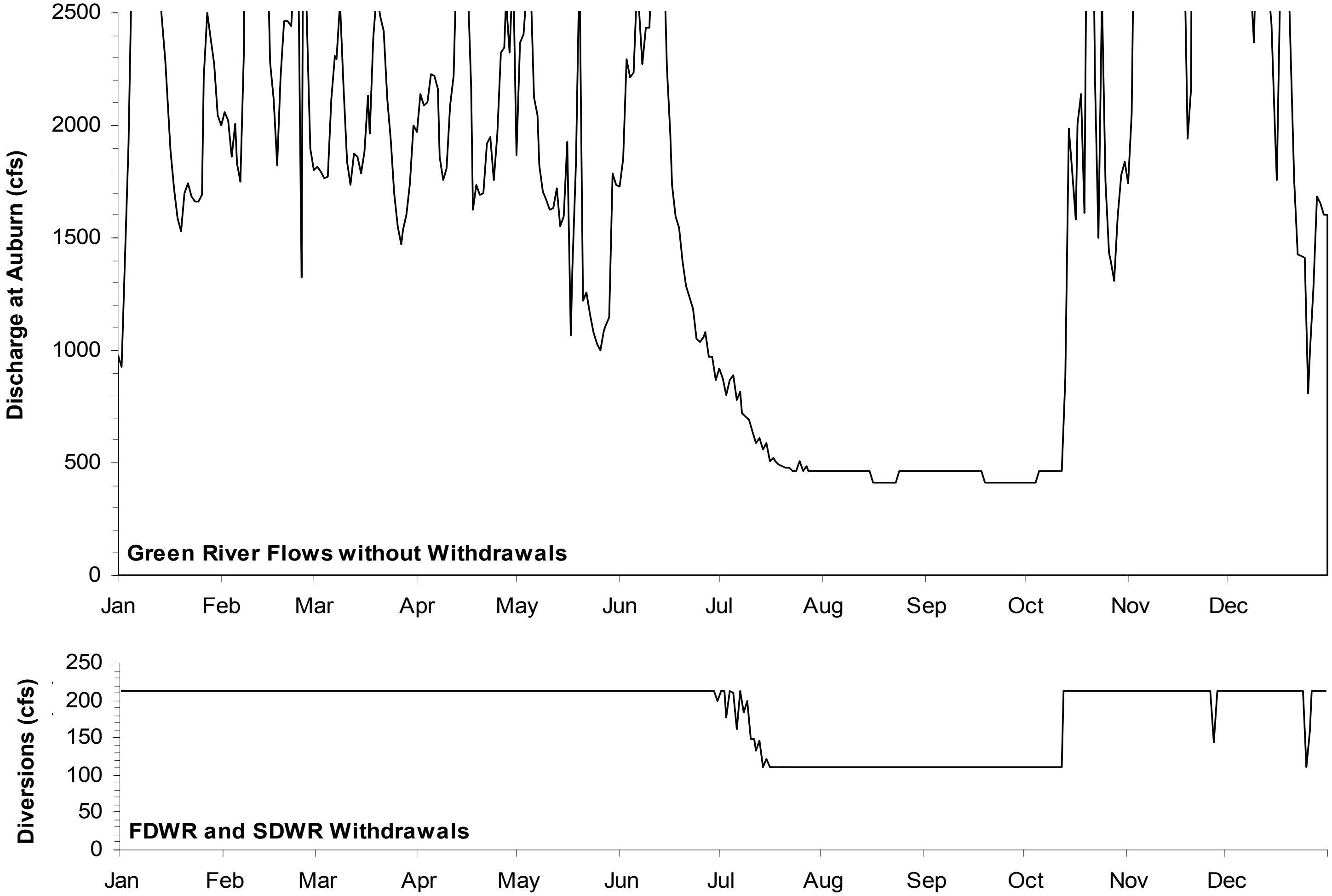


Figure 7-2. Annual hydrograph of Green River at Auburn gage under Green River flow conditions **without** AWS project and **without** Tacoma water withdrawals during dry year (1992). For comparison purposes, water available to Tacoma under the FDWRC and SDWR during 1992 are shown in the bottom graph.

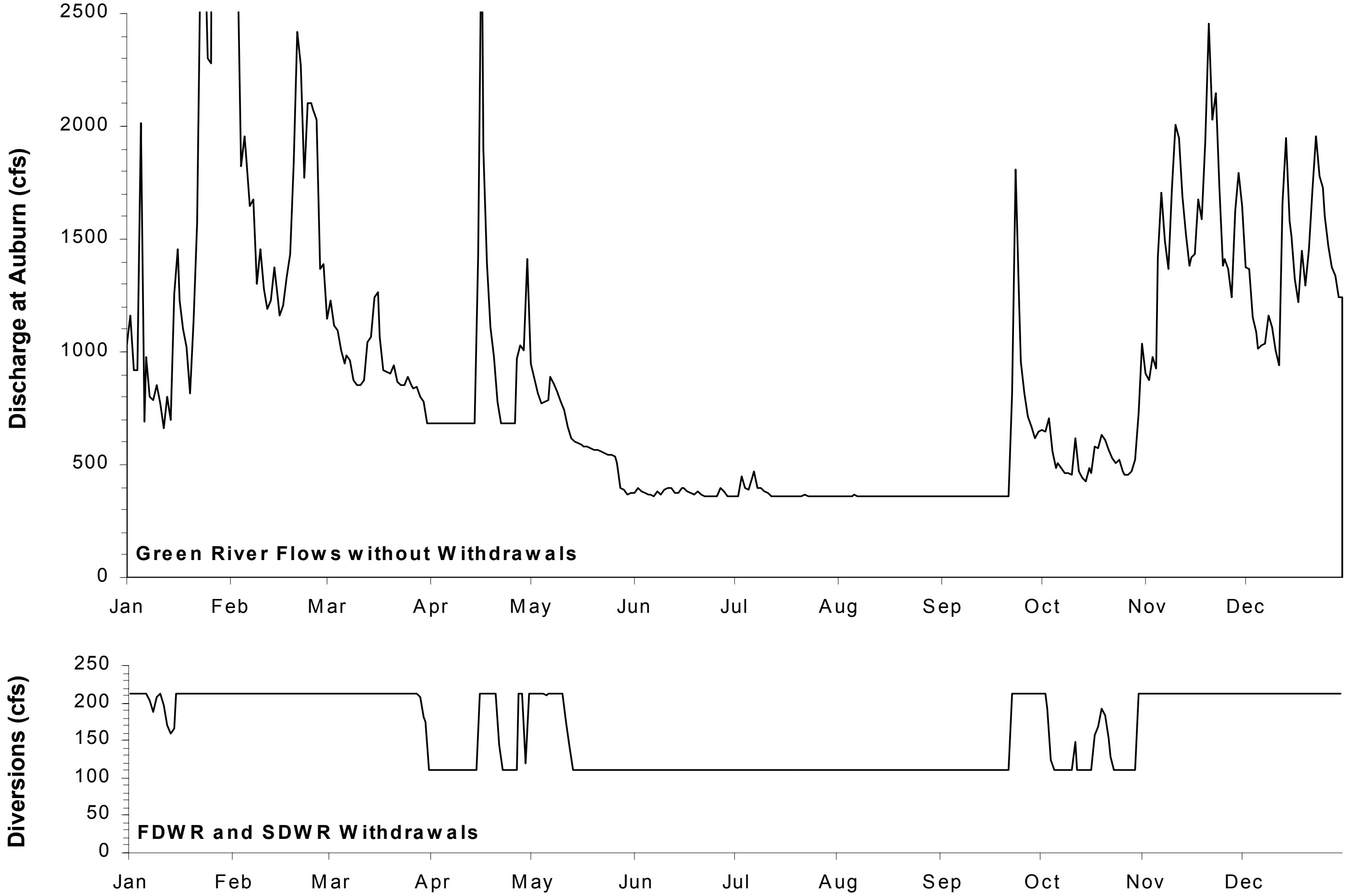


Figure 7-3. Annual hydrograph of Green River at Auburn gage under Green River flow conditions **without** AWS project and **without** Tacoma water withdrawals during wet year (1990). For comparison purposes, water available to Tacoma under the FDWRC and SDWR during 1990 are shown in the bottom graph.

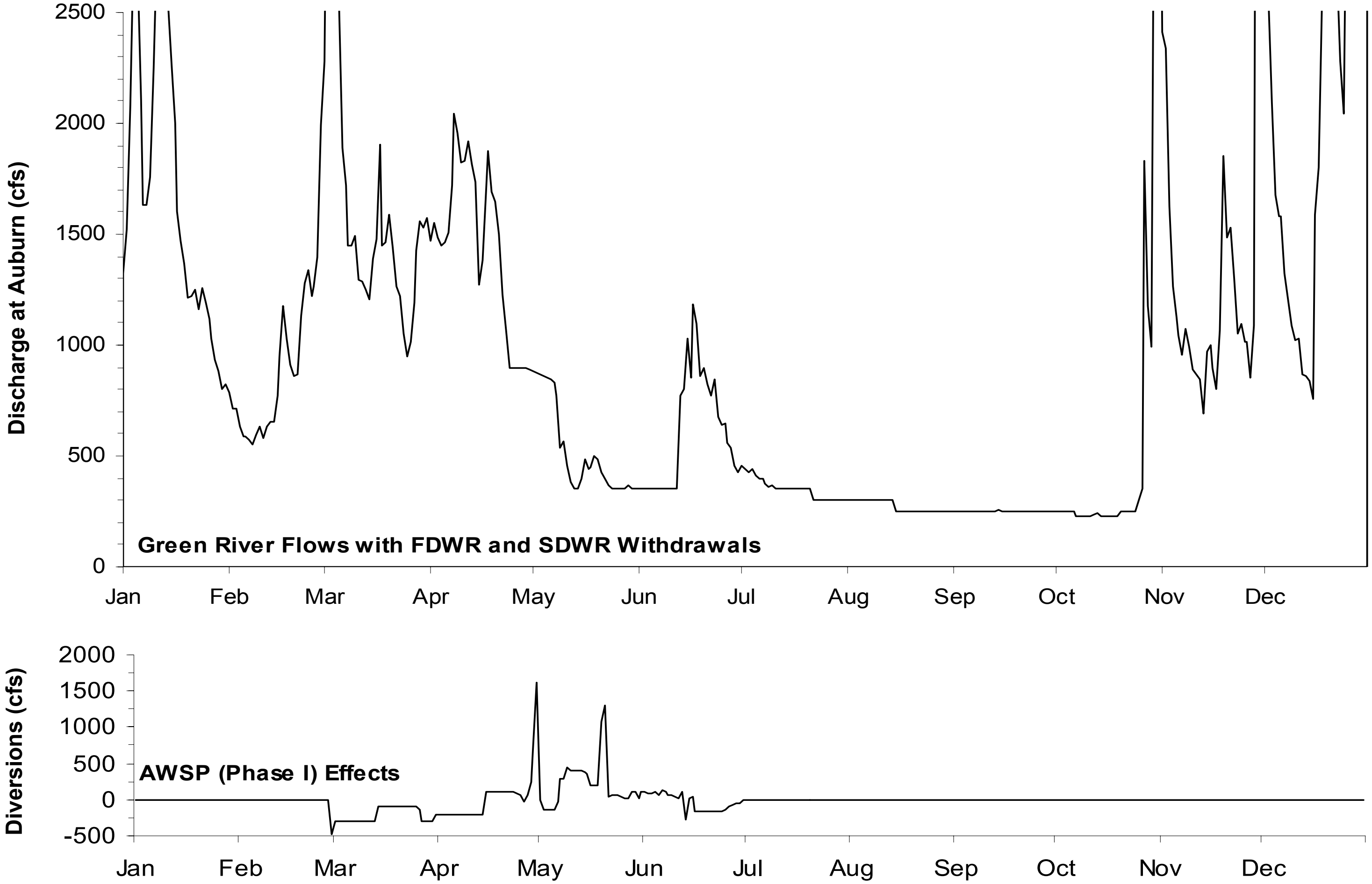


Figure 7-4. Annual hydrograph of Green River at Auburn gage **without** AWS project but **with** Tacoma FDWRC and SDWR withdrawals during average year (1994). For comparison purposes, flow changes to this hydrograph under HCP conditions (**with** AWS project and **with** Tacoma withdrawals) are shown in the bottom graph).

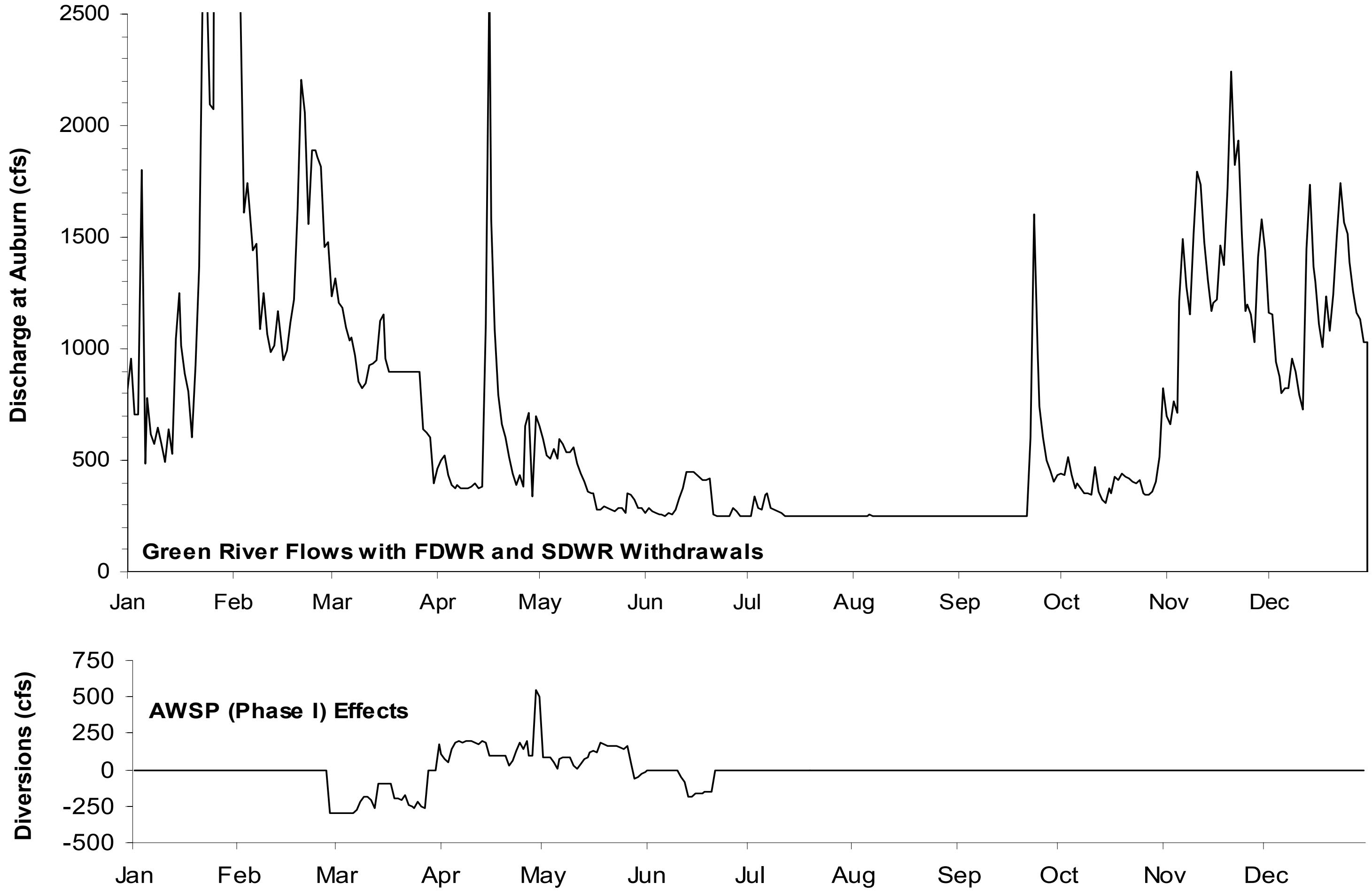


Figure 7-5. Annual hydrograph of Green River at Auburn gage **without** AWS project but **with** Tacoma FDWRC and SDWR withdrawals during dry year (1992). For comparison purposes, flow changes to this hydrograph under HCP conditions (**with** AWS project and **with** Tacoma withdrawals) are shown in the bottom graph).

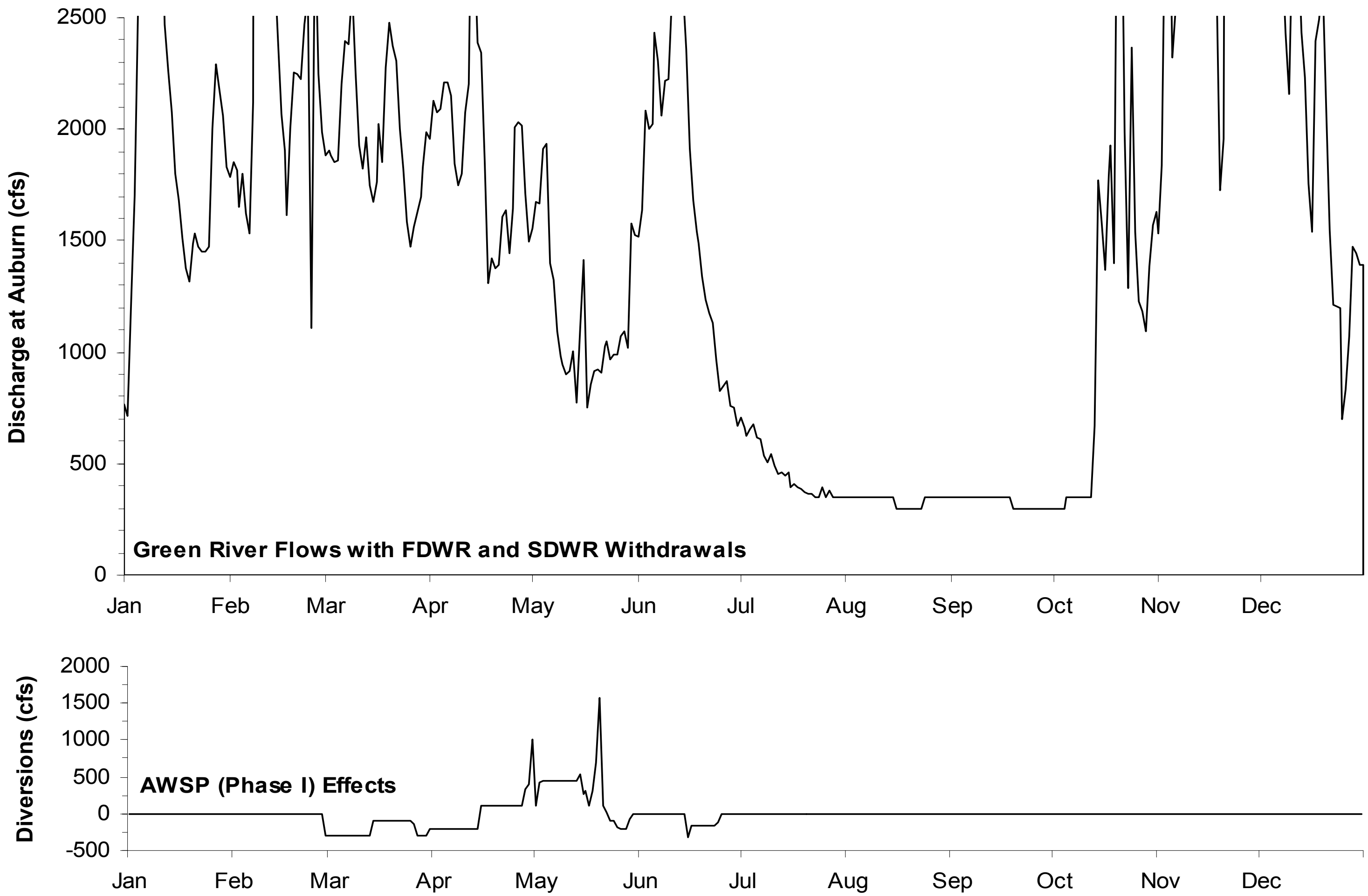
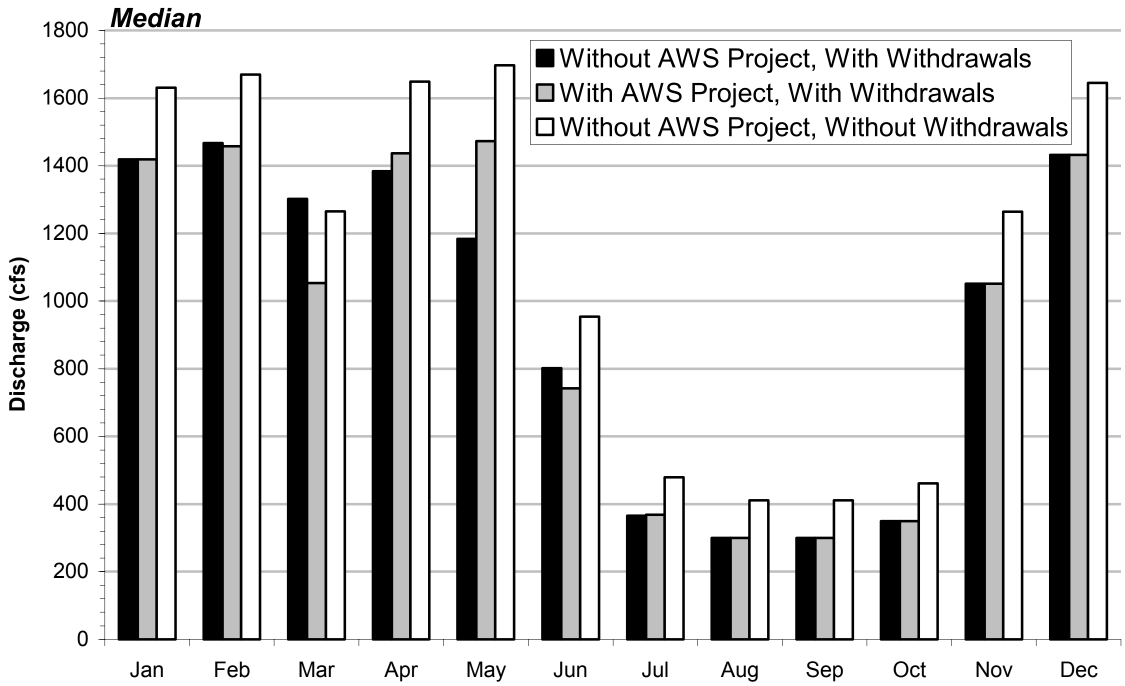


Figure 7-6. Annual hydrograph of Green River at Auburn gage **without** AWS project but **with** Tacoma FDWRC and SDWR withdrawals during wet year (1990). For comparison purposes, flow changes to this hydrograph under HCP conditions (**with** AWS project and **with** Tacoma withdrawals) are shown in the bottom graph).



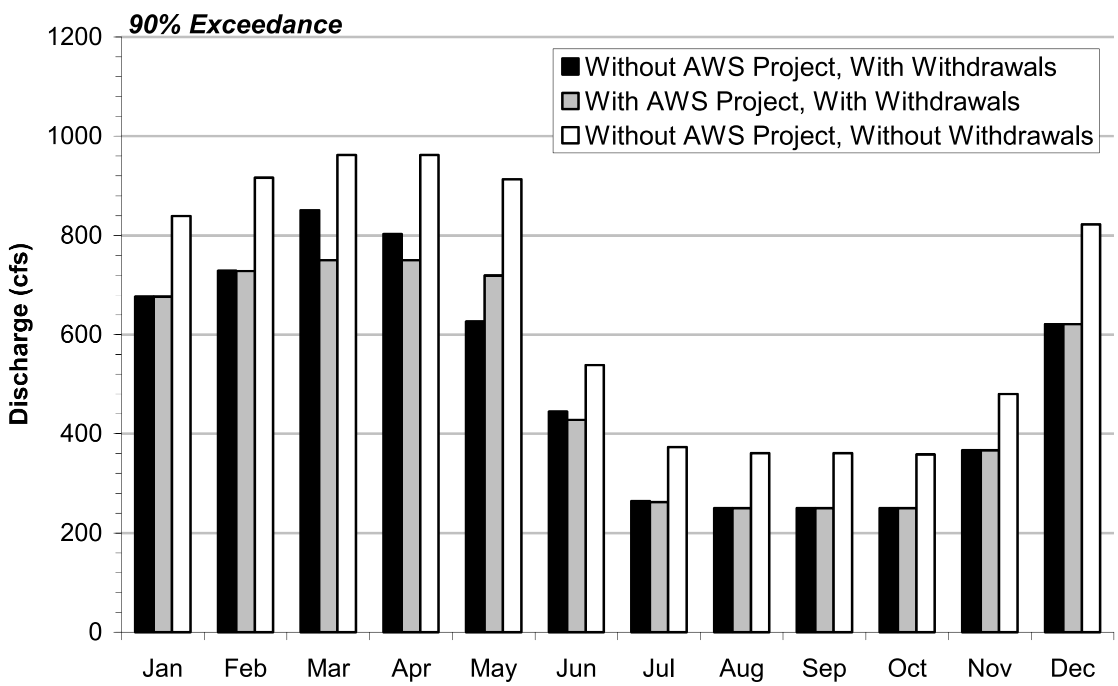


Figure 7-7. Green River flows **without** AWS project but **with** Tacoma and FDWRC and SDWR withdrawals; 1964-1995 period of record; median and 90 percent exceedance flows for Green River at Auburn gage under HCP conditions (Green River flows **with** AWS project and **with** Tacoma water withdrawals); and Green River flow conditions **without** AWS project and **without** Tacoma water withdrawals.

Effects of Watershed Management and Habitat Conservation Measures on Aquatic Species and Forest Wildlife Habitats

Forest Habitats

The objective of Tacoma land management in the upper watershed is to protect water quality for use as a source of municipal water supply. While this objective is complementary to fish and wildlife protection, a variety of measures will be implemented to further enhance upper watershed habitat over the term of the ITP.

Current and future conditions of forest habitats in the Upper HCP Area were described according to forest stand type and age. Forest stand types were distinguished according to the dominant overstory tree species (conifer or hardwood). Forest stand age was delineated as one of 11 categories ranging from 0–5 years old to 156 + years old. Current conditions were based on current forest inventory data collected by Tacoma. Future conditions were predicted by simply adding 10 years to the age of each stand at each decade. Stands to be held in reserves (e.g., all stands in the Natural Zone and riparian buffers in other zones) continued to age for the term of the HCP. Stands in the Commercial Zone were assumed to be harvested in the decade after turning 70 years old (the target rotation age under the HCP) and then returned to age 0.

Tacoma's management of lands in the Upper HCP Area will result in three general trends in forest habitat conditions:

- an overall increase in the average age of forest stands;
- an overall reduction in the total acreage of hardwood forest; and
- a substantial increase in the total area of mature coniferous riparian forest.

The combined effect of these three trends will be an increase in habitat for species associated with upland and riparian late-seral coniferous forest. While there will be a corresponding decrease in the total area of hardwood forest in the Upper HCP Area, this habitat type will persist in those areas where it occurs naturally (e.g., on moist soils and in areas of frequent natural disturbance).

Over the first 50 years of the HCP, the total amount of mature coniferous forest (106 to 155 years old) in the Upper HCP Area will increase from 268 acres to 4,027 acres out of a total of 11,644 acres, and the total amount of late-seral coniferous forest (over 155 years old) will increase from 41 acres to 292 acres (Figure 7-8). By the year 2048, 83 percent of the forestland in the Upper HCP Area (9,688 of 11,644 acres) will be more than 55 years old, the standard rotation age for commercial forest in western Washington, and over one-third (39 percent) will be more than 100 years old (Figure 7-8). During that same period, the total amount of hardwood forest will decrease from 2,905 acres to 1,973 acres (Figure 7-9). All hardwood forest stands present in 2048 will have gone at least 65 years without management intervention. Some of these hardwood stands will contain mature hardwood trees, while others will have developed naturally into coniferous forest or undergone natural disturbance and regenerated into young hardwoods again.

Mature and late-seral forest in the Upper HCP Area will be concentrated in the Natural and Conservation Zones, and along streams in the Commercial Zone. By the year 2048, approximately 82 percent of the late-seral forest (238 of 292 acres) and 64 percent of the mature forest (2,593 of 4,027 acres) will be in the Natural Zone, where forest habitats will be allowed to develop without intervention (Figure 7-10). Another 5 percent (15 acres) of the late-seral forest and 29 percent (1,161 acres) of the mature coniferous forest will be in the Conservation Zone (Figure 7-11). The remaining mature and late-seral coniferous forest will be in riparian management areas and Upland Management Areas (UMA) in the Commercial Zone (Figure 7-12). Tacoma's no-harvest riparian buffers will occupy 686 acres in the Conservation and Commercial Zones of the Upper HCP Area. This amounts to approximately 10 percent of the forested habitat in these two zones. In addition, there will be 1,440 acres of Riparian Management Zone (RMZ) in the natural zone. Roughly 56 percent of the riparian areas currently support second-growth coniferous forest; the remaining 44 percent are hardwood forests. In 1998, roughly 39 percent of the coniferous riparian forests were less than 50 years old. Approximately 1 percent supported late-seral stands (over 155 years old). By the year 2048, all forest stands in the riparian areas will be over 50 years old, and 4 percent of the coniferous stands will have reached late-seral stage (Figure 7-13).

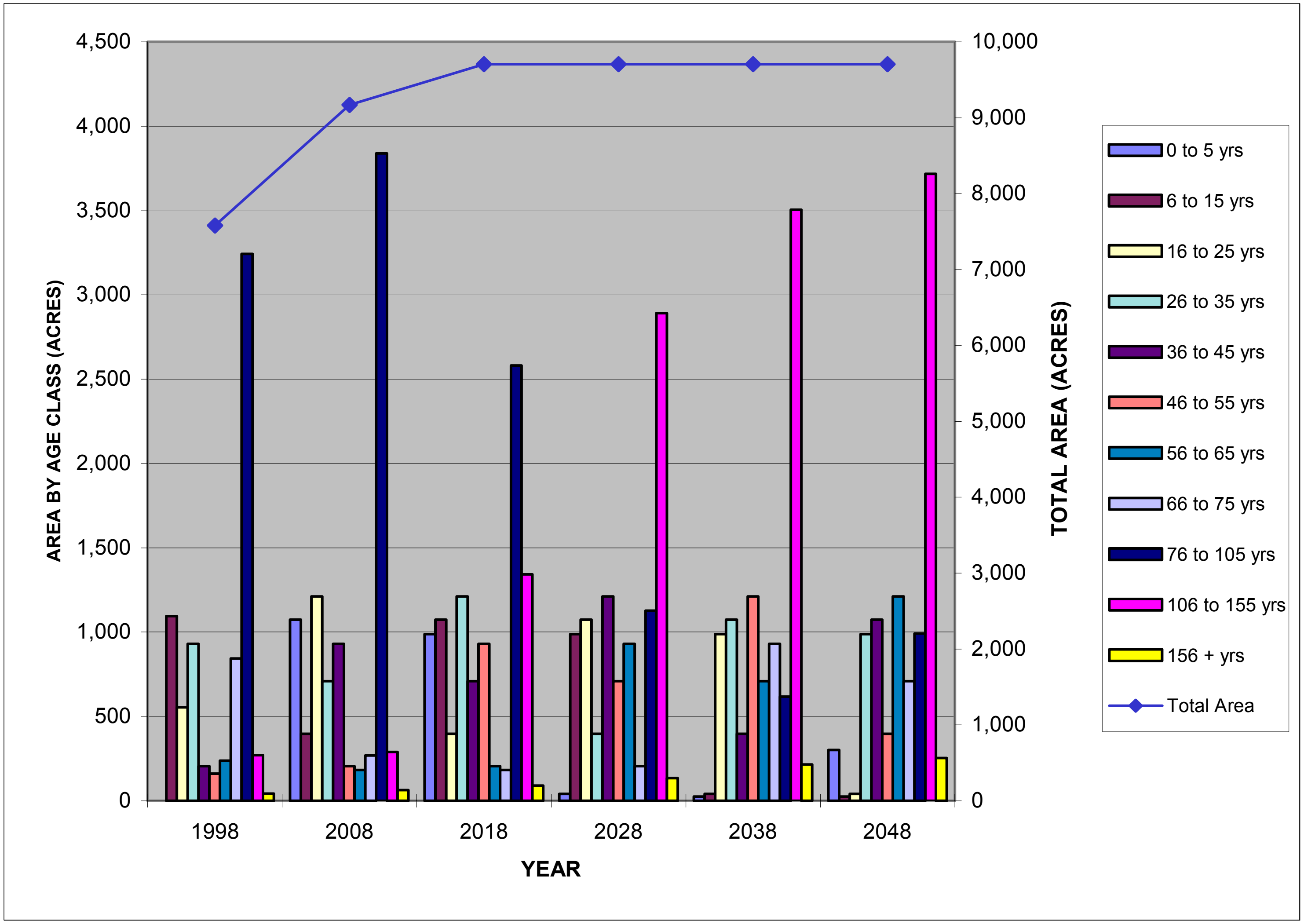


Figure 7-8. Projected trend in coniferous forest stand area by age class in Tacoma's Upper Green River HCP Area over the term of the ITP.

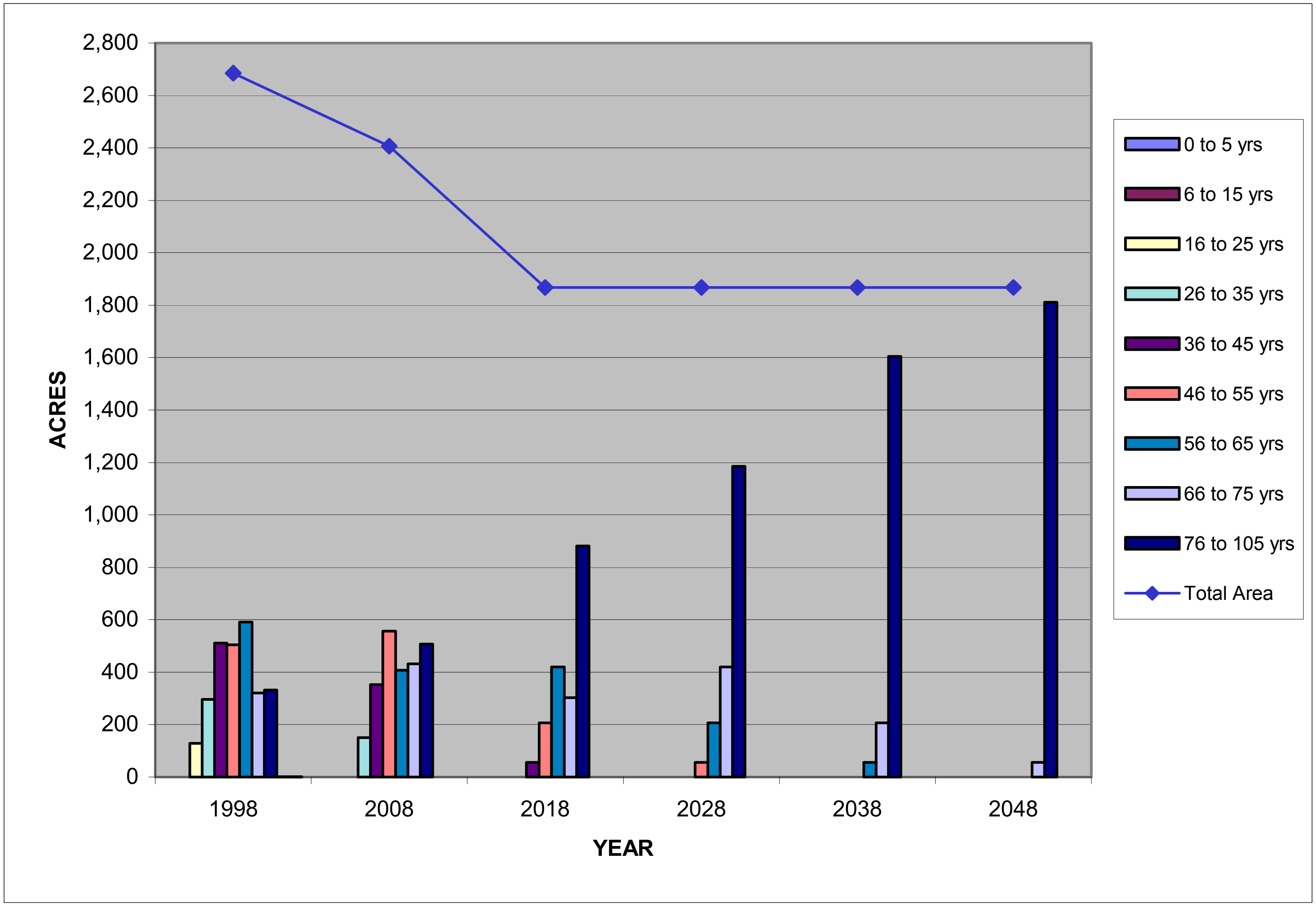


Figure 7-9. Projected trend in hardwood forest stand area by age class in Tacoma's Upper Green River HCP Area over the term of the ITP.

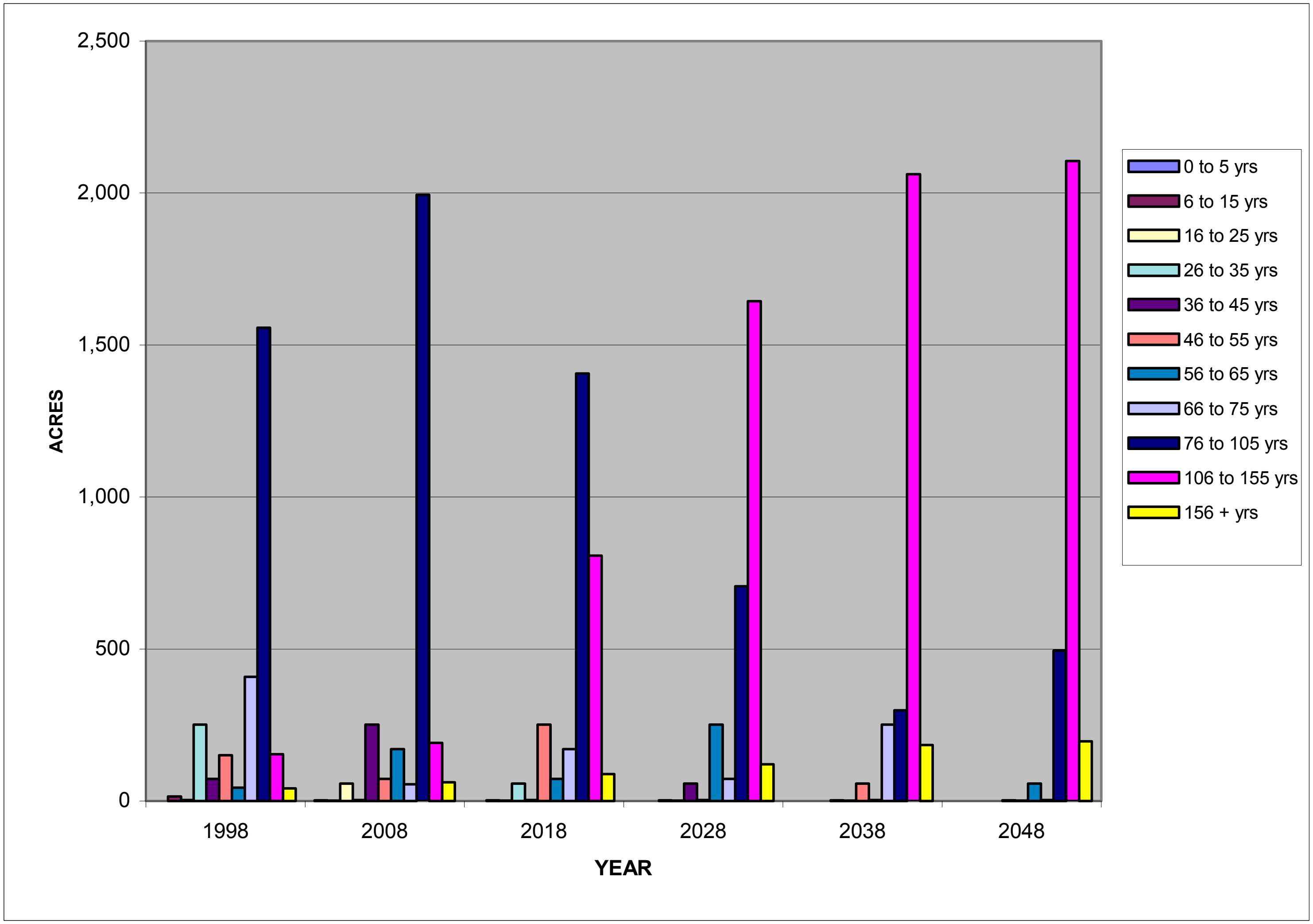


Figure 7-10. Projected trend in forest stand area by age class in the Natural Zone of Tacoma's Upper Green River HCP Area over the term of the ITP.

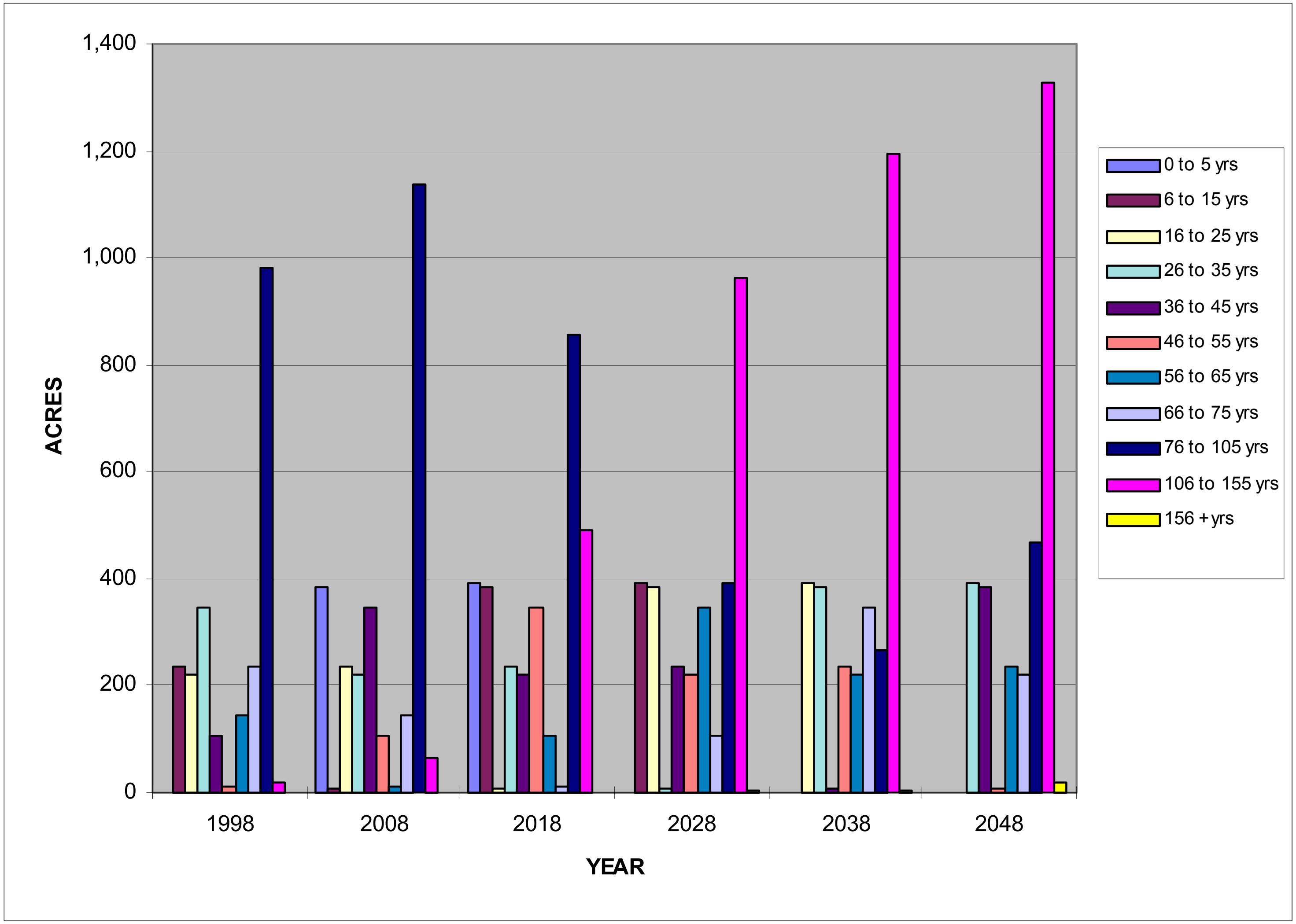


Figure 7-11. Projected trend in forest stand area by age class in the Conservation Zone of Tacoma's Upper Green River HCP Area over the term of the ITP.

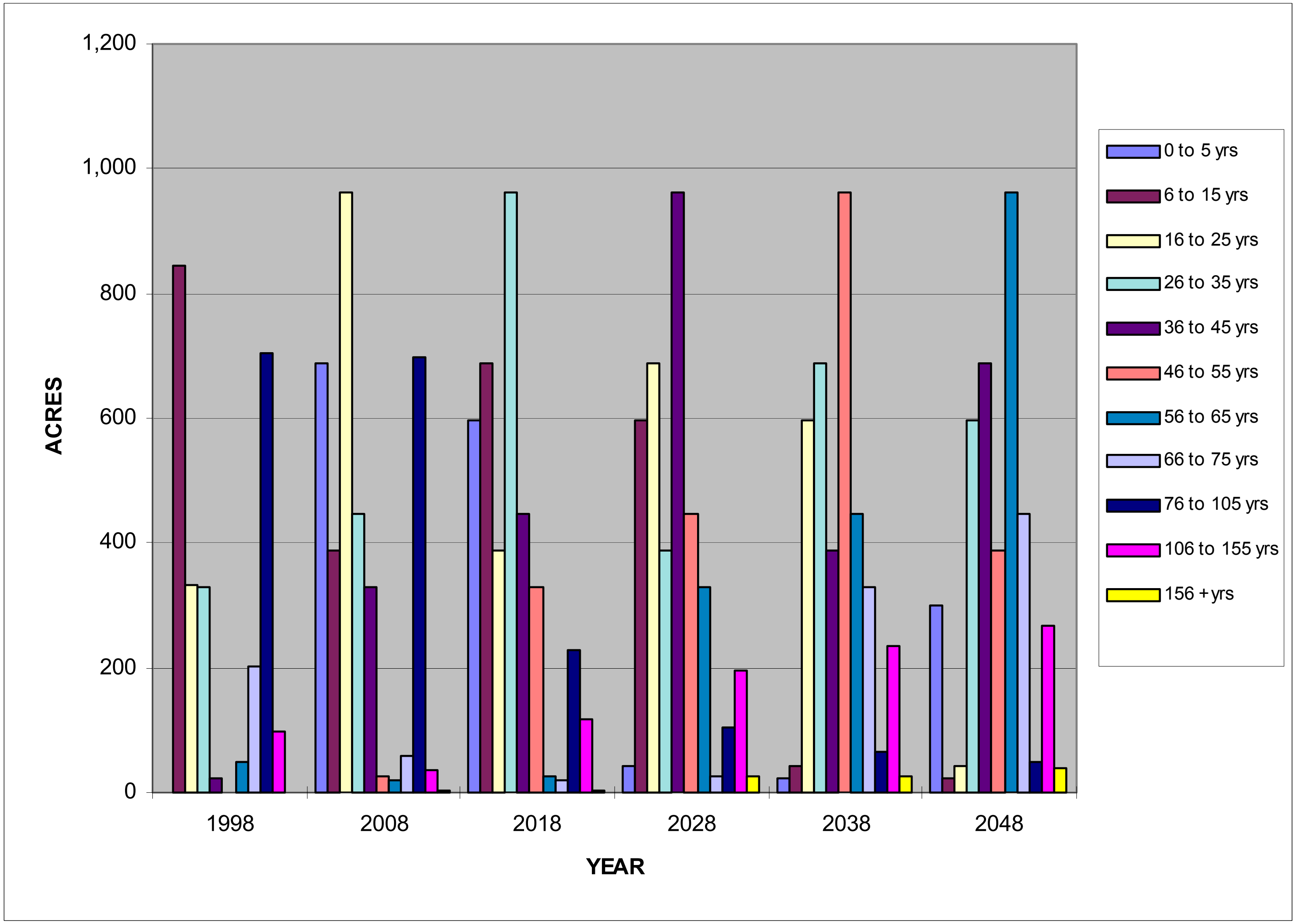


Figure 7-12. Projected trend in forest stand area by age class in the Commercial Zone of Tacoma's Upper Green River HCP Area over the term of the ITP.

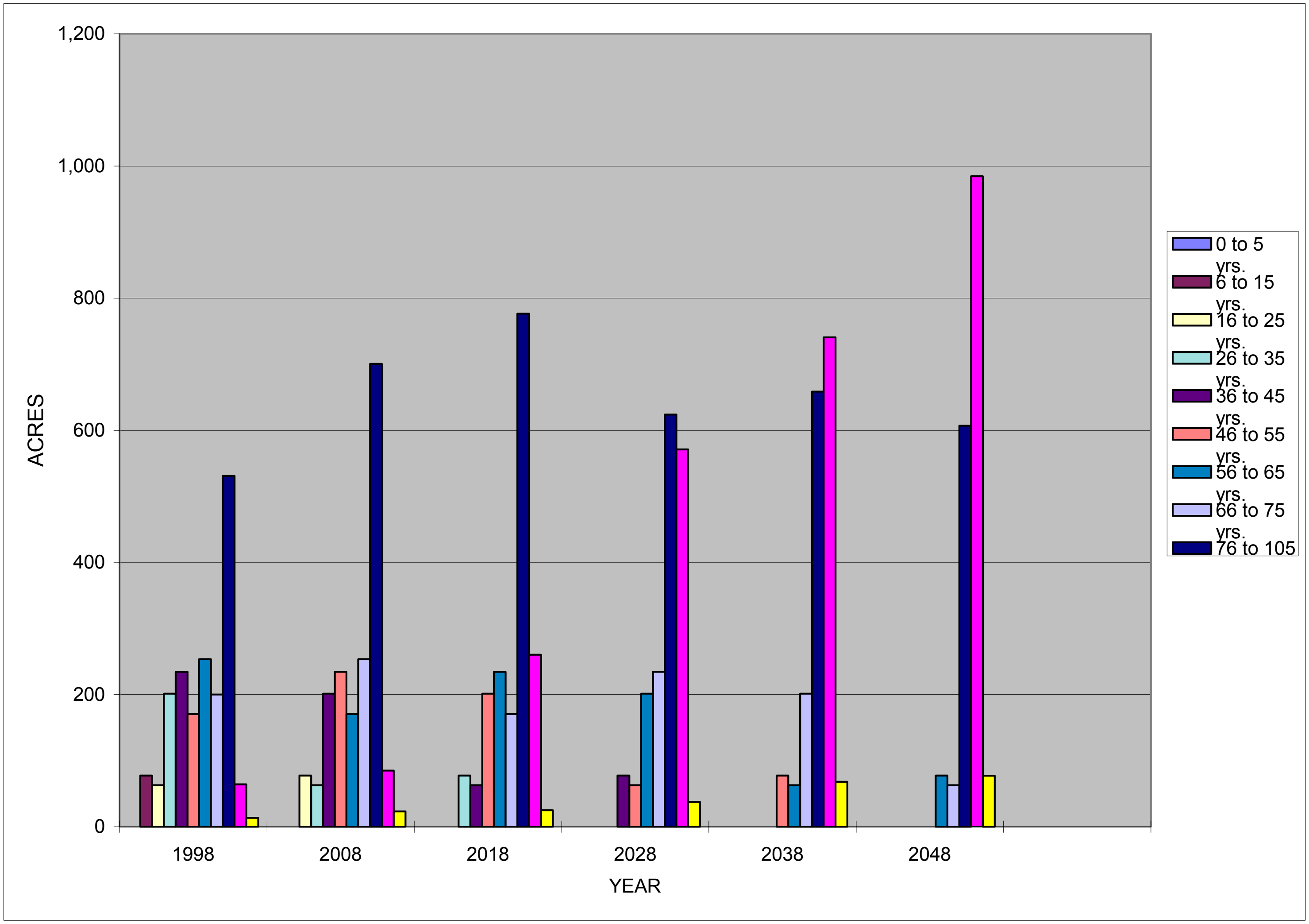


Figure 7-13. Projected trend in riparian forest stands by age class in Tacoma's Upper Green River HCP Area over the term of the ITP.

Roads

There are currently 97 miles of forest road on Tacoma's land in the Upper HCP Area, and the overall road density is 4.2 miles/mi^2 (see table below). The majority of roads are located in the Commercial and Conservation Zones, where the road density is approximately 5.5 miles/mi^2. The road density in the Natural Zone is low (2.1 mi/mi^2). Most forest roads within the Upper HCP Area (87 percent) are located in the controlled area and are closed to public access. The remaining forest roads (13 percent) are accessible to the public via Stampede Pass, and will remain open under the HCP to facilitate recreational access to U.S. Forest Service (USFS) lands within the upper Green River basin.

Road Class	Commercial Zone	Conservation Zone	Natural Zone	Total HCP Area
Active Road Length (mi)	26.8	34.4	17.2	78.4
Inactive Road Length (mi)	6.2	10.6	2.1	18.9
Total Road Length (mi)	33.0	45.0	19.3	97.3
Management Zone Area (mi ^{2})	6.0	8.1	9.1	23.3
Road Density (mi/mi ^{2}) [1]	5.5	5.6	2.1	4.2

[1] Total Road Length/Management Zone Area

It is expected that the overall road density in the HCP Area will decrease over the term of the HCP. Decommissioning roads where feasible is a stated goal of both the Plum Creek HCP (Plum Creek 1996) and a watershed analysis of the upper Green River completed by the USFS (1996) as required by the Northwest Forest Plan. In combination, lands owned by Tacoma, the USFS and Plum Creek comprise 32 percent of the Green River basin. Watershed analyses sponsored by Plum Creek, which Tacoma is actively participating in, require completion of a basin-scale Road Sediment Reduction Plan (RSRP), which will include an analysis of short- and long-term transportation needs. By working cooperatively with other landowners to develop a coordinated transportation management plan, Tacoma will ensure that the future road network in the Upper HCP Area is limited to only those roads required to meet future access needs. However, until that planning process is complete, the location and extent of roads that may be abandoned is unknown.

The amount of fine sediment delivered to stream channels from roads is determined by two primary factors: 1) the amount of sediment produced by surface erosion; and 2) the amount of water flowing off of road surfaces that reaches the channel network. The overall effect of implementing the road-management measures will be to reduce the amount of road-related sediment that is delivered to stream channels in the HCP Area.

Road construction and maintenance measures prescribed by Watershed Analysis, or as part of this HCP have the two-fold purpose of: 1) identifying and correcting existing sediment sources; and 2) minimizing future erosion and sediment delivery. The goal of the RSRP prescribed by Watershed Analysis is to reduce fine sediment inputs from the road system to less than 50 percent of the estimated natural background sediment yield in all subbasins. Implementation of the recommendations that result from the RSRP, in conjunction with conservation measures that require mulching or seeding steep cutbanks near streams, maintaining gravel surfacing on all mainline, primary and secondary roads, and restricting access to approximately 85 miles of road in the controlled area, is expected to reduce delivery of fine sediment from road surfaces.

Roads can also contribute sediment to the stream network by initiating mass wasting. Watershed Analysis prescriptions define landforms with a moderate and high risk of mass wasting, and prohibit road construction on extremely high-risk landforms (e.g., earthflow toes) that can deliver sediment to streams, or require implementation of proven design techniques such as full-bench construction and use of bridges or fords; geotechnical evaluations; or, (on lower risk sites), field inspections by trained personnel to identify low hazard inclusions. Road construction and maintenance measures to be implemented under this HCP also prohibit side-cast construction techniques on slopes greater than 60 percent, and requires that new culverts have the capacity to pass 100-year flows. Implementation of these measures is expected to reduce the incidence of road-related failures, thus future management-related contributions of coarse and fine sediment are expected to decrease over the term of the ITP.

7.1 Effects of Water Withdrawal and Habitat Conservation Measures on Chinook Salmon *(Oncorhynchus tshawytscha)*

This section describes both the potential effects of Tacoma's exercise of the FDWRC and SDWR on chinook salmon and the potential benefits resulting from habitat conservation measures. The following analysis has been limited to chinook salmon, a key species that has been listed under the Endangered Species Act (ESA), although NMFS acknowledges that populations in the Green River are healthy. Separate analyses are presented for each of the major life history stages of chinook, including upstream migration, downstream migration, spawning and incubation, and juvenile rearing. Detailed information concerning specific life history characteristics and habitat requirements is presented in Appendix A. The analysis is further segregated by different segments of the Green River, corresponding to upper watershed, middle watershed, and lower watershed (see Chapter 2). Other species for which coverage is being sought under this HCP will be similarly analyzed and described in following sections.

7.1.1 Chinook Upstream Migration

7.1.1.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Upstream Migration

Water Withdrawal. The Headworks diversion structure currently prevents the upstream migration of adult chinook salmon above RM 61.0. Additionally, HHD at RM 64.5 has been a barrier to the upstream migration of chinook salmon into the upper Green River watershed since its construction in the early 1960s. Howard Hanson Dam was originally authorized and built by the USACE without fish passage facilities. Blockage of migration into the upper watershed prevents access to approximately 40 percent of watershed. Chinook are typically mainstem river spawners, and likely will not use the HHD reservoir or the upper reaches of smaller tributaries for spawning. Nevertheless, based on gradient and elevation, there are approximately 24 miles of mainstem Green River available in the upper watershed (above the reservoir) suitable for chinook spawning (USACE 1998).

Adult chinook salmon will be reintroduced into the upper Green River watershed above HHD following the installation of a permanent fish collection and transport facility that will be located at the Headworks. The trap-and-haul facility will allow fish to be collected from a ladder at the Headworks, placed in tanker trucks and transported upstream to be released above HHD. Tacoma, in conjunction with the USACE, will provide important structural and operational features that will extend the range of anadromous fish to historic habitats. The reconnection of the upper watershed, through Tacoma's upstream fish passage facility and a combined USACE and Tacoma downstream fish passage facility, may be the single greatest measure available for restoring anadromous fish to the Green River basin. There are 220 square miles of watershed area and approximately 66 miles of stream and river habitat in the upper watershed that were historically used by salmon and steelhead. Roughly 24 miles of the 66 miles of stream habitat represent mainstem or large tributary reaches that are suitable for chinook salmon spawning. Comparing the upper watershed adult chinook escapement goal estimated by the USACE (1998, Appendix F1), to the Tribal and state escapement goals for the middle and lower Green River and Newaukum Creek (WDFW et al. 1994) suggests that the upper watershed represents about 28 percent of chinook habitat potentially available in the Green/Duwamish basin.

Watershed Management. The four primary means by which forest management activities may affect the upstream migration of chinook are: 1) through deposition of coarse sediment from management-related landslides, which creates or exacerbates subsurface flow conditions in low gradient sections of large tributaries or the mainstem Green River in late summer; 2) through elevation of temperatures caused by harvest of streamside vegetation, which may cause upstream migrating fish to avoid spawning areas with high temperatures; 3) through a reduction in LWD inputs, which may reduce the frequency and quality of deep pools and resting areas; and 4) by preventing access where roads cross streams. Recent watershed analyses (Plum Creek 1996; USFS 1996) indicate that deep pools required by adult salmonids for holding habitat are common in some portions of the mainstem and large tributaries in the Upper HCP Area. Flow is perennial in the mainstem and most large tributaries, although subsurface flows have been noted in lower Sawmill Creek and the North Fork Green River (USFS 1996). Subsurface flows are believed to have been exacerbated by sediment deposition from management-related mass wasting. Temperatures have been measured periodically throughout the WAU since 1965, and, since they are generally less than 66°F (19°C) even in the late summer, are not believed to impede upstream migration. However, locally high temperatures have been attributed to low summer flows and harvest of riparian vegetation (Plum Creek 1996; USFS 1996).

Implementation of upland forest and riparian conservation measures will have a positive effect on upstream migration in the Upper HCP Area. Implementation of mass-wasting prescriptions developed through watershed analysis is expected to reduce management-related contributions of coarse sediment. Over the long term, this could reduce the extent of aggraded reaches that consistently experience subsurface flows during dry summers. Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will increase shade, moderating elevated summer temperatures caused by lack of adequate shade. Increasing the proportion of riparian stands greater than 50 years of age from 61 to 100 percent will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming deep pools in larger channels. Tacoma's ownership encompasses most of the mainstem and large tributary habitat preferred as holding habitat by large-bodied salmonids such as chinook, thus temperature reductions and increased LWD inputs resulting from development of mature coniferous riparian forests on Tacoma's lands are expected to be especially beneficial for this species.

Stream-crossing culverts on Tacoma's land will be inventoried, and repaired or replaced as necessary within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure could increase the amount of habitat that is accessible to upstream migrating chinook, although the magnitude of that increase cannot be estimated until the inventory is complete.

7.1.1.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Upstream Migration

Water Withdrawal. The middle section of the Green River is much less channelized than the lower river, and certain areas represent a more natural condition (e.g., O'Grady Park section, RM 36.9 to 40.6) (Fuerstenberg et al. 1996). Because it is less constrained by levees, the middle Green River is significantly wider and shallower than the lower Green River. At a flow of 1,000 cfs at Auburn, the average wetted width of the middle Green River below the Green River Gorge is 148 feet, while the average wetted width of the lower Green River at the same flow is 119 feet (Caldwell and Hirschey 1989). Consequently, upstream passage of adult chinook salmon through the middle section of the river is susceptible to blockage by shallow riffles during late summer and fall low flow conditions.

The WDFW and MIT excavated channels through specific riffles for upstream migrating adult chinook salmon during severe drought conditions in 1987 when the annual 7-day low flow measured at the Auburn gage was 157 cfs (USGS gaging records). Under modeled natural conditions, the minimum annual 7-day low flow observed at the Auburn gage during the period from 1964 to 1996 was 172 cfs in October 1991 (Table 7-1), and the annual 7-day low flow in 1987 would have been approximately 193 cfs. Analysis of transect and stage discharge data collected by Ecology (Caldwell and Hirschey 1989) at shallow riffles in the middle Green River indicate that passage for adult chinook salmon should not be impeded by flows greater than 225 cfs (i.e., those flows providing passage depths of 1 foot and greater). Modeled flow data suggest that flows fell below this level approximately 10 percent of the time during early September under unregulated or modeled natural conditions (Figure 7-14).

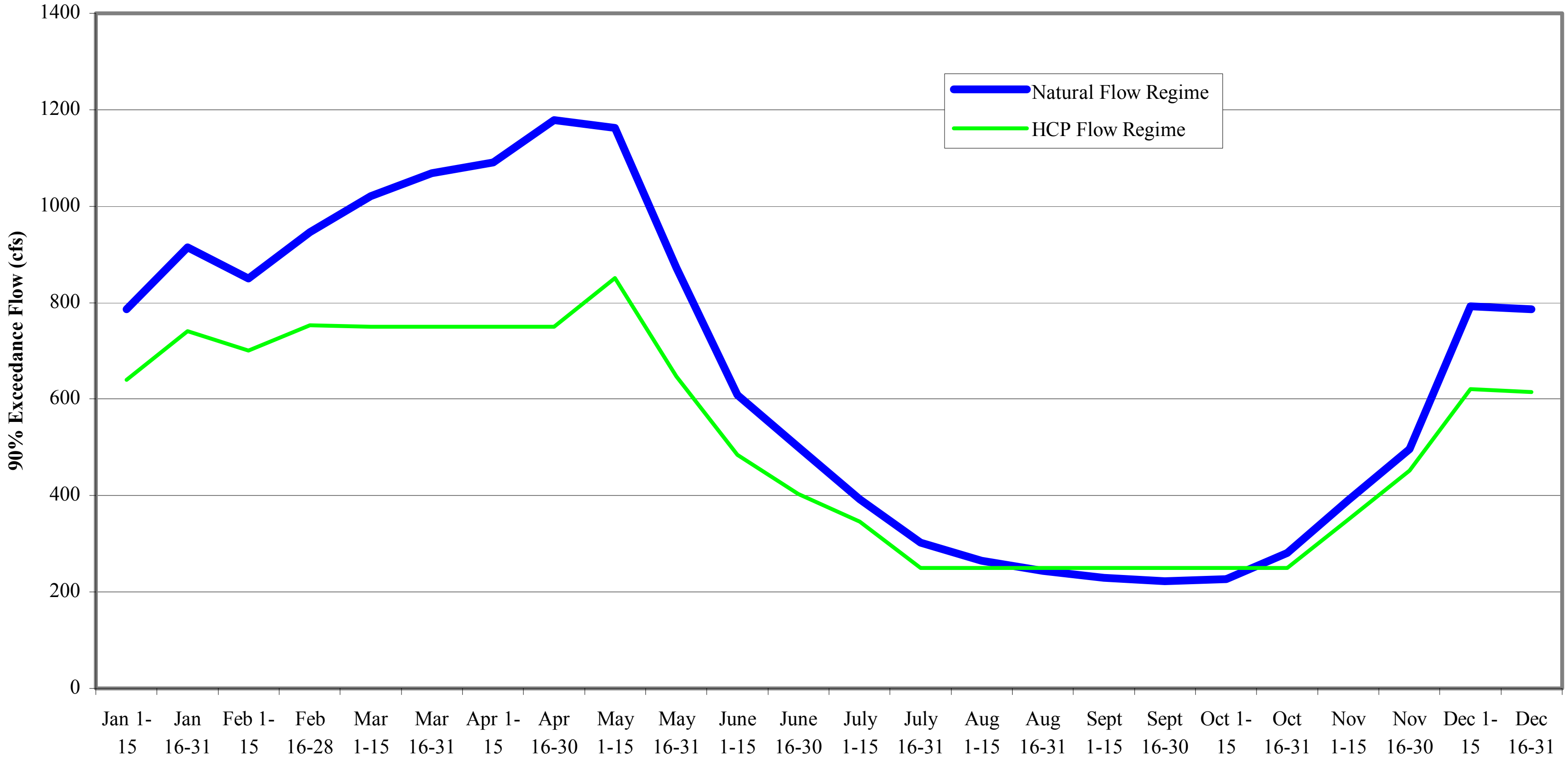


Figure 7-14. Ninety percent exceedance flows for the period of 1964 through 1995 at the Green River near Auburn USGS gage (12113000) under the HCP flow regime and modeled unregulated flow regime (Source: CH2M Hill 1997).

Table 7-1. Selected hydrologic characteristics of flows in the Green River at Auburn under the modeled unregulated flow regimes for the period from 1964 to 1995 (Source: CH2M Hill 1997).

	Unregulated			HCP		
	Min	Mean	Max	Min	Mean	Max
Annual 3-day Max.	3,447	8,798	17,759	3,349	7,561	12,000
Annual Mean Daily Flow	932	1,409	2,086	773	1,231	1,893
Annual Number of Spring Freshets[1]	0	4.60	10	0	5.30	10
Duration of Spring Freshets	1	5	28	1	5	27
7-day Low Flow						
April 1-May 30	447	1,178	2,123	385	876	1,998
July 15-Sept 15	203	290	462	250	294	400
Annual	172	268	462	183	303	429

[1] Spring freshets equal continuous flows greater than or equal to 2,500 cfs that occur between 1 February and 30 June.

Under HCM 1-01, Tacoma guarantees minimum flows of 250 cfs or greater at the Auburn gage from 15 July to the end of flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs following coordination with resource agencies and the MIT (see Appendix B). Consequently, Tacoma's water withdrawals are not expected to result in blocked upstream passage of adult chinook salmon through the middle Green River even during drought years. The provision of a minimum flow of 225 cfs during drought conditions should satisfy the upstream passage requirements of chinook salmon in the middle Green River. The 225 cfs minimum flow provided under the HCP represents an increase of more than 10 percent relative to the extreme 7-day low flow observed between 15 July and 15 September under the modeled natural, or unregulated, flow regime. The model data indicate that average 7-day low flows of as little as 183 cfs could occur at the Auburn gage under the HCP during late September or October; however, these extreme events still represent a 6 percent increase over the minimum annual 7-day low flow under modeled unregulated conditions for the same time period (Table 7-1). Flows exceed 250 cfs at Auburn more than 90 percent of the time under the modeled HCP flow regime; however, the overall duration of low flows increased by approximately two weeks (Figure 7-14). These analyses represent potential worst-case conditions since under HCM 1-01, Tacoma has committed to maintain flows in excess of 225 cfs at Auburn from 15 July to the end of HHD low flow augmentation.

The end of low flow augmentation from HHD typically occurs after 15 October. For modeling purposes, the end of flow augmentation was assumed to be 15 September.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect chinook upstream migration in the middle watershed.

7.1.1.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Upstream Migration

Water Withdrawal. Tacoma's water withdrawals have the potential to influence the upstream passage of chinook salmon more than other anadromous fish species present in the Green River. Adult chinook salmon are larger than most other salmonids and require greater water depths to move upstream over riffle areas. Chinook salmon also migrate upstream during the late summer and early fall, coincident with the lowest flow levels occurring in the Green River. Based on data collected at riffle areas in the lower river during Ecology's instream flow study (Caldwell and Hirschey 1989), water depths in the lower river are sufficient for upstream passage of chinook when flows at the Auburn gage exceed 200 cfs. Between 1962 and 1996, the lowest 7-day flow measured at the Auburn gage was 157 cfs during October 1987 (Source: USGS gaging records). Under modeled natural conditions, the minimum annual 7-day low flow observed at the Auburn gage during the period from 1964 to 1996 was 172 cfs in October 1991 (Table 7-1), and the annual 7-day low flow in 1987 would have been approximately 193 cfs.

The lower basins of large rivers are typically sediment deposition zones and are characterized by low-gradient, meandering river channels and broad floodplains. Prior to the 1900s, the lower Green River was broad and meandering; however, levees and other flood control measures have narrowed the channel considerably (Blomquist 1996) (see Chapter 4). Flows greater than 200 cfs at Auburn may provide sufficient water depths for passage, but poor water quality conditions can also hinder upstream movement and affect pre-spawn egg viability and subsequent survival. Warm water temperatures and low dissolved oxygen (DO) concentrations could result in delayed upstream passage of chinook salmon in the lower Green River and Duwamish estuary, though these water quality conditions were not found to block migration (Fujioka 1970). Also, sustained low flow conditions occurring during dry years may not provide flow cues necessary to move chinook salmon upstream. Adult chinook typically move into rivers and streams following fall freshets or increased seasonal flows.

The minimum instream flow requirements for the fall migration period of chinook salmon, established under the MIT/TPU Agreement and maintained by reductions in diversions and low flow augmentation storage in HHD, will result in flows that provide adequate water depths for the upstream passage of chinook salmon in the lower river compared to those occurring under natural conditions. The minimum flows required under the MIT/TPU Agreement (i.e., 250 cfs at Auburn during average and dry years and 250 to 225 cfs during drought years) will provide the physical conditions necessary for upstream passage of this species. However, some delay may continue to occur during sustained low flow periods due to poor water quality conditions and lack of migration cues.

The AWS project includes a provision for the optional annual storage of up to 5,000 ac-ft of water to be used for fisheries purposes. Under dry year or drought conditions, some of this storage could be targeted to augment flows or provide a freshet in the late summer or early fall when adult chinook salmon are holding in the lower Green/Duwamish rivers prior to upstream migration. The instream flows contained in the MIT/TPU Agreement should be sufficient for upstream chinook passage, but under the adaptive management strategy, the opportunity exists to adjust releases to meet unanticipated fisheries needs.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect chinook upstream migration in the lower watershed.

7.1.2 Chinook Downstream Migration

7.1.2.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Downstream Migration

Water Withdrawal. The potential effects of Tacoma's water withdrawals on the downstream passage of juvenile chinook salmon occur largely below the Headworks diversion facility (including the diversion dam and pool). The only exception to this is the pumping of water from the North Fork well field above HHD, and its effects on flows in the North Fork Green River. Potential effects of water storage on downstream migration are addressed as a USACE activity to be covered under Section 7 of the ESA and are not addressed in this HCP.

While the majority of Tacoma's M&I water withdrawal from the Green River basin occurs at the Headworks at RM 61.0, water is pumped at the North Fork well field above HHD when the turbidity in the mainstem Green River approaches 5 nephelometric turbidity units (NTU). Periods of high turbidity in the mainstem Green River are typically associated with late fall, winter and early spring storm events that wash sediments into the reservoir. High turbidity levels may also occur as a result of mass-wasting events along the HHD reservoir shoreline or upper mainstem tributaries. Groundwater from the North Fork well field is always clear and free of suspended sediments, and provides an alternate water source for use during such periods of high turbidity in the river. The well field is used approximately 11 days per month between November and May to supplement flow into Pipeline No. 1 (P1) to maintain a turbidity level of less than 5 NTU.

Active pumping of the North Fork well field reduces surface flow in the North Fork of the Green River above HHD and can affect downstream migration conditions for juvenile chinook in the North Fork. There is an assumed continuity between North Fork well field groundwater and surface flow in the North Fork, but the effect of pumping on surface flows is difficult to discern when North Fork surface flows are high. The North Fork well field is used during periods of high turbidity in the mainstem Green River, which typically coincide with high surface flows in the North Fork. Use of the well field during the spring outmigration season is therefore assumed to have minimal effects on outmigrating chinook juveniles.

While the USACE is responsible for the effects of water storage and release at HHD, Tacoma will be the local sponsor of the downstream fish passage facility to be installed at HHD. The operation of this facility is important to maintain high levels of chinook salmon smolt survival through Howard Hanson Reservoir and Dam following reintroduction of this species into the upper Green River. The estimated survival rate for combined reservoir and dam passage resulting under operation of the HHD fish passage facility is 64 percent, compared to a survival rate of 8 percent under pre-AWS project conditions (USACE 1998, Appendix F1, Section 8E).

Watershed Management. Extensive harvest of forest stands at elevations that commonly develop a snowpack but also frequently experience heavy, warm winter rains may increase the magnitude of peak flows (WFPB 1997). However, in the Pacific Northwest, the majority of such events occur during late November and February, prior to the period when juvenile salmonids begin to move downstream. Prescriptions developed through watershed analysis constrain harvest activities in subbasins deemed to be vulnerable to peak flow increases (Appendix D). Since forestry activities are not expected to influence flows during the salmonid outmigration season (April through June in the Green River basin) and watershed analyses prescriptions will prevent excessive peak flow increases, neither Tacoma's forest-management activities or conservation measures will affect downstream migration.

7.1.2.2 Middle and Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Downstream Migration

Water Withdrawal. Tacoma's water withdrawals could have two effects on the survival of outmigrating juvenile chinook salmon. First, some of the outmigrating juveniles passing through the Headworks diversion pool could be impinged on the existing screens or entrained into the water intake at the diversion. Fish impinged on the screens or entrained into the water supply system are assumed to ultimately perish. Existing screens at the Headworks do not meet NMFS design criteria. Since the NMFS design criteria represents state-of-the-art in downstream fish passage protection, screens that do not meet design criteria present a potential risk to outmigrating salmonids. Data on existing outmigrant entrainment and survival at Tacoma's Headworks are not available.

Second, the survival of outmigrating juvenile salmon in the middle and lower Green River below the Headworks is assumed to be affected by the timing and quantity of instream flows. Although the relationship between flow and migration survival is poorly understood, survival is assumed to increase as flows increase (Wetherall 1971). Tacoma's water withdrawals of up to 113 cfs under the FDWRC at the Headworks represent about 10 percent of the flow in the Green River during the mid-March to mid-June chinook outmigration season. Based on the assumptions of Wetherall (1971), Tacoma's diversions are expected to result in decreased outmigrant survival conditions by reducing flows in the Green River below the Headworks. Using Wetherall's data for juvenile chinook salmon, the USACE developed a survival-to-flow function for outmigrating juvenile salmonids in the Green River for the purpose of assessing the benefits of proposed flow augmentation during May and June under the AWS project (USACE 1998; Appendix F, Section 5).

In order to assess the impact of Tacoma's diversions on the survival of outmigrating chinook salmon, daily estimates of changes in chinook outmigration conditions were calculated for Green River flows under the HCP (Green River flows **with** the AWS project and **with** Tacoma withdrawals) and compared to Green River flows **without** the AWS project and **without** Tacoma withdrawals. Using the survival-to-flow function developed for the Green River from the Wetherall 1971 data, estimated daily changes in survival conditions were calculated during the chinook salmon outmigration period (15 March through 15 June) from daily flow values predicted by the HHD hydrology model for the period 1964-1995. For flows of 2,500 cfs or less, daily changes in survival conditions were calculated using the following polynomial equation:

$$S_i = 10.825 + 0.0532Q_i - 0.000009Q_i^2$$

where:

S_i = juvenile outmigrant survival for i^{th} day (%);

Q_i = mean daily discharge at Auburn for i^{th} day (cfs).

For flows greater than 2,500 cfs, the survival rate was assumed to remain constant at 87.6 percent based on the peak of the chinook survival and flow function. Although survival conditions of chinook outmigrants may decrease under extremely high flow conditions, there is scarce data to support modifications to the flow and survival function. Wetherall (1971) only accepted data on chinook outmigrants released at flows up to 2,500 cfs and rejected data suggesting lower outmigrant survival occurred at higher flows. In the absence of more substantive data, the survival rate was held constant at flows greater than 2,500 cfs. The total change in survival condition between the two flow regimes for a given year was calculated using the following equation:

$$S_y = \sum (Sp_i - Sb_i) \times N_i$$

where:

S_y = total change in juvenile outmigrant survival for a given year from Green River flows **with** the AWS project and **with** Tacoma withdrawals to Green River flows **without** the AWS project and **without** Tacoma withdrawals (%);

Sp_i = survival of migrating juveniles under Green River flows **with** the AWS project and **with** Tacoma withdrawals flows for the i^{th} day (%);

Sb_i = survival of migrating juveniles under Green River flows **without** the AWS project and **without** Tacoma withdrawals for i^{th} day (%);

N_i = proportion of total yearly migration of juveniles through the lower Green River for i^{th} day (%).

The results of this analysis indicate that the flow reductions below the Headworks caused by diversions under the FDWRC and SDWR result in an estimated average reduction in juvenile chinook outmigrant survival conditions of 5 percent (Table 7-2). Reductions in estimated yearly outmigrant survival conditions ranged from 1.3 to 7.1 percent for the 1964-1995 period.

Under this HCP, Tacoma will install a downstream fish bypass facility at the Headworks at RM 61.0 that includes a 220-by-24-foot conventional screen. This screen will employ state-of-the-art design and ensure that juvenile impingement and entrainment are kept to the technically feasible minimum. If impingement or entrainment is occurring with the existing screen, it will be reduced or eliminated.

Flow augmentation in May and June resulting from implementation of the AWS project-Phase I will also improve outmigration survival conditions for juvenile chinook salmon in the Green River. The benefits to chinook salmon migrants provided by AWS project spring flow augmentation measures were calculated using the same method used to calculate the impacts of the diversions on outmigrant survival conditions, except that the benefits were calculated by subtracting the daily survival values occurring under Green River flows **with** the AWS project and **with** Tacoma withdrawals from those occurring under Tacoma withdrawals assuming the AWS project was not completed. The average improvement in the index of juvenile chinook outmigrant survival condition resulting from the AWS project is 2.3 percent (Table 7-2). Estimated increases in yearly survival conditions resulting from the implementation of this measure range from 0.5 percent to 4.2 percent improvement for the 1964 through 1995 period.

The predicted change in juvenile salmonid migration conditions calculated as part of this HCP represents a net change between modeled scenarios. The values do not translate to a specific number of fish, or to a measurable change in fish survival. The values represent an index of migration survival; that is, changes in downstream migration condition are assumed to relate to changes in outmigrant survival, but the specific relationship is unclear. The effect of small changes in the index of downstream migrant condition could have effects unforeseen based simply on the calculated degree of change. If stream conditions are already marginal, a small change in instream conditions could have unanticipated effects. The analysis used in the HCP does not identify the baseline condition of the population, but simply describes the percent change between modeled scenarios.

Watershed Management. Tacoma's watershed management activities and measures will not affect chinook downstream migration in the middle and lower watershed.

7.1.3 Chinook Spawning and Incubation

7.1.3.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals at the Headworks will not affect spawning habitat and incubation of chinook salmon in the upper Green River basin above HHD. However, pumping of groundwater from the North Fork well field could affect chinook spawning and incubation in the North Fork of the Green River. During late summer, surface flows in the North Fork channel upstream of the well field drop below 5 cfs and in some years cease to flow for several days to weeks. During this time, groundwater in the vicinity of the well field can contribute to surface flows in the lower North Fork channel one-half mile or more downstream of the well field. If pumping reduces surface flows in the lower North Fork, adult chinook transported upstream past the Headworks and HHD may not find suitable spawning habitat there until fall rains increase surface flows. Since pumping of the North Fork well field typically occurs with the onset of fall rains, effects on chinook spawning and incubation will be minor.

As previously mentioned, the upper Green River watershed will be opened up to spawning and rearing of chinook salmon through the use of an upstream trap-and-haul facility to be installed at the Headworks. Transporting fish upstream will increase the total area of the Green River watershed that can potentially be used by anadromous fish by 40 percent over the habitat area currently available in the Green River basin (USACE 1998). Fall chinook salmon are expected to spawn mainly in the lower gradient reaches within the upper watershed. Fall chinook adult spawning capacity estimates developed by the WDFW for Olympic Peninsula streams vary according to gradient and elevation, and using these data the USACE estimated there are 24 miles of mainstem and large tributary chinook spawning habitat in the upper Green River watershed (USACE 1998). This represents about 28 percent of the total chinook habitat in the Green/Duwamish Basin.

Watershed Management. Salmonids require stable gravels that have low concentrations of fine sediment and organic material for successful spawning. Forest harvest and road building can substantially increase the delivery of fine sediment to streams through both surface erosion and mass wasting. Recent watershed analyses conducted in the upper Green River basin identified a number of landforms with high rates of management-related mass wasting, and noted a number of tributary basins where the amount of road-related surface erosion increased sediment delivery by over 50 percent of the background rate (Plum Creek 1996; USFS 1996). Data on spawning gravel quality from the Lester WAU indicate that tributary spawning habitat currently contains moderate to high levels of fine sediment (> 12 percent by volume) (Plum Creek 1996).

Implementation of mass-wasting prescriptions and the RSRP developed through watershed analysis will reduce management-related contributions of fine sediment to less than 50 percent over background. Reducing fine sediment inputs is expected to result in a decrease in the proportion of fine sediment contained by spawning gravels, and could result in increased survival to emergence. Species such as chinook, which spawn in low gradient reaches prone to deposition of fine sediment, will benefit most from improved gravel quality.

Loss of LWD through decreased recruitment or intentional removal may result in a loss of spawning gravels, particularly in higher gradient channels with a high sediment transport capacity. Approximately 57 percent of the moderate to high gradient channels in the Lester WAU had "poor" LWD frequencies (< 1 piece/channel width) (Plum Creek 1996). Lack of spawning gravel was identified as a potential limiting factor to salmonids in the upper Green River watershed (USFS 1996). Since gravel recruitment has increased as a result of management-related mass wasting, the current lack of spawning gravel is hypothesized to be the result of the lack of storage sites provided by LWD.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming stable flow obstructions in larger channels. The net result should be an increase in in-channel LWD and an associated increase in the availability of spawning gravel. Spawning chinook may benefit most from increased spawning gravel availability in moderate to high gradient tributary streams where storage is currently limited.

7.1.3.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals can affect the availability of chinook spawning habitat in both the mainstem river and side-channel areas of the middle Green River. The side channels in this section of the river provide important habitat for salmon spawning, incubation, and juvenile rearing (Fuerstenberg et al. 1996; USACE 1998).

Reduced flows can also increase the susceptibility of chinook salmon redds to dewatering by exposing mainstem and side-channel areas during the incubation period.

The potential effects of Tacoma's withdrawals on mainstem spawning habitat in the middle Green River were quantified using the results of an instream flow study conducted in the lower and middle Green River by Ecology (Caldwell and Hirschey 1989). Potential habitat area and flow functions were developed for chinook salmon spawning at four IFIM (Instream Flow Incremental Methodology) study sites established in the middle Green River. The potential habitat area values produced by this study represent the total amount of potential habitat resulting from a given flow, weighted according to the suitability for spawning of the velocity, depth, and substrate that are predicted to occur under that flow. The daily potential habitat values occurring during the spawning period of chinook salmon under Green River flows **with** Tacoma withdrawals and Green River flows **without** Tacoma withdrawals were calculated using these potential habitat and flow functions. Daily flow values for Auburn and Palmer gaging control points were obtained from the CH2M Hill hydrology model; these values were modified to remove inflows from Big Soos Creek and Newaukum Creek for IFIM sites located above these tributaries. Based upon this analysis, chinook salmon spawning habitat in the main channel of the middle Green River could be reduced by an average of 11.1 percent by exercise of the FDWRC and SDWR (Table 7-3). The greatest decrease in spawning habitat caused by the diversions (-31.5 percent) was predicted during 1987, a drought year. In contrast, the diversions resulted in an 11.4 percent improvement in spawning habitat area during 1968, a wet year. High flows occurring during the fall of 1968 exceeded the range of flows determined to be optimal for chinook salmon spawning by the IFIM model. The PHABSIM model of the IFIM uses measurements and subsequent modeling of depth, velocity, substrate, and cover to describe potential salmon spawning habitat. Chinook salmon also have a strong preference for subgravel flow in the choice of redd sites. The chinook's apparent selection of areas containing strong subsurface flow may mean that suitable chinook spawning habitat is more limited than what the model results might otherwise suggest.

The potential effects of Tacoma's water withdrawals on chinook spawning habitat area in the side channels of the middle Green River were quantified using wetted side-channel area versus discharge relationships developed based on field studies conducted in support of the AWS project (USACE 1998). Separate curves were developed for side channels located between RM 57.0 and RM 60.3 (referred to as Palmer Segment), and for side channels located between RM 33.8 and RM 45.5 (referred to as Middle Green Segment). Quantities of side-channel habitat areas in each of these two segments were calculated on a daily basis for the chinook salmon spawning period (1 September through 30

November) using daily discharge values predicted at the Palmer and Auburn gages by the CH2M Hill hydrology model. Side-channel habitat values were calculated for Green River flows **with** the AWS project and **with** Tacoma withdrawals compared to Green River flows **without** the AWS project and **without** Tacoma withdrawals. The results of these analyses indicate that Tacoma's withdrawals could reduce the wetted area of side channels in the middle Green River (both segments combined) by an average of 16 percent during the 1964-1995 period (Table 7-4). This represents a 1.5-acre reduction in the average wetted area of side channels in the middle Green River during the chinook salmon spawning period.

Chinook salmon redds constructed during periods of high flow are more susceptible to dewatering than redds constructed when Green River flows are low, which have a higher chance of remaining wetted through the incubation period. Conversely, chinook spawning during periods of low flow may result in the concentration of redds near the center of the channel; these redds are susceptible to destruction by bed movement during flood events. The analysis of spawning and incubation identified potential loss of redds due to dewatering, but did not address redd destruction due to flood events.

The potential impacts of Tacoma's FDWRC and SDWR withdrawals on chinook salmon incubation were assessed by calculating spawnable widths and dewatered channel widths on a daily basis during the chinook spawning period. The *spawnable width* for chinook salmon was calculated by: 1) determining the stage of the river for a given daily flow; 2) subtracting 1 foot from this stage because chinook salmon require a 1 foot minimum depth to spawn; and 3) calculating the wetted width of the river channel for this lower stage value. The *dewatered width* was calculated by determining the spawnable width for a given day, and then subtracting the width occurring during the lowest 2-day flow event in the 90 days (i.e., chinook salmon egg-to-fry emergence period) following that given day. Spawnable widths and dewatered widths for chinook salmon were calculated from transect and rating curve data obtained from Nealy Bridge Transect 4 of Ecology's Green River instream flow study. Ecology observed a high intensity of chinook salmon spawning in the vicinity of this transect (Caldwell and Hirschey 1989).

The average spawnable width of the main river channel during the chinook salmon spawning period was predicted to be 135.7 feet without Tacoma's water withdrawals, and 134.5 feet with the water withdrawals (Table 7-5). For days when dewatering was predicted to occur, the dewatered spawnable width of the channel averaged 3.9 feet without Tacoma's water withdrawals, and 4.1 feet with the water withdrawals (Table 7-5). Thus, the water withdrawals are predicted to result in an average increase of 0.2 feet in the dewatered width of the channel for those days when dewatering is predicted to occur. This represents a very small portion of the total width of the channel (i.e., 0.15 percent) within which chinook salmon can potentially spawn. The modeled water withdrawals were not found to increase the frequency of dewatering during the 90-day chinook salmon incubation period. Dewatering of some portion of the spawnable width of the channel during the 90-day chinook incubation period is predicted to occur for an average of 14 days both with and without the withdrawals. The results of this analysis indicate that Tacoma's water diversions will have a minor impact on the risk of dewatering of chinook salmon eggs and embryos in mainstem sections of the middle Green River.

In addition to changes in the amount of time that redds are exposed to dewatering, changes in streamflow can affect the survival of chinook eggs by reducing the rate of oxygen exchange as water flows over the eggs (Healey 1991). Chinook have the largest eggs of the Pacific salmon species and thus their eggs have a small surface-to-volume ratio compared to other salmon. The small surface-to-volume ratio of the eggs suggests that chinook salmon eggs may be especially sensitive to low oxygen concentration. Reductions in surface streamflow can affect the velocity of the water flowing through the gravel and reduce the rate of oxygen exchange at the egg surface. During the period of drought extending through late October, extreme low flow conditions could affect the survival of chinook eggs by reducing the rate of oxygen exchange. In addition, during drought conditions, the temperature of the water may increase and as the temperature of water increases, the maximum concentration of DO decreases. Tacoma's water withdrawals under the SDWR during October are constrained by instream flows specified in the MIT/TPU Agreement. The minimum flow levels in the MIT/TPU Agreement during October are 300 cfs, compared to state minimum flows of 190 to 240 cfs (Chapter 173-509 WAC).

The impacts of Tacoma's water withdrawals on chinook incubation habitat in the side channels of the middle Green River were assessed using the side-channel habitat area versus discharge curves developed by the USACE (1998). Effects of the diversions on chinook incubation habitat were quantified by comparing continuously wetted side channel habitat for the lowest 2-day flow event during the chinook incubation period between Green River flows **with** the AWS project and **with** Tacoma withdrawals compared to Green River flows **without** the AWS project and **without** Tacoma withdrawals. The results of this analysis indicated that Tacoma's diversions could reduce side-channel habitat between RM 61.0 and RM 33.8 by 1.4 acres (i.e., change of 18.2 percent) from that occurring without the diversions (Table 7-6).

The foremost mitigation measure that will increase the availability of chinook salmon spawning habitat in the Green River is the fish collection and transportation facility, which will add 24 miles of mainstem spawning habitat for chinook salmon in the upper Green River watershed to that currently available to fish in the lower and middle Green River. The gravel nourishment conservation measure (see Chapter 5) will also benefit spawning habitat conditions in the middle Green River by augmenting gravel recruitment lost from the upper watershed due to the construction of HHD. Reconnection and rehabilitation of side channels will increase spawning habitat availability by providing up to 3.4 acres of accessible habitat in the middle Green River.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have little effect on chinook spawning and incubation. These mitigation measures affect flows in the Green River from late February to June, whereas the combined spawning and incubation period for chinook salmon extends from September through February.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect chinook spawning and incubation in the middle watershed.

7.1.3.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Spawning and Incubation

Water Withdrawal. Spawning habitat in the lower Green River watershed is relatively poor compared to that in the middle watershed because of both the nature of the geologic deposits and as a consequence of extensive channelization and sedimentation. Potential chinook spawning habitat and discharge relationships obtained for the Kent Site of the Ecology instream flow study (Caldwell and Hirschey 1989) were used to quantify the potential impacts to chinook salmon spawning habitat in the lower Green River. Tacoma's water withdrawals were estimated to reduce potential chinook spawning habitat in the lower Green River by an average of 15.5 percent (Table 7-3). This estimate applies to main channel habitat only; there are few side channels of significant size in the lower Green River due to the presence of flood control dikes and levees along most of the lower river.

As stated earlier, the foremost conservation measure for increasing chinook salmon spawning habitat in the Green River is the set of fish passage facilities, which will enable salmon and steelhead to be reintroduced to the upper watershed to spawn naturally. The construction and operation of the facilities will add 24 miles of potentially high quality spawning habitat for chinook salmon in the upper Green River watershed to the habitat currently existing in the lower and middle Green River. The opportunities for improving spawning habitat in the lower Green River are very limited due to the disturbed condition of the river channel for flood control.

7.1.4 Chinook Juvenile Rearing

7.1.4.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Juvenile Rearing

Water Withdrawal. The potential effects of Tacoma's water withdrawals on juvenile chinook habitat will occur primarily in the lower and middle Green River (i.e., below Headworks). Pumping of groundwater from the North Fork well field is expected to have little effect on chinook rearing in the North Fork Green River since well field pumping primarily occurs during late fall, winter and early spring high flow periods. Researchers from the USFWS (Wunderlich and Toal 1992) observed an abundance of chinook rearing sites in the lower North Fork, but noted that chinook appeared to use the North Fork for short-term rearing and as a transportation corridor. Use of the North Fork by juvenile chinook appeared to be completed by early July when flows naturally begin to decrease.

The observed movement of chinook fry out of the North Fork channel by early July is consistent with an ocean-type early life history where chinook fry migrate to the estuary within 30 to 90 days of emergence (see Appendix A). Although USFWS researchers observed movement of chinook fry out of the North Fork channel by early July, the proportion of chinook juveniles migrating as newly emerged fry, fingerlings or yearlings may change if a naturally reproducing stock is reestablished in the upper watershed.

A number of habitat rehabilitation projects will be implemented by Tacoma and the USACE in the upper watershed as the restoration component associated with Phase I of the AWS project. Although aquatic habitat in the upper watershed is in good condition compared to the lower watershed, much of the area has been impacted by logging (Plum Creek 1996). Restoration projects to be implemented during the AWS project include placement of LWD in approximately 1.5 miles of the mainstem Green River, and approximately 2.6 miles of tributary habitat in the North Fork Green River, Charley, Gale, MacDonald, Cottonwood, and Piling creeks. Large woody debris loadings will be brought up to levels considered representative of "good" habitat conditions according to the Washington Department of Natural Resources (WDNR) watershed analysis criteria (WFPB 1997) or comparable metrics approved by the Services. In addition, approximately 2.4 acres of off-channel habitat will be created adjacent to the mainstem Green River, North Fork Green River, and large tributaries. Creation of off-channel habitat will involve excavating and placing wood in side channels, beaded ponds, or dendrites. The addition of LWD and creation of off-channel areas will provide immediate benefits to rearing and overwintering juvenile chinook.

The pool raise associated with the AWS project is a USACE action and will replace free-flowing streams with a slack-water reservoir pool. The loss of rearing habitat in the inundated stream areas may be partially offset by the larger HHD pool. U.S. Fish and Wildlife Service studies of HHD reservoir (Dilley and Wunderlich 1992, 1993; Dilley 1994) found tremendous growth rates for chinook juveniles in lower and upper reservoir areas. The physical loss of stream habitat resulting from the AWS project pool raise will be mitigated by the USACE through a series of habitat improvements implemented in the inundation zone, reservoir perimeter, and mainstem channel and tributaries. These actions, which include placement of LWD in 11.5 miles of mainstem and 2.4 miles of tributary habitat in the inundation zone and channels upstream of the reservoir, will provide additional benefits for juvenile salmonid rearing. An additional 1.1 acres of off-channel habitat (beaded ponds, side channels, and dendrites) will be created, and boulders and LWD will be used to stabilize the banks and maintain the existing channel configuration in the new seasonally inundated reaches. Although these mitigation actions are associated with water storage in the HHD reservoir by the USACE (a federal action), Tacoma will fund the construction, monitoring, and maintenance costs over the 50-year project period under this HCP.

Watershed Management. Most juvenile salmonids rear in pools or in quiet areas along channel margin. In the summer, juvenile fish require adequate flows, cover, cool temperature, and sufficient food inputs. Juvenile chinook that remain in fresh water through the winter move out of tributary streams into the mainstem, seeking out low velocity pools with LWD for cover, or holding in crevices within coarse cobble and boulder substrate. Large woody debris may be particularly important for providing cover and refuge from high flows.

Forest-management activities can have a profound effect on rearing habitat. Management-related landslides can bury LWD, and fill pools and interstitial spaces in the substrate. Increased fine sediment inputs may also increase embeddedness. Lack of adequate LWD recruitment may decrease the frequency of deep pools with abundant cover. Blocked or inappropriately designed culverts may prevent young fish from accessing small tributaries and off-channel habitat. Dam-break floods may travel long distances down moderate to high gradient tributaries, particularly in reaches that lack large coniferous trees in the riparian zone (Coho 1993). Such events may scour virtually the entire bed, injuring or killing fish residing in the channel. Low pool frequencies, lack of LWD, and the scarcity of off-channel habitat all currently limit salmonid fishes in the upper Green River basin (Plum Creek 1996; USFS 1996).

Implementation of upland forest and riparian management conservation measures will have a positive long-term effect on juvenile rearing in the Upper HCP Area. Implementation of mass-wasting prescriptions is expected to reduce the frequency of landslides that deliver sediment to low gradient channels or initiate dam-break floods. Management-related contributions of fine sediment will be reduced to less than 50 percent over background under the RSRP. These measures are expected to result in a decrease in embeddedness, which will benefit juvenile chinook overwintering in interstitial spaces.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. As in-channel LWD increases, the frequency of pools is also expected to increase. Pool quality will improve as a result of the additional cover provided by LWD. The net result should be an increase in the quality and quantity of pool habitat used for summer and winter rearing by all species. As riparian stands mature, the number of large conifers capable of acting as barrier trees during dam-break floods will increase. The increased abundance of barrier trees, combined with the decreased frequency of mass wasting, is expected to reduce the risk of dam-break floods.

7.1.4.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Juvenile Rearing

Tacoma's water withdrawals could affect chinook salmon juvenile rearing habitat by reducing flows in the Green River below the Headworks up to 213 cfs on a daily basis. Chinook salmon fry begin emerging in the Green River in January and some migrate seaward immediately after yolk absorption. Prior studies conducted in the Green River and general reviews of the life history of fall chinook salmon suggest that most chinook fry outmigrate in April to June. Surveys of side-channel habitats in the middle Green River in 1998 support the assumption that most chinook fry in the Green River system migrate downstream 30 to 90 days after emergence (Jeanes and Hilgert 1998). However, based on those sampling efforts and sampling efforts by MIT biologists in the Duwamish estuary, some chinook juveniles are thought to move seaward as fingerlings in the late summer of their first year, while others overwinter and migrate as yearling fish. The proportion of fingerling and yearling migrants may vary from year to year.

The evaluation of the potential effects of Tacoma's water withdrawals and habitat conservation measures assumed the majority of chinook fry in the Green River migrate seaward from April through early June after spending 30 to 90 days rearing in fresh water. While rearing in the Green River, chinook fry occupy backwater and low-velocity areas along the mainstem margin and side channels. During this period, flows in the mainstem Green River are generally higher than considered optimal by Ecology's instream flow study (Caldwell and Hirschey 1989).

The potential effects of Tacoma’s withdrawals were quantified using IFIM potential habitat area and flow functions developed by Ecology for juvenile chinook salmon in the middle Green River. Daily habitat values occurring under HCP conditions (Green River flows **with** the AWS project and **with** Tacoma withdrawals) were compared with those occurring under Green River flows **without** the AWS project and **without** Tacoma withdrawals (see Chapter 7.1.3.2 for a description of the methods used for this habitat analysis). The results of this analysis indicate that the effects of the FDWRC and SDWR modeled from 1964 through 1995 was a 11.4 percent increase in available juvenile chinook habitat in the middle Green River (Table 7-7). Increases in juvenile habitat area resulting from the municipal water use occur because flows in the middle Green River are usually higher than the flows considered to be optimal for juvenile chinook salmon by the Ecology instream flow study (Caldwell and Hirschey 1989).

The Ecology study did not develop potential habitat and flow functions for chinook fry, but since chinook fry are weaker swimmers than the larger juveniles modeled in the Ecology study, chinook fry should benefit even more than juveniles from the benefits of lower velocities in the mainstem channel. Tacoma's water withdrawals will reduce flows in the mainstem during the spring rearing period, but the benefit of lower velocities associated with reduced flows is countered by loss of side-channel rearing areas. In addition, the results of Ecology's instream flow model have been questioned by state and Tribal biologists who maintain the model did not adequately portray the effects of reduced flow on mainstem margins.

The potential effects of Tacoma’s water withdrawals on chinook fry rearing habitat in the side channels of the middle Green River were quantified using wetted side-channel area versus discharge relationships developed by the USACE (USACE 1998, Appendix F1, Section 7). Changes in availability of side-channel area were calculated for the period 15 February through 31 May. The results of the modeling effort identified an average

18.4 percent reduction in wetted side-channel area between RM 61.0 and RM 33.8 during the 32-year period from 1964 through 1995 (Table 7-8). This represents a 1.42-acre reduction in the average wetted area of side channels in the middle Green River during the chinook fry rearing period.

The conservation measures designed to improve juvenile chinook salmon habitat in the middle Green River include reconnecting and restoring the Signani Slough side channel, and placement of LWD in the river channel. These measures will improve juvenile chinook salmon habitat by providing up to 3.4 acres of additional off-channel habitat, which is important for overwintering, and by increasing the structural complexity of main channel habitats. Anchored LWD will be placed at two sites upstream of Tacoma's Headworks but downstream of HHD. Approximately half the wood currently intercepted by HHD will be placed or anchored downstream of the Headworks (see HCM 2-08). Adding LWD will increase the complexity and quality of habitat in the middle Green River.

In addition, benefits will also be realized for several miles of the Green River immediately below HHD by improving (decreasing) water temperatures for fish. To evaluate this benefit, a temperature model was developed for HHD and the lower and middle Green River basins (Valentine 1996; USACE 1998). Analyses compared the AWS project alternative (existing tower with a selective water withdrawal) with use of the existing tower with no modification. The objective of the USACE analyses was to determine if measures could be implemented to correct historic summer water temperature problems associated with HHD. The analysis used WESTEX, a one-dimensional, numerical, thermal budget model, which was modified to include the fish passage facility. Under the AWS project, spring, summer and fall flows will be released from HHD through selective withdrawal from the new fish passage facility with a surface intake, and from the radial gates at the bottom of the reservoir when releases exceed the capacity of the new fish passage facility. Temperature modeling results indicated that the natural inflow to HHD exceeds the state Class "AA" temperature standard of 16.0ºC (61ºF) in most years. Modeling results for the AWS project indicated that releases will exceed this temperature in only one of 33 years. The preferred fish passage alternative, therefore, has a reliability of 97 percent for maintaining HHD release temperatures below the state standard. By the time the water reaches the downstream end of the Palmer spawning reach (RM 58.0-61.0), the benefit will be diminished as stream temperatures reach equilibrium with air temperatures.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect juvenile chinook rearing in the middle watershed.

7.1.4.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chinook Juvenile Rearing

Water Withdrawal. As with the middle Green River, flow reductions resulting from the FDWRC and SDWR could improve mainstem habitat conditions for late summer or yearling juvenile chinook salmon in the lower Green River but could reduce availability of side-channel habitats. Municipal water use modeled using daily flows from 1964 through 1995 for the lower river resulted in an average 19.0 percent increase in mainstem habitat for juvenile chinook (Table 7-7). Improvements in mainstem juvenile habitat area resulting from the water supply diversions occur because flows in the lower Green River are usually higher than the flow considered to be optimal for juvenile chinook salmon by Ecology's instream flow study. Since there is little off-channel habitat in the lower Green River due to channelization and flood control, loss of off-channel habitat will be small.

Water quality problems within the lower Green River include water temperature, DO, nutrient enrichment, and a variety of pollutants (see Chapter 4.5). Dissolved oxygen problems are related to both elevated water temperatures and nutrients and are most severe in the lower Duwamish within the tidal zone (up to RM 11.0). Such conditions can stress fish and render them more susceptible to the effects of other pollutants. However, the effects of HHD, Tacoma's water withdrawal activities, and the habitat conservation measures on water temperature do not extend sufficiently far downstream to materially affect the lower Green River basin.

Because juvenile chinook salmon habitat is generally poor as a result of channelization in the lower Green River, mitigation measures for juvenile chinook salmon will focus on habitat enhancement of the upper and middle Green River, including LWD placement and side channel restoration.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect juvenile chinook rearing in the lower watershed.

Table 7-2. Comparison of the effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and the AWS project on an index of outmigrant survival conditions for chinook salmon fry in the Green River, Washington, 1964-1995. Changes in outmigration survival conditions were calculated based on a methodology using Wetherall (1971).

	Total of Daily Difference in Survival Values (percent)	
Year	Effects of Water Withdrawals	Effects of AWS Project
1964	-2.28	2.19
1965	-5.26	2.50
1966	-5.34	2.85
1967	-5.26	2.28
1968	-6.28	2.98
1969	-3.37	1.03
1970	-5.37	3.03
1971	-3.34	0.81
1972	-2.72	0.77
1973	-7.13	2.85
1974	-1.34	1.27
1975	-3.92	0.92
1976	-4.82	0.82
1977	-6.94	2.65
1978	-6.64	2.06
1979	-5.38	2.53
1980	-5.33	2.47
1981	-5.67	0.50
1982	-5.59	2.40
1983	-6.51	4.18
1984	-4.04	2.38
1985	-4.79	3.12
1986	-5.86	3.14
1987	-5.15	2.21
1988	-4.82	2.32
1989	-4.84	2.92
1990	-4.28	2.82
1991	-5.48	2.93
1992	-5.75	2.69
1993	-5.23	1.41
1994	-5.95	4.08
1995	-5.89	3.80
Mean	-5.02	2.34
Minimum	-7.13	0.50
Maximum	-1.34	4.18

Table 7-3. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on mainstem spawning habitat for chinook salmon in the lower and middle Green River, Washington; 1964-1995. Potential habitat area values calculated from weighted usable area and flow functions developed by Ecology (Caldwell and Hirschey 1989).

	Change in Mean Daily Potential Mainstem Spawning Habitat Area			
	Lower River		Middle River	
Year	Acres	Percent	Acres	Percent
1964	-0.2	-0.3	2.2	2.0
1965	-15.2	-22.7	-18.8	-16.3
1966	-10.9	-17.2	-11.2	-11.1
1967	-13.2	-22.1	-12.0	-12.7
1968	2.8	4.9	8.9	11.4
1969	-6.8	-9.6	-9.4	-7.9
1970	-10.3	-15.6	-11.3	-10.4
1971	-2.5	-4.0	-4.8	-5.1
1972	-4.5	-6.5	-7.0	-6.1
1973	-14.8	-24.1	-16.4	-16.7
1974	-10.7	-16.1	-17.1	-15.4
1975	-4.1	-7.5	-7.0	-7.9
1976	-7.0	-9.9	-10.3	-8.7
1977	-6.5	-11.0	-8.8	-9.0
1978	-3.0	-4.4	-3.6	-3.2
1979	-19.2	-30.8	-25.8	-23.9
1980	-7.2	-11.4	-10.6	-10.4
1981	-5.5	-7.8	-9.1	-7.7
1982	-5.8	-8.4	-6.2	-5.6
1983	-4.7	-8.1	-10.2	-10.8
1984	-5.2	-7.5	-2.7	-2.4
1985	-11.5	-20.5	-11.4	-12.7
1986	-11.7	-19.6	-14.0	-14.0
1987	-24.5	-47.6	-29.5	-31.5
1988	-7.7	-14.8	-10.4	-12.6
1989	-18.7	-35.3	-20.4	-23.9
1990	-5.1	-10.5	-7.9	-10.3
1991	-13.6	-28.3	-17.8	-20.8
1992	-8.1	-12.6	-7.5	-7.8
1993	-16.6	-25.3	-23.8	-21.0
1994	-15.3	-27.2	-12.4	-13.9
1995	-6.7	-13.9	-5.6	-7.5
Mean	-9.2	-15.5	-11.0	-11.1

Table 7-4. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on side channel habitat area during the chinook salmon spawning period (September through November) in the middle Green River, Washington; 1964-1995. Habitat area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Mean Daily Side Channel Habitat Area Due to Water Withdrawals	
Year	Acres	Percent
1964	-1.7	-14.4
1965	-1.4	-21.6
1966	-1.5	-16.5
1967	-1.5	-16.9
1968	-2.0	-12.8
1969	-1.4	-18.6
1970	-1.4	-16.7
1971	-1.7	-15.6
1972	-1.5	-17.4
1973	-1.5	-18.6
1974	-1.4	-19.6
1975	-1.5	-10.7
1976	-1.5	-19.3
1977	-1.5	-11.9
1978	-1.5	-15.9
1979	-1.2	-22.6
1980	-1.5	-15.5
1981	-1.3	-16.7
1982	-1.5	-17.8
1983	-1.6	-13.1
1984	-1.4	-16.5
1985	-1.4	-11.6
1986	-1.3	-12.2
1987	-1.1	-24.4
1988	-1.6	-12.2
1989	-1.4	-15.4
1990	-1.3	-7.5
1991	-1.2	-16.3
1992	-1.7	-17.5
1993	-1.3	-21.4
1994	-1.4	-15.5
1995	-1.4	-9.2
Mean	-1.5	-16.0
Minimum	-2.0	-24.4
Maximum	-1.1	-7.5

Table 7-5. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on spawnable widths and dewatered widths during the chinook salmon spawning period in the middle Green River, Washington; 1964-1995. Spawnable width and dewatered width values were calculated from transect cross-section and stage-discharge data collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Spawnable Width (ft)					Dewatered Width (ft)				
Year	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project
1964	136.3	136.3	137.8	-1.5	0.0	7.9	7.9	7.1	0.8	0.0
1965	132.2	132.2	133.5	-1.3	0.0	0.0	0.0	0.0	0.0	0.0
1966	133.9	133.9	135.2	-1.3	0.0	2.4	2.4	2.4	0.0	0.0
1967	133.9	133.9	135.2	-1.3	0.0	4.0	4.0	3.7	0.3	0.0
1968	138.2	138.2	139.5	-1.3	0.0	3.0	3.0	2.8	0.2	0.0
1969	133.2	133.2	134.5	-1.3	0.0	1.0	1.0	0.8	0.2	0.0
1970	133.6	133.6	134.9	-1.3	0.0	5.1	5.1	4.9	0.2	0.0
1971	135.4	135.4	136.6	-1.2	0.0	5.3	5.3	4.8	0.5	0.0
1972	133.8	133.8	135.1	-1.3	0.0	2.4	2.4	2.1	0.3	0.0
1973	133.1	133.1	134.4	-1.3	0.0	1.9	1.9	1.6	0.3	0.0
1974	132.6	132.6	133.8	-1.2	0.0	2.1	2.1	1.6	0.5	0.0
1975	137.2	137.2	138.3	-1.1	0.0	5.7	5.7	5.2	0.5	0.0
1976	133.1	133.1	134.4	-1.3	0.0	0.2	0.2	0.1	0.1	0.0
1977	136.6	136.6	137.9	-1.3	0.0	9.8	9.8	9.0	0.8	0.0
1978	134.6	134.6	135.8	-1.2	0.0	3.0	3.0	2.9	0.1	0.0
1979	131.3	131.3	132.5	-1.2	0.0	0.0	0.0	0.0	0.0	0.0
1980	133.0	133.0	134.2	-1.2	0.0	3.9	3.9	3.9	0.0	0.0
1981	133.4	133.4	134.6	-1.2	0.0	1.2	1.2	1.4	-0.2	0.0
1982	133.7	133.7	135.0	-1.3	0.0	1.8	1.8	1.8	0.0	0.0
1983	135.5	135.5	136.7	-1.2	0.0	3.7	3.7	3.6	0.1	0.0
1984	134.1	134.1	135.3	-1.2	0.0	0.5	0.5	0.7	-0.2	0.0
1985	135.9	135.9	137.0	-1.1	0.0	7.3	7.3	6.9	0.4	0.0
1986	135.3	135.3	136.5	-1.2	0.0	12.6	12.6	12.4	0.2	0.0
1987	130.6	130.6	131.7	-1.1	0.0	0.0	0.0	0.0	0.0	0.0
1988	136.4	136.4	137.5	-1.1	0.0	4.1	4.1	3.6	0.5	0.0
1989	133.9	133.9	135.0	-1.1	0.0	4.4	4.7	4.0	0.7	0.3
1990	140.1	140.1	141.1	-1.0	0.0	9.8	9.8	9.2	0.6	0.0
1991	132.5	132.5	133.5	-1.0	0.0	5.6	5.6	5.5	0.1	0.0
1992	134.4	134.4	135.7	-1.3	0.0	2.2	2.2	2.2	0.0	0.0
1993	131.7	131.7	132.9	-1.2	0.0	3.7	3.7	3.7	0.0	0.0
1994	134.3	134.3	135.5	-1.2	0.0	7.5	7.5	7.6	-0.1	0.0
1995	138.7	138.7	139.7	-1.0	0.0	9.2	9.2	9.2	0.0	0.0
Mean	134.5	134.5	135.7	-1.2	0.0	4.1	4.1	3.9	0.2	0.0
Minimum	130.6	130.6	131.7	-1.5	0.0	0.0	0.0	0.0	-0.2	0.0
Maximum	140.1	140.1	141.1	-1.0	0.0	12.6	12.6	12.4	0.8	0.3

Table 7-6. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on continuously wetted side channel habitat area (i.e., two-day low flow event) during chinook salmon incubation period (November through mid-February) in the middle Green River, Washington; 1964-1995. Habitat area changes calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Continuously Wetted Side Channel Area due to Water Withdrawals		Change in Continuously Wetted Side Channel Area due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-	-	-	-
1965	-1.9	-23.4	0.0	0.0
1966	-1.2	-19.2	0.0	0.0
1967	-1.9	-24.9	0.0	0.0
1968	-2.0	-23.0	0.0	0.0
1969	-1.7	-16.9	0.0	0.0
1970	-1.2	-18.4	0.0	0.0
1971	-1.1	-15.5	0.0	0.0
1972	-1.7	-13.5	0.0	0.0
1973	-1.3	-18.0	0.0	0.0
1974	-1.1	-15.2	0.0	0.0
1975	-1.2	-21.4	0.0	0.0
1976	-1.6	-11.7	0.0	0.0
1977	-1.3	-17.3	0.0	0.0
1978	-1.8	-17.9	0.0	0.0
1979	-1.1	-16.9	0.0	0.0
1980	-1.2	-22.5	0.0	0.0
1981	-1.2	-19.5	0.0	0.0
1982	-1.1	-16.2	0.0	0.0
1983	-1.3	-16.7	0.0	0.0
1984	-1.3	-18.9	0.0	0.0
1985	-1.1	-15.2	0.0	0.0
1986	-1.2	-15.5	0.0	0.0
1987	-1.4	-19.4	0.0	0.0
1988	-0.8	-18.1	0.0	0.0
1989	-1.8	-17.6	0.0	0.0
1990	-1.3	-25.8	0.1	2.3
1991	-1.2	-13.2	0.0	0.0
1992	-0.7	-17.7	0.0	0.0
1993	-1.1	-15.8	0.0	0.0
1994	-1.2	-20.4	0.0	0.0
1995	-1.9	-18.0	0.0	0.0
Mean	-1.4	-18.2	0.0	0.1

Table 7-7. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on mainstem juvenile rearing habitat for chinook salmon in the lower and middle Green River, Washington; 1964-1995. Habitat area values calculated from weighted usable area and flow functions discharge relationships collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Change in Mean Daily Mainstem Habitat Area due to Water Withdrawals				Change in Mean Daily Mainstem Habitat Area due to AWS Project			
	Lower River		Middle River		Lower River		Middle River	
Year	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
1964	2.3	13.6	1.3	5.6	0.6	3.2	0.6	2.5
1965	4.6	19.1	2.7	10.7	1.1	3.9	1.1	4.0
1966	6.7	24.6	4.0	15.2	0.8	2.4	0.9	3.1
1967	5.4	21.4	3.6	13.5	2.0	6.9	1.9	6.7
1968	5.9	23.0	3.6	14.0	-0.1	-0.4	0.3	1.0
1969	4.4	18.5	2.9	10.9	1.5	5.6	0.9	3.3
1970	5.2	21.1	3.1	11.9	1.3	4.4	1.1	3.9
1971	2.4	14.2	1.5	6.6	0.9	4.9	0.9	3.9
1972	1.5	9.5	0.7	3.1	0.2	1.0	0.1	0.5
1973	9.4	24.4	6.2	20.0	-0.3	-0.7	0.2	0.5
1974	1.0	6.8	0.7	2.9	0.4	2.3	0.5	2.4
1975	4.0	19.7	2.6	10.8	0.9	4.1	0.8	3.1
1976	5.2	22.2	3.2	12.6	2.3	8.9	1.8	6.9
1977	8.5	23.9	5.0	17.2	-0.3	-0.7	0.0	0.1
1978	8.2	24.6	5.3	18.2	0.8	2.1	0.6	1.8
1979	4.5	16.7	2.5	9.3	0.6	1.9	0.6	2.2
1980	5.3	19.6	3.3	12.4	0.3	0.9	0.5	1.5
1981	5.3	20.2	3.4	12.5	0.2	0.7	0.3	1.1
1982	4.6	20.5	2.9	11.4	1.2	4.6	1.3	5.0
1983	7.2	22.3	4.6	16.1	-0.7	-1.7	-0.1	-0.2
1984	3.0	16.6	1.9	8.0	0.8	3.8	0.7	2.8
1985	5.8	20.1	3.3	12.2	0.7	2.2	0.9	2.9
1986	5.6	19.3	3.2	11.7	-0.2	-0.7	-0.2	-0.7
1987	5.0	17.0	2.9	10.5	0.1	0.3	0.4	1.3
1988	4.4	19.1	2.3	9.3	0.4	1.6	0.3	1.2
1989	5.2	19.7	3.4	12.7	-0.4	-1.1	0.3	0.9
1990	2.6	14.6	1.3	5.5	-0.5	-2.2	-0.1	-0.5
1991	4.2	19.7	2.8	11.3	0.3	1.1	0.6	2.1
1992	6.6	15.1	4.0	11.7	-0.6	-1.2	0.3	0.7
1993	5.2	22.1	2.9	11.5	0.7	2.4	0.5	1.7
1994	6.6	20.2	3.9	13.6	-1.1	-2.8	-0.5	-1.4
1995	5.9	18.2	3.8	12.8	0.0	-0.1	0.6	1.9
Mean	5.0	19.0	3.1	11.4	0.4	1.8	0.6	2.1

Table 7-8. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on the area of side channels during the rearing period (mid-February through June) of chinook salmon fry in the middle Green River, Washington; 1964-1995. Surface area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Continuously Wetted Side Channel Area Due to Water Withdrawals		Change in Continuously Wetted Side Channel Area Due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-1.8	-17.5	-0.7	-7.0
1965	-1.2	-17.8	-0.1	-1.9
1966	-2.0	-23.1	-0.4	-4.6
1967	-1.1	-16.5	-0.5	-7.5
1968	-1.3	-16.0	0.0	0.0
1969	-1.7	-19.9	-1.0	-12.3
1970	-1.3	-17.5	0.0	0.0
1971	-1.8	-15.7	-0.1	-1.1
1972	-1.8	-14.9	-0.5	-3.9
1973	-1.5	-20.0	0.5	7.3
1974	-1.7	-13.5	-0.6	-4.6
1975	-1.9	-19.1	-1.1	-11.2
1976	-2.0	-22.8	-0.2	-2.4
1977	-1.2	-19.1	-0.1	-2.1
1978	-1.1	-17.3	0.0	0.0
1979	-1.2	-19.9	-0.9	-14.1
1980	-1.1	-16.6	-0.6	-9.0
1981	-1.1	-14.5	0.0	0.0
1982	-1.3	-17.1	-0.1	-1.6
1983	-1.1	-17.4	0.7	10.4
1984	-1.8	-17.2	-0.5	-4.6
1985	-1.2	-17.2	0.0	0.0
1986	-1.2	-20.0	0.0	0.0
1987	-1.3	-24.5	0.0	0.0
1988	-1.1	-16.3	0.0	0.0
1989	-1.2	-18.2	-0.1	-1.2
1990	-1.9	-19.1	0.0	0.0
1991	-1.8	-20.5	0.0	0.5
1992	-1.3	-25.9	0.0	0.0
1993	-1.1	-14.0	0.0	0.0
1994	-1.2	-18.7	0.5	7.4
1995	-1.2	-19.8	0.1	2.0
Mean	-1.4	-18.4	-0.2	-1.9

7.2 Effects of Water Withdrawal and Habitat Conservation Measures on Bull Trout *(Salvelinus confluentus)* and Dolly Varden *(Salvelinus malma)*

This section describes both the potential effects of Tacoma's water withdrawal and watershed management activities on bull trout and Dolly Varden, and the potential benefits resulting from habitat conservation measures. The population status and distribution of bull trout and Dolly Varden in the Green River watershed remains uncertain. Populations of both bull trout and Dolly Varden are present in western Washington (WDFW 1998). These species occur sympatrically in several northern Puget Sound streams and rivers (64 FR 58910). Unfortunately, the species composition of native char (bull trout and Dolly Varden) is largely unknown in most Puget Sound drainages, including the Green River. Because these species are difficult to distinguish and have similar life history traits and habitat requirements, they are managed as the same species (i.e., "native char") by WDFW. Tacoma is seeking coverage of both bull trout and Dolly Varden under the ITP, and is therefore including both species in this HCP. Because of the close similarities in the physical appearance, biological characteristics, and habitat requirement of bull trout and Dolly Varden, both species are addressed together in this document. As such, they are jointly referred to as either "native char" or "bull trout" in this HCP, which follows the same convention employed by the WDFW (1998) and the USFWS (64 FR 58910).

Bull trout have several possible life history forms, including: 1) *anadromous*, in which adults enter salt water to feed and return to streams and rivers to spawn and rear; 2) *adfluvial*, in which adults reside in lakes and reservoirs but migrate to streams to spawn; 3) *fluvial*, in which adults reside in mainstem sections of larger streams and rivers but move into smaller tributaries to spawn; and 4) *resident*, in which adults remain in smaller headwater streams throughout their entire life cycle. If bull trout are present in the upper Green River watershed, they will likely be fluvial and resident forms. No bull trout have been captured or observed in Howard Hanson Reservoir (see Appendix A), and it is unlikely that adfluvial forms will reside in this reservoir due to the extensive drawdown that is required for flood protection. Any bull trout present in the lower watershed will likely be anadromous forms.

The USFS has conducted surveys in the upper Green River watershed in recent years, and has not found any bull trout in the tributaries and mainstem sections surveyed (USFS 1996). The Plum Creek Timber Company conducted presence/absence surveys for bull trout in the mainstem and tributaries of upper Green River; no bull trout were observed during these surveys (Watson and Hillman 1997). Potential bull trout distribution may be limited by warm temperatures in the upper Green River, since this species requires coldwater temperatures and is typically found at higher elevations in Cascade streams (Goetz 1994). However, bull trout are present in the nearby Cedar River watershed at elevations and water temperatures similar to those in the upper Green River watershed (Connor et al. 1998).

There is evidence that bull trout have historically occurred in the lower Green River/Duwamish River drainage (Grette and Salo 1986). Historical records report thousands of char (possibly bull trout or Dolly Varden) in the Green/White River system in the 1800s (see Appendix A). The White River was disconnected from the Green River in 1906 and diverted to the Puyallup River. The White River system continues to support a large population of native char.

There is no evidence for a reproducing bull trout population in the Green River below HHD at the present, despite the fact that a number of fish surveys have been conducted within the lower and middle reaches of the river in recent years (see Appendix A). An observation of a single bull trout was reported in Soos Creek in 1956. More recently, a single bull trout was observed near the mouth of the Duwamish River in the spring of 1994. These single sightings are likely anadromous forms of bull trout that have temporarily moved into the lower portions of the Green River. Small numbers of bull trout could be present in isolated populations in cold, spring-fed tributaries of the middle watershed (e.g., Soos Creek, Newaukum Creek, Burns Creek) but there is no evidence that such populations exist. The presence of a reproducing, self-sustaining population of bull trout is unlikely in the Green River below HHD due to warm water temperatures and extensive habitat degradation (i.e., urbanization, roads, logging). Water temperatures in the middle and lower Green River frequently exceed 18ºC (64ºF) during the summer, and often exceed 20ºC (68ºF) (Caldwell 1994). Water temperatures in the Green River at Auburn were found to exceed 18ºC (64ºF) during 46 percent of total hours in August 1992. Water temperatures above 15ºC (59ºF) are believed to limit the distribution of bull trout (Goetz 1989; Rieman and McIntyre 1993; McPhail and Baxter 1996).

The Green River is part of the Coastal-Puget Sound bull trout distinct population segment (DPS), and encompasses all Pacific coast drainages. This population segment is composed of 34 subpopulations of "native char" (63 FR 31693). Bull trout populations in the Coastal-Puget Sound, Columbia River, and Klamath River drainages have declined in the past century due to habitat degradation (including elevated water temperatures), dams, population fragmentation, overfishing, competition with non-native species, and interbreeding with non-native char (i.e., brook trout). All bull trout populations in the conterminous United States, including the Coastal-Puget Sound DPS, were listed as a threatened species by the USFWS on 1 November 1999 (64 FR 58910). Dolly Varden were not listed as a threatened species in the DPS when the USFWS listed bull trout in November 1999 (64 FR 58910). However, the USFWS indicated in January 2001 that Dolly Varden are being considered for listing as threatened due to their similarity of appearance to bull trout (66 FR 1628).

7.2.1 Bull Trout Upstream Migration

Potential Effects of Covered Activities and Conservation Measures on Bull Trout Upstream Migration

Water Withdrawal. If bull trout are present in the Green River system, the upstream migration of adult bull trout will not likely be prevented by Tacoma's water withdrawals. Because water depths in the lower river are sufficient for upstream passage of chinook salmon when flows at the Auburn gage exceed 200 cfs, Tacoma's water withdrawals are not expected to impede the upstream passage of bull trout in the lower Green River (see Chapter 7.2.1.1). Anadromous and fluvial forms of bull trout migrate upstream to spawn from August through November, which coincides with the chinook salmon migration period.

The Headworks diversion structure prevents upstream fish migration of bull trout, if present in the system (i.e., anadromous or fluvial forms) above RM 61.0. Additionally, HHD at RM 64.5 has been a barrier to the upstream migration of bull trout (if present) into the upper Green River watershed since its construction in the early 1960s. However, these structures will not have prevented the occurrence of bull trout in the upper Green River watershed, since bull trout will have been able to migrate and become established in the upper watershed as resident or fluvial forms on a historical basis. (Note: Bull trout could have colonized the upper watershed following the recession of the glaciers during the late Pleistocene.) Like steelhead (rainbow) and cutthroat trout, bull trout can have both anadromous and resident life history strategies. Like these other species, these life history strategies are not "fixed," and the presence of an anadromous run can result in the subsequent establishment of resident populations in streams and rivers.

Under HCM 1-01, Tacoma will guarantee minimum flows of at least 250 cfs at the Auburn gage from 15 July to the end of low flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs. Tacoma will not use the SDWR if instream flows at Palmer fall below 200 cfs during the remainder of the year. These minimum instream flow requirements provide adequate water depths for the upstream passage of bull trout. Some delay to anadromous forms may occur during sustained low flow periods early in the migration period due to poor water quality conditions and lack of migration cues in the lower river.

The upstream trap-and-haul facility to be installed at the Headworks will provide upstream passage for any anadromous bull trout that migrate up the Green River to the Headworks diversion. Any adult bull trout caught in the trap facility will be transported and released into the upper watershed. Release of bull trout above HHD could establish an anadromous run of bull trout in the Green River. However, this is unlikely because of the very low numbers of adult bull trout that have been observed in the lower Green River in recent years. Bull trout, which are a potential predator of juvenile salmon and steelhead, could be captured as part of predator abatement programs (i.e., selective hook-and-line removal of predatory fish) implemented in the section of the Green River between HHD and Headworks. All bull trout captured will be immediately released since the numbers captured, if any, will be very low and will not be expected to have any impact on juvenile salmon and steelhead populations.

Watershed Management. Bull trout require large, deep pools for holding habitat as they move upstream. Such pools are common in some reaches of the mainstem and large tributaries above HHD (Fox 1996). Temperatures in the upper Green River basin are generally suitable for bull trout although maximum temperatures in some tributaries may exceed 15ºC (59ºF). Locally high temperatures in the upper basin have been attributed to low summer flows and harvest of riparian vegetation (Plum Creek 1996; USFS 1996). Subsurface flows have been noted in lower Sawmill Creek and the North Fork Green River (USFS 1996). Subsurface flows are believed to have been exacerbated by increased sediment deposition from management-related mass wasting.

Tacoma's watershed management activities and conservation measures will not alter bull trout upstream migration in the lower or middle Green River. However, implementation of upland forest and riparian conservation measures will have a positive effect on upstream migration in the Upper HCP Area.

Mass-wasting prescriptions developed through watershed analysis are expected to reduce management-related contributions of coarse sediment. Over the long term, this could reduce the extent of aggraded reaches that consistently experience subsurface flows during dry summers. Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will increase shade, moderating elevated summer temperatures caused by lack of adequate shade. Increasing the proportion of riparian stands greater than 50 years of age from 61 to 100 percent will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming deep pools in larger channels. Tacoma's ownership encompasses most of the mainstem and large tributary habitat that could provide holding habitat for adult bull trout, thus temperature reductions and increased LWD inputs resulting from development of mature coniferous riparian forests on Tacoma's lands are expected to be especially beneficial.

Stream-crossing culverts on Tacoma's land will be inventoried, and repaired or replaced within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure could increase the amount of habitat that is accessible to upstream migrating bull trout, although the magnitude of that increase cannot be estimated until the inventory is complete.

7.2.2 Bull Trout Downstream Migration

Potential Effects of Covered Activities and Conservation Measures on Bull Trout Downstream Migration

Water Withdrawal. Bull trout juveniles generally remain in their natal streams and rivers up to 3 years before migrating to large rivers (fluvial forms), lakes (adfluvial forms), or the ocean (anadromous forms). The outmigration timing of bull trout juveniles is not well known, though anadromous forms probably outmigrate to the ocean in the spring (Wydoski and Whitney 1979). If bull trout are reproducing in the Green River, Tacoma's water withdrawals could potentially impact the survival of outmigrating juvenile bull trout in ways similar to that of steelhead juveniles (see Chapter 7.7.2.1), which also outmigrate in the spring after 2 to 3 years of freshwater residency. Using a flow survival relationship based on Wetherall's (1971) analysis of salmonid outmigrant survival, Tacoma's withdrawals were calculated to potentially reduce the condition of steelhead smolt outmigrant survival by 4.9 percent.

If bull trout juveniles are present in the Green River, and if Tacoma withdrawals have an effect on bull trout juvenile outmigration similar to that of steelhead, then flow augmentation in May and June resulting from implementation of the AWS project will likely improve the survival of outmigrating bull trout juveniles (anadromous forms) in the Green River. The AWS project flow measures were considered to improve by 3.3 percent the condition of downstream survival of steelhead smolts, which like bull trout outmigrate in the spring after 2 to 3 years of freshwater residency (see Chapter 7.7.2.2).

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect bull trout downstream migration in the Green River basin.

7.2.3 Bull Trout Spawning and Incubation

Potential Effects of Covered Activities and Conservation Measures on Bull Trout Spawning and Incubation

Water Withdrawal. Bull trout have a spawning periodicity similar to chinook salmon (i.e., fall spawners). Tacoma's water withdrawals were assumed to impact bull trout spawning in ways similar to fall chinook salmon spawning in the mainstem sections of the river. Tacoma's water withdrawals were calculated to potentially reduce chinook spawning in the mainstem middle Green River by 11.1 percent. However, it is unlikely that spawning and incubation of bull trout in the lower and middle Green River will be productive, since temperatures in most sections of the river are too warm in the summer for the survival of juvenile bull trout. Tacoma's water withdrawals will not be expected to have any direct impacts on bull trout spawning and incubation in the upper Green River except for the North Fork, where groundwater pumping could have minor impacts on spawning and incubation of bull trout (see Chapter 7.1.3.1) if present in the system.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have little effect on bull trout spawning and incubation in the lower and middle Green River. These mitigation measures affect flows in the Green River from late February to June, while the spawning period for bull trout extends from September through November.

Watershed Management. Tacoma's watershed management activities are assumed to impact bull trout (if present) spawning in ways similar to fall chinook. Implementation of watershed management conservation measures will have a positive effect on bull trout spawning and incubation in the Upper HCP Area. Implementation of mass-wasting prescriptions and the RSRP developed through watershed analysis is expected to reduce management-related contributions of fine sediment to less than 50 percent over background. This may result in a decrease in the proportion of fine sediment contained by spawning gravels, and could result in increased survival to emergence.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming stable flow obstructions in larger channels. The net result should be an increase in in-channel LWD and an associated increase in the availability of spawning gravel. Bull trout will benefit from increased spawning gravel availability in moderate to high gradient tributary streams.

7.2.4 Bull Trout Juvenile and Adult Habitat

Potential Effects of Covered Activities and Conservation Measures on Bull Trout Juvenile Rearing

Water Withdrawal. As stated previously, water temperatures are probably too warm, and habitat conditions too degraded, to support juvenile bull trout in the lower and middle Green River. Tacoma's water withdrawals are not expected to have any impact on juvenile and adult bull trout in the lower and middle sections of the Green River, since this species is not likely to be present in these sections.

Tacoma's water withdrawals will not have any impact on juvenile bull trout habitat in the upper Green River, except in the North Fork where occasional groundwater pumping may temporarily reduce flows.

Bull trout are able to colonize higher gradient streams than most salmonids (Rieman and McIntyre 1993) and, if present, will likely be able to reside in all tributaries in the upper Green River that do not have passage barriers. Based upon this assumption, bull trout could potentially utilize up to 106 miles of mainstem and tributary habitat in the upper Green River (i.e., above HHD).

A number of habitat rehabilitation projects will be implemented by Tacoma and the USACE in the upper watershed during Phase I of the AWS project; these projects will benefit bull trout potentially inhabiting the upper Green River watershed. As described for chinook salmon (see Chapter 7.1.4.1), these rehabilitation projects will provide increased rearing and overwintering habitat for anadromous and resident salmonids, including juvenile and adult bull trout if present. The rehabilitation projects include the creation of 2.4 acres of off-channel habitat, which could provide important overwintering habitat for bull trout in the upper watershed. As described earlier, LWD will be introduced into these off-channel areas, and to a total of 4.1 miles of mainstem and tributary habitat. Projects associated with mitigation for the AWS project will add 1.1 acres of off-channel habitat, increase the LWD loading in over 11 miles of mainstem and tributary habitat, and stabilize the banks of seasonally inundated channels.

The reintroduction of chinook salmon, coho salmon, and steelhead into the upper Green River will have both positive and negative effects on bull trout if they inhabit the watershed. Bull trout adults and larger juveniles are piscivorous (Goetz 1989; McPhail and Baxter 1996), and have been known to feed upon chinook salmon fry (Brown 1995). Bull trout will likely feed on coho salmon and steelhead juveniles as well. The addition of a high quality food supply through the reintroduction of salmon and steelhead to the upper watershed will be beneficial to bull trout. Adult chinook salmon reintroduced into the upper watershed could conceivably compete with bull trout for spawning areas, or disturb bull trout redds, since these two species spawn during the early fall. However, adult chinook salmon are predicted to use the lower mainstem sections of the river and tributaries (i.e., total of 24 miles of spawning), whereas bull trout could potentially spawn in any accessible tributary (i.e., up to 106 miles of habitat). Finally, juvenile coho salmon and steelhead occurring in the upper watershed as a result of the trap-and-haul program may potentially compete with bull trout for habitat space. Bull trout, if present, are likely to be found in the upper reaches of tributaries since they prefer coldwater temperatures. Consequently, the impacts of competition from juvenile coho salmon and steelhead on bull trout are likely to be minor because these coho and steelhead juveniles inhabit mainly lower and middle gradient reaches of the Green River above HHD.

Watershed Management. Mass-wasting prescriptions will reduce the frequency of landslides and debris flows that may degrade habitat and injure or kill juvenile bull trout overwintering in moderate to high gradient tributary streams. As riparian stands mature, the number of large conifers capable of acting as barrier trees during dam-break floods will increase. The increased abundance of barrier trees, combined with the decreased frequency of mass wasting, is expected to reduce the risk of dam-break floods. Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. As in-channel LWD increases, the frequency of pools is also expected to increase. Cover will also improve as a result of the additional LWD. The net result should be an increase in the quality and quantity of pool habitat used for summer and winter rearing by bull trout. Stream crossing culverts on Tacoma's lands will be inventoried and repaired or replaced within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure will increase the amount of habitat that is accessible to bull trout.

7.3 Effects of Water Withdrawal and Habitat Conservation Measures on Coho Salmon *(Oncorhynchus kisutch)*

This section describes the potential effects of Tacoma's water withdrawal and watershed management activities on coho salmon and the potential benefits resulting from habitat conservation measures. Coho salmon are considered to be the most abundant anadromous fish species in the Green/Duwamish basin (King County Planning Division 1978). The run-size of coho salmon in the Green River and Soos Creek has averaged 14,950 fish from 1982 to 1991, with an estimated escapement averaging 2,970 for this same period. Population data for Green River and Soos Creek coho stocks (WDFW et al.

1994) are indicative of stable escapement and production levels. Because of the abundance and stability of coho populations in the Green River and Soos Creek, this stock is considered to be healthy (WDFW et al. 1994). However, the Newaukum Creek coho stock has been classified as depressed because of short-term declines in escapement (WDFW et al. 1994). The coho salmon Evolutionarily Significant Unit (ESU) for the Puget Sound/Strait of Georgia continues to be impacted by loss of inland habitat, high harvest rates, and a recent decline in average spawner size. This species is not listed as threatened or endangered, although future listing under the ESA is likely if populations decline.

Separate analyses are presented for each of the major life history stages of coho salmon, including upstream migration, downstream migration, spawning and incubation, and juvenile rearing. The methods used in these analyses are the same as those applied to chinook salmon in Chapter 7.1, except for differences in the periodicity of coho salmon life stages (see Appendix A), and in the habitat and flow requirements of these life stages. The analysis is further segregated by different segments of the Green River, corresponding to upper watershed, middle watershed, and lower watershed (see Chapter 2).

7.3.1 Coho Upstream Migration

7.3.1.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Upstream Migration

Water Withdrawal. The Headworks diversion structure prevents the upstream migration of adult coho salmon above RM 61.0. Additionally, since its construction in the early 1960s, HHD at RM 64.5 has been a barrier to the upstream migration of coho salmon into the upper Green River watershed. Coho salmon are mainstem and tributary spawners. There are 49 miles of mainstem and tributary habitat in the upper Green River watershed (above HHD) that are suitable for coho spawning (i.e., total mileage for all stream and mainstem sections of 3 percent or less gradient).

Adult coho salmon will be reintroduced into the upper Green River watershed above HHD following the installation of a permanent fish collection and transport facility at the Headworks. Coho salmon will be reintroduced into the upper Green River watershed using the same methods applied to chinook salmon. Since the upper watershed contains more than 40 percent of the historic anadromous stream reaches, restoring anadromous fish access to the upper watershed significantly increases the availability of suitable habitat for coho salmon in the Green River basin. The potential benefits to coho salmon production are even greater than those for chinook salmon because coho salmon can potentially spawn in a wider variety of mainstem and tributary habitats (i.e., higher gradient reaches) than can chinook salmon. Resource agencies and Tribes also believe coho salmon are more likely than chinook to establish naturally reproducing, self-sustaining runs above HHD.

There are approximately 220 square miles of watershed area and 66 miles of stream and river habitat in the upper watershed that were historically used by salmon and steelhead. Approximately 49 miles of this habitat have been estimated to be accessible and suitable for coho salmon spawning (USACE 1998, Appendix F1). Comparing the upper watershed adult coho escapement goal, estimated by the USACE (1998, Appendix F1), to the Tribal and state escapement goals for the middle and lower Green River and Newaukum Creek (WDFW et al. 1994) suggests that the upper watershed represents about 43 percent of coho habitat potentially available in the Green/Duwamish basin.

Watershed Management. Watershed management activities will impact coho upstream migration in a manner similar to that described for chinook. Implementation of upland forest and riparian conservation measures will have a positive effect on coho upstream migration in the Upper HCP Area. Mass-wasting prescriptions developed through watershed analysis are expected to reduce management-related contributions of coarse sediment. Over the long term, this could reduce the extent of aggraded reaches that consistently experience subsurface flows during dry summers. Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will increase shade, moderating elevated summer temperatures caused by lack of adequate shade. These measures will be somewhat less beneficial for coho than chinook because they move upstream later in the fall when flows are generally higher and temperatures are lower. Increasing the proportion of riparian stands greater than 50 years of age from 61 to 100 percent will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming pools and providing cover in larger channels.

Stream-crossing culverts on Tacoma’s land will be inventoried and, if necessary, repaired or replaced within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure could increase the amount of habitat that is accessible to upstream migrating coho, although the magnitude of that increase cannot be estimated until the inventory is complete.

7.3.1.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Upstream Migration

Water Withdrawal. Analysis of transect and stage-discharge data collected by Ecology (Caldwell and Hirschey 1989) at shallow riffles in the middle Green River indicates that passage for adult chinook salmon should not be impeded by flows greater than 225 cfs (assuming a minimum passage depth of 1.0 feet). The upstream passage of coho salmon, which have a shallower passage depth requirement (0.6 feet), should also not be impeded.

Under HCM 1-01, Tacoma will guarantee minimum flows greater than 225 cfs at the Auburn gage from 15 July to the end of low flow augmentation from HHD during all years. The SDWR is conditioned on maintaining a minimum flow of 400 cfs at Auburn gage throughout the rest of the coho upstream migration period. Because these minimum flows satisfy the upstream passage requirements of chinook salmon, they will also satisfy the upstream passage requirement of coho salmon.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho upstream migration in the middle watershed.

7.3.1.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Upstream Migration

Water Withdrawal. Tacoma's water withdrawals will influence coho salmon less than chinook salmon, since coho salmon can migrate upstream through shallower areas than can fall chinook salmon (the minimum depth of passage for coho is 0.6 feet [Laufle et al. 1986]). Moreover, coho initiate upstream migration and spawning about 1 month later than chinook salmon in the Green River, with coho spawning continuing through mid-January (Grette and Salo 1986).

Because water depths in the lower river are sufficient for upstream passage of chinook salmon when flows at the Auburn gage exceed 200 cfs, Tacoma's water withdrawals are not expected to impede the upstream passage of coho salmon in the lower Green River. Due to their later migration and spawning period, warmwater temperatures and low DO concentrations in the lower Green River have less of an influence on the upstream migration of coho salmon when compared to chinook salmon. Adult coho salmon typically move into rivers and streams following fall freshets or increased seasonal flows. These flow events have a much higher probability of occurring during the migration period (September through mid-January) of coho salmon when compared to that of chinook salmon (July through November). For this reason, Tacoma's water withdrawals will have less of an effect on the upstream migration of coho salmon than on chinook salmon.

Under HCM 1-01, Tacoma will guarantee minimum flows of at least 250 cfs at the Auburn gage from 15 July to the end of low flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs. Tacoma will not use the SDWR if instream flows at Auburn fall below 400 cfs during the remainder of the year. These minimum instream flow requirements provide adequate water depths for the upstream passage of coho salmon through the remainder of the year. Some delay may occur during sustained low flow periods early in the migration period due to poor water quality conditions and lack of migration cues, though these conditions will have less of an impact on coho salmon than on chinook salmon.

The AWS project includes a provision for the optional annual storage of up to 5,000 ac-ft of water to be used for fisheries purposes. Under dry year or drought conditions, any storage targeted to augment flows or provide a freshet in the late summer and early fall for adult chinook salmon migration and holding will also benefit coho salmon (though coho are less likely to be impacted by these conditions). The instream flows contained in the MIT/TPU Agreement should be sufficient for upstream coho salmon passage, but under the adaptive management strategy, the opportunity exists to adjust releases to meet unanticipated fisheries needs.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho upstream migration in the lower watershed.

7.3.2 Coho Downstream Migration

7.3.2.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Downstream Migration

Water Withdrawal. Tacoma's water withdrawals primarily affect the downstream passage of juvenile coho salmon in the Green River below the Headworks diversion facility (including the diversion dam and pool). Consequently, Tacoma's water supply diversions will have little direct impact on downstream migration in the upper watershed. Effects of water storage are addressed as a USACE activity under Section 7 of the ESA.

Since active pumping of the North Fork well field may reduce surface flow in the North Fork of the Green River above HHD (see Figure 2-2), groundwater withdrawals could affect the downstream migration of juvenile coho salmon. The North Fork well field is used during periods of high turbidity in the mainstem Green River that typically occur during periods of high surface flow in the North Fork. Use of the well field during the spring outmigration season is assumed to have minimal effects on outmigrating coho juveniles.

While the USACE is responsible for the effects of water storage and release at HHD, Tacoma will be the local sponsor of the downstream fish passage facility to be installed at HHD. The operation of this facility is important to maintain high levels of coho salmon smolt survival through Howard Hanson Reservoir and Dam following reintroduction of this species into the upper Green River. The estimated coho salmon survival rate for combined reservoir and dam passage resulting under operation of the HHD fish passage facility is 87.5 percent, compared to a survival rate of 20 percent under pre-AWS project conditions (USACE 1998, Appendix F1, Section 8E).

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho downstream migration in the upper watershed.

7.3.2.2 Middle and Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Downstream Migration

Water Withdrawal. Tacoma's water withdrawals will have two impacts on the survival of outmigrating juvenile coho salmon in the middle and lower watershed. First, some of the outmigrating juveniles passing through the Headworks diversion pool could be impinged on the existing screens or entrained into the water intake at the diversion. Fish impinged on the screens or entrained into the water supply system are assumed to ultimately perish. Existing screens at the Headworks do not meet NMFS design criteria, and data on existing outmigrant entrainment and survival are not available.

Second, the survival of outmigrating coho salmon in the middle and lower Green River below the Headworks is assumed to be related to the timing and volume of flow. Like juvenile chinook salmon, Tacoma's diversions are expected to result in decreased outmigrant survival values of juvenile coho salmon by reducing flows in the Green River below Headworks.

In order to quantify the impact of Tacoma's diversions on the survival of outmigrating coho salmon, daily estimates of survival conditions were calculated for Green River flows under the HCP (Green River flows **with** the AWS project and **with** Tacoma withdrawals) and compared to Green River flows **without** the AWS project and **without** Tacoma withdrawals. Coho outmigrant survival condition was estimated for each of these flow conditions using the same method used for chinook salmon (Wetherall 1971, see Chapter 7.1.2.2); daily survival rates were estimated during the coho salmon outmigration period (1 April through 30 June).

The results of this analysis indicate that the flow reductions below the Headworks caused by diversions under the FDWRC and SDWR result in an estimated average reduction in coho smolt survival of 4.9 percent (Table 7-9). Estimated reductions in yearly outmigrant survival values ranged from 1.2 to 7.2 percent for the 1964-1995 period.

Tacoma will install a downstream fish bypass facility at the Headworks at RM 61.0 that includes a 220-by-24-foot conventional screen. This conservation measure will improve the survival of outmigrating coho smolts passing Tacoma's Headworks by preventing fish from being impinged or entrained into the water supply intake. Upgrading the existing Headworks screens to meet NMFS design criteria is assumed to improve coho smolt survival.

Flow augmentation in May and June resulting from implementation of the AWS project will also improve the survival of outmigrating coho salmon in the Green River. Because the period of spring flow augmentation under the AWS project occurs during the peak coho salmon outmigration period (i.e., mid-April through mid-June), this measure is expected to improve outmigrant survival. The benefits to coho salmon migrants provided by AWS project spring flow augmentation measures were estimated using the same method (Wetherall 1971) used for juvenile chinook salmon. The average improvement in juvenile coho outmigrant survival resulting from the AWS project will be 3.3 percent (Table 7-9). Estimated increases in yearly survival values resulting from the implementation of this measure range from 0.5 percent to 5.7 percent for the 1964-1995 period.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho downstream migration in the lower and middle watershed.

7.3.3 Coho Spawning and Incubation

7.3.3.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Spawning and Incubation

Water Withdrawal. Like chinook salmon, spawning habitat and incubation of coho salmon in the upper Green River basin above HHD will not be affected by Tacoma's water withdrawals at the Headworks. Pumping of groundwater from the North Fork well field, however, could affect coho salmon spawning and incubation in the North Fork of the Green River. Adult coho transported upstream past the Headworks and HHD may not find suitable spawning habitat in the North Fork until fall rains increase surface flow in the North Fork. Since pumping of the North Fork well field typically occurs with the onset of fall rains, effects on coho spawning and incubation should be minor.

As previously mentioned, the upper Green River watershed will be opened up to spawning and rearing of coho salmon through the use of an upstream trap-and-haul facility to be installed at the Headworks. Coho salmon are expected to spawn mainly in the lower to moderate gradients (3 percent or less) of mainstem and tributary reaches within the upper watershed (USACE 1998, Appendix F1, Section 2). The USACE estimated there are 49 miles of mainstem and tributary coho spawning habitat in the upper Green River watershed that are accessible to upstream migrants and that have channel gradients of 3 percent and less (USACE 1998, Appendix F1, Section 2). The USACE estimated an escapement value of 6,500 adult coho spawners for these 49 miles of upper Green River habitat, and calculated that this added habitat area could potentially produce 161,000 coho smolts. Habitat rehabilitation projects implemented under this HCP, including placement of LWD and reconnection of side channels, are expected to increase the amount of available coho spawning habitat.

Watershed Management. Potential impacts to coho spawning habitat resulting from Tacoma's watershed management activities are expected to be similar to those described for chinook. Implementation of watershed management conservation measures will have a positive effect on salmonid spawning and incubation in the Upper HCP Area. Mass-wasting prescriptions and the RSRP developed through watershed analysis are expected to reduce management-related contributions of fine sediment to less than 50 percent over background. This may result in a decrease in the proportion of fine sediment contained by spawning gravels, and could result in increased survival to emergence. Species such as coho that spawn in low gradient reaches prone to deposition of fine sediment will benefit most from improved gravel quality.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. The net result should be an increase in in-channel LWD and an associated increase in the availability of spawning gravel. Coho in particular will benefit from increased spawning gravel availability in small, moderate gradient tributary streams.

7.3.3.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals will affect the availability of coho spawning habitat in both the mainstem river and side-channel areas of the middle Green River in ways similar to the effects on chinook salmon. The side channels in this section of the river provide important habitat for salmon spawning, incubation, and juvenile rearing (Fuerstenberg et al. 1996; USACE 1998, Appendix F1, Section 7). Reduced flows may also increase the susceptibility of coho salmon redds to dewatering by exposing mainstem and side-channel areas during the incubation period.

The potential effects of Tacoma's withdrawals on mainstem coho salmon spawning habitat in the middle Green River were quantified using the same method applied to chinook salmon (i.e., based upon Ecology's Green River IFIM study; see Chapter 2.1.3.2). The daily potential habitat values occurring during the spawning period of coho salmon under Green River flows **with** Tacoma withdrawals and Green River flows **without** Tacoma withdrawals were calculated using potential habitat and flow functions developed for the Green River for coho salmon by Ecology (Caldwell and Hirschey 1989). Based on this analysis, potential coho salmon spawning habitat in the main channel of the middle Green River is increased by an average of 9.4 percent by exercise of the FDWRC and SDWR over the 32-year period of daily flows (Table 7-10). The only annual decrease in spawning habitat caused by the diversions (-3.7 percent) was predicted during 1987, a drought year. Results of Ecology's IFIM study predicted that flows between 240 and 375 cfs provide optimal spawning habitat for coho salmon in the middle Green River. Because flows in the Green River exceed this optimal range of flows throughout much of the mid-September through mid-January spawning period of coho salmon, Tacoma's withdrawals were predicted to result in an overall improvement in spawning conditions in the middle Green River.

The potential effects of Tacoma's water withdrawals on coho spawning habitat area in the side channels of the middle Green River were quantified using wetted side-channel area and discharge relationships. The same method used for estimating chinook salmon spawning habitat area in the side channels was applied to coho salmon. Values of side channel habitat were calculated on a daily basis for the coho salmon spawning period (15 September through 15 January). The results of these analyses indicate that Tacoma's withdrawals will reduce the wetted area of side channels in the middle Green River (both segments combined) by an average of 12.3 percent during the 1964-1995 period (Table 7-11). This represents a 1.6-acre reduction in the average wetted area of side channels in the middle Green River during the coho spawning period.

The potential impacts of Tacoma's FDWRC and SDWR withdrawals on coho salmon incubation in the mainstem channel were assessed by calculating the width of the channel subject to redd dewatering (i.e., dewatered spawnable width). The same method and the same Neal Bridge transect (No. 4) from Ecology's instream flow study (Caldwell and Hirschey 1989) used to assess chinook spawning and incubation was used for coho. Spawnable and dewatered channel widths were calculated on a daily basis for the mid-September through mid-January coho spawning period assuming a 90-day incubation period.

Coho redds constructed during periods of high flow are susceptible to dewatering while redds constructed when Green River flows are low have a higher chance of remaining wetted throughout the incubation period. However, coho spawning during periods of low flow may construct redds near the center of the channel that are more susceptible to destruction by bed movement during flood events. The analysis of spawning and incubation identified potential loss of redds due to dewatering, but did not address redd destruction due to flood events.

Using Ecology's instream flow data, the average spawnable width of the mainstem river channel during the coho spawning period was predicted to be 137.6 feet without Tacoma withdrawals, and 136.4 with Tacoma water withdrawals (Table 7-12). In the absence of Tacoma's water withdrawals, an average of 5.3 feet of the spawnable channel width was subject to potential dewatering (Table 7-12). Tacoma's water withdrawals were predicted to potentially dewater 5.6 feet of the spawnable channel width (Table 7-12). These values only consider the number of days within the 90-day incubation period when potential redd dewatering was predicted to occur. On the majority of days when coho spawning could occur, the redds will be protected throughout the 90-day incubation period.

The potential impacts of Tacoma's water withdrawals on coho incubation habitat in the side channels of the middle Green River were assessed using the side channel-habitat area and discharge curves developed by the USACE (1998). Effects of the diversions on coho incubation habitat were quantified using the same method used for chinook salmon (see Chapter 7.1.3.2). The results of this analysis indicated that Tacoma's diversions will reduce side-channel habitat between RM 61.0 and RM 33.8 by an average of 1.5 acres (i.e., loss of 17.3 percent) from that occurring without the diversions (Table 7-13).

The fish collection and transportation facility at Tacoma's Headworks will substantially increase the availability of coho salmon spawning habitat in the Green River basin, and will open up an additional 49 miles of mainstem and tributary habitat suitable for coho salmon in the upper Green River. The gravel-nourishment conservation measure (see Chapter 5) will also benefit coho spawning habitat conditions in the middle Green River by augmenting gravel recruitment lost from the upper watershed due to HHD. Reconnection and rehabilitation of side channels will improve spawning habitat conditions by providing up to 3.4 acres of side-channel habitat in the middle Green River.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have little effect on coho spawning and incubation. These mitigation measures will affect flows in the Green River from late February to June, and will subsequently have no impact on coho salmon spawning that extends from mid-September through mid-January. The AWS project is predicted to have little effect on coho salmon incubation; the average increase in dewatered width predicted to occur due to the AWS project is 0.30 feet (Table 7-12).

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho spawning and incubation in the middle watershed.

7.3.3.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Spawning and Incubation

Water Withdrawal. Due to extensive channelization, spawning habitat for coho salmon is relatively poor in the lower Green River watershed compared to that in the middle watershed. Potential coho spawning habitat and discharge relationships obtained for the Kent Site of the Ecology instream flow study (Caldwell and Hirschey 1989) were used to quantify the impacts to coho salmon spawning habitat in the lower Green River. Tacoma's water withdrawals were found to potentially increase coho spawning habitat in the lower Green River by an average of 12.2 percent (Table 7-10). This estimate applies to main channel habitat only; there are few side channels of significant size in the lower Green River due to the presence of flood control dikes and levees along most of the lower river.

The most important conservation measures for increasing coho salmon spawning habitat in the Green River are the fish passage facilities, which will enable coho salmon to be reintroduced to the upper watershed to spawn naturally. The construction and operation of the facilities will add 49 miles of high quality spawning habitat for coho salmon in the upper Green River watershed to the habitat currently existing in the lower and middle Green River. The opportunities for improving spawning habitat in the lower Green River are very limited due to the disturbed condition of the river channel, which has been modified for flood control purposes.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have little effect on coho spawning and incubation in the lower Green River for the same reasons described previously for the middle Green River in Chapter 7.3.3.2. Impacts of the AWS project on coho salmon incubation in the lower Green River are expected to be minor, since the channel in this section of the river is narrower than that in the middle Green River due to channelization (i.e., the outer margins of the channel subject to dewatering are very small relative to the total wetted width). As stated previously, the lower Green River provides poor spawning and incubation habitat relative to that found in the middle Green River due to extensive physical habitat disturbance.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho spawning and incubation in the lower watershed.

7.3.4 Coho Juvenile Rearing

7.3.4.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals will primarily affect juvenile coho habitat in the lower and middle Green River (i.e., below Headworks). Pumping of groundwater from the North Fork well field is expected to have a minor effect on coho rearing in the North Fork Green River since well field pumping primarily occurs during periods of high turbidity during the late fall, winter and early spring. Rapid flow increases in the winter flow are largely responsible for the elevated turbidity levels that necessitate the use of the groundwater pumping facility. Pumping during the summer and early fall, though rare, is expected to have a negative effect on coho salmon rearing habitat in the North Fork once this species is reintroduced into the upper watershed. Most coho salmon juveniles are expected to rear in the upper watershed for at least 1 year.

The trap-and-haul facility to be built by Tacoma will allow adult coho salmon that reach the Headworks diversion structure to be captured and then released into the upper watershed above HHD. In addition to reconnecting the upper watershed to the lower watershed using the trap-and-haul and downstream fish passage facilities, habitat rehabilitation projects will also be implemented by Tacoma and the USACE in the upper watershed during Phase I of the AWS project. As described in Chapter 7.1.4.1, the rehabilitation projects to be implemented as part of the AWS project will provide increased rearing and overwintering habitat for anadromous and resident salmonids, including juvenile coho salmon. These rehabilitation projects include creation and placement of LWD in 2.4 acres of off-channel habitat, and placement of LWD in over 4 miles of mainstem and tributary habitat. As described earlier, projects implemented as mitigation for the AWS project include placement of LWD into an additional 11.5 miles of mainstem and tributary habitat, and creation of 1.1 acres of off-channel habitat in the seasonally inundated zone. Additional off-channel areas and increased LWD loadings will provide high quality habitat for juvenile coho salmon, which prefer off-channel habitats or pools with abundant LWD cover.

Watershed Management. Coho prefer low velocity pools with abundant LWD cover in the summer and seek out small, low energy tributaries; deep, slow pools; or groundwater-fed off-channel habitat. LWD may be particularly important for providing cover and refuge from high flows in larger channels. The potential effects of Tacoma's forest harvest and road-building activities on juvenile coho are similar to those previously described for chinook.

Implementation of watershed management conservation measures will have a positive effect on juvenile coho rearing in the Upper HCP Area. Mass-wasting prescriptions are expected to reduce the frequency of landslides that deliver sediment and initiate dam-break floods. Management-related contributions of fine sediment will be reduced to less than 50 percent over background under the RSRP. These measures are expected to result in a decrease in embeddedness and may increase the number and size of pools in small, low gradient tributaries.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. As in-channel LWD increases, the frequency of pools is also expected to increase. Hiding cover will also improve as a result of the additional LWD. The net result should be an increase in the quality and quantity of pool habitat used for summer and winter rearing by coho. As riparian stands mature, the number of large conifers capable of acting as barrier tress during dam-break floods will increase. The increased abundance of barrier trees, combined with the decreased frequency of mass wasting is expected to reduce the risk of dam-break floods.

Stream-crossing culverts on Tacoma's lands will be inventoried and repaired or replaced within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure will increase the amount of small tributary and off-channel habitat that are accessible to coho for use as off-channel rearing habitat, although the magnitude of that increase cannot be estimated until the inventory is complete.

7.3.4.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals will affect coho salmon rearing habitat by reducing flows in the Green River below the Headworks by up to 213 cfs on a daily basis. The withdrawals likely will have a greater effect on coho salmon compared to chinook salmon (see Chapter 7.1.4.2), since most juvenile coho reside in the Green River for at least 1 year prior to migrating to the ocean. These withdrawals will affect coho salmon rearing in both the main river channel and side channels present along the middle Green River. These side-channel areas may be particularly important rearing areas for juvenile coho salmon, which prefer off-channel habitats having abundant cover (e.g., overhanging vegetation, LWD).

The potential effects of Tacoma's withdrawals on mainstem habitat were quantified using IFIM potential habitat area and flow functions developed for juvenile coho salmon in the middle Green River by Ecology. Daily habitat values occurring under HCP conditions (Green River flows **with** the AWS project and **with** Tacoma withdrawals) were compared to those occurring under Green River flows **without** the AWS project and **without** Tacoma withdrawals (see Chapter 7.1.3.2 for a description of the methods used for this habitat analysis). The analysis indicated that Tacoma's withdrawals (both FDWRC and SDWR) will result in an average 10.2 percent increase in juvenile coho salmon habitat in the mainstem middle Green River (Table 7-14). Flows in the mainstem middle Green River are usually higher than those considered to be optimal for juvenile coho salmon by the Ecology instream flow study (Caldwell and Hirschey 1989). Consequently, Tacoma's withdrawals were found to have a potentially positive net effect on coho salmon rearing habitat in the main channel of the middle Green River.

One problem with Ecology's instream flow analysis, identified by state and Tribal fisheries biologists, is that it did not consider the relative importance of mainstem channel margin habitats to juvenile coho salmon. These margin areas generally possess the slow currents and cover types (woody debris or overhanging vegetation) that provide the highest quality habitat to rearing coho in many rivers and streams. Potential reductions in the wetted width in the mainstem middle Green River channel resulting from Tacoma's withdrawals were estimated to average 7.5 feet (3.25 feet per side) during summer low flow conditions (i.e., 250 cfs baseflow at Auburn). This reduction in channel width could result in some reduction in the amount of margin habitat available to coho salmon in the mainstem channel of the middle Green River.

The potential effects of Tacoma's water withdrawals on coho rearing habitat in the side channels of the middle Green River were quantified using the same wetted side-channel area versus discharge relationships employed in the chinook salmon analysis (see Chapter 7.1.4.2). Changes in availability of side-channel area were calculated on a year-round basis, since most coho salmon reside in the Green River at least 1 year. The results of this modeling effort predicted an average 12.6 percent reduction in total wetted area for the side channels located between RM 61.0 and RM 33.8 (i.e., majority of side channels in the Green River below HHD) during the year-round coho rearing period (Table 7-15). This represents a 1.6-acre reduction in the wetted area of side channels in the middle Green River during the coho salmon rearing period.

The conservation measures designed to improve juvenile coho salmon habitat are the same as those described to improve juvenile chinook habitat in the middle Green River (see Chapter 7.1.4.2). These measures include reconnecting and restoring the Signani Slough side channel, and placement of LWD in the river channel. These measures will improve coho salmon rearing habitat by providing up to 3.4 acres of additional off-channel habitat, which is important for overwintering, and by increasing the structural complexity of main channel habitats. As mentioned previously, LWD provides important cover habitat to juvenile coho salmon.

As described for chinook salmon, some benefits will also be realized for several miles of the Green River below HHD by improving (decreasing) water temperatures for salmonids. Temperature modeling results indicated that the natural inflow to HHD exceeds the state Class "AA" temperature standard of 16.0ºC (61ºF) during the summer and early fall of most years. Water temperature modeling results for the AWS project (described in Chapter 7.1.4.2) suggest that water released from HHD will exceed this temperature in only 1 of 33 years. The preferred fish passage alternative under the AWS project has a 97 percent reliability for maintaining HHD release temperatures below the state standard. By the time the water reaches the downstream end of the Palmer spawning reach (RM 61.0-58.0), this benefit will progressively diminish as stream temperatures approach equilibrium conditions with the air temperatures.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho juvenile rearing in the middle watershed.

7.3.4.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Coho Juvenile Rearing

Water Withdrawal. As with the middle Green River, flow reductions resulting from the FDWRC and SDWR will improve mainstem habitat conditions for juvenile coho salmon in the lower Green River but reduce availability of side-channel habitats. Municipal water withdrawals modeled using daily flows from 1964-1995 for the lower river resulted in an average 15.1 percent increase in mainstem habitat for juvenile coho salmon (Table 7-14). Improvements in mainstem juvenile habitat area resulting from the water supply diversions occur because flows in the lower Green River are usually higher than the flow considered to be optimal for juvenile coho salmon by Ecology's instream flow study. Because the lower river has been extensively channelized, the wetted width of the mainstem channel will not significantly change (2.3-foot reduction in total width; 1.15 feet per side) during summer low flow periods (i.e., 250 cfs at Auburn) as a result of the municipal water withdrawals. Impacts to mainstem channel margin habitat will therefore be minor. Since there is little off-channel habitat in the lower Green River due to channelization and flood control, impacts of municipal water withdrawals to off-channel habitat will be small.

As described for chinook salmon (see Chapter 7.1.4.3), water quality problems within the lower Green River include water temperature, DO, nutrient enrichment, and a variety of pollutants. However, the effects of HHD and Tacoma's water withdrawal activities will not extend sufficiently far downstream to significantly affect water quality conditions (particularly temperature) in the lower Green and Duwamish rivers.

Juvenile coho salmon habitat is generally poor in the lower Green River as a result of channelization for flood control. For this reason, mitigation measures for juvenile coho salmon, like chinook salmon, focus on habitat enhancement of the upper and middle Green River, including LWD placement and side-channel restoration.

The implementation of freshets during fall low flow conditions, if included as part of the optional storage of 5,000 ac-ft for low flow augmentation, could potentially provide short-term improvements in water quality conditions in the lower Green River to induce and improve upstream passage of adult coho and chinook salmon. However, these freshets will not be sufficient in duration to provide tangible benefits to rearing salmon and steelhead.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect coho juvenile rearing in the lower watershed.

Table 7-9. Comparison of the effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and the AWS project on an index of outmigrant survival conditions for coho salmon juveniles in the Green River, Washington, 1964-1995.

	Total of Daily Difference in Survival Values (percent)	
Year	Effects of Water Withdrawals	Effects of AWS Project
1964	-1.99	3.04
1965	-5.01	3.97
1966	-5.45	3.62
1967	-4.92	3.64
1968	-6.31	3.97
1969	-3.05	2.30
1970	-5.19	4.23
1971	-2.93	1.37
1972	-2.54	1.10
1973	-7.17	3.21
1974	-1.20	1.80
1975	-3.38	1.30
1976	-4.60	1.73
1977	-7.05	3.46
1978	-6.43	3.57
1979	-5.27	3.72
1980	-5.45	3.62
1981	-5.67	0.54
1982	-5.27	3.70
1983	-6.54	5.70
1984	-3.89	3.24
1985	-4.80	4.49
1986	-5.71	4.10
1987	-5.08	3.41
1988	-5.12	2.88
1989	-5.13	3.78
1990	-4.50	3.81
1991	-5.50	3.72
1992	-5.74	2.99
1993	-5.33	2.19
1994	-6.03	5.36
1995	-5.80	5.48
Mean	-4.94	3.28
Minimum	-7.17	0.54
Maximum	-1.20	5.70

Table 7-10. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on mainstem spawning habitat for coho salmon in the lower and middle Green River, Washington; 1964-1995. Potential habitat area values calculated from weighted usable area and flow functions developed by Ecology (Caldwell and Hirschey 1989).

	Change in Mean Daily Potential Mainstem Spawning Habitat Area			
	Lower River		Middle River	
Year	Acres	Percent	Acres	Percent
1964	8.7	23.9	11.9	22.2
1965	6.4	10.3	8.7	10.9
1966	4.4	10.6	4.2	6.7
1967	6.1	12.8	5.8	8.9
1968	6.7	28.3	7.5	17.5
1969	8.8	15.8	12.7	17.3
1970	7.5	14.8	9.0	12.9
1971	4.7	12.7	5.0	8.9
1972	6.6	13.7	10.3	15.6
1973	3.7	8.0	3.1	4.6
1974	4.9	9.1	4.6	6.1
1975	3.0	9.7	2.0	3.6
1976	9.7	16.0	12.1	15.6
1977	5.3	13.8	7.6	12.7
1978	8.0	17.2	10.2	16.0
1979	2.7	4.6	1.6	2.0
1980	4.1	9.5	4.4	6.8
1981	7.7	15.7	10.1	14.5
1982	8.5	18.2	10.2	15.2
1983	4.6	10.9	5.0	7.9
1984	8.3	16.4	10.2	14.7
1985	7.2	13.9	7.5	10.3
1986	7.3	14.9	8.1	11.6
1987	0.5	0.6	-3.6	-3.7
1988	3.9	11.5	3.0	5.3
1989	2.7	5.7	0.5	0.7
1990	3.1	9.9	2.8	5.1
1991	3.3	6.1	1.5	2.0
1992	7.5	15.3	10.0	15.7
1993	3.6	5.8	3.2	3.8
1994	2.7	6.2	2.9	4.6
1995	3.1	9.3	3.1	5.9
Mean	5.5	12.2	6.1	9.4

Table 7-11. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on side channel habitat area during the coho salmon spawning period (September through January) in the middle Green River, Washington; 1964-1995. Habitat area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Mean Daily Side Channel Habitat Area Due to Water Withdrawals	
Year	Acres	Percent
1964	-1.8	-11.6
1965	-1.5	-16.5
1966	-1.5	-9.8
1967	-1.7	-12.9
1968	-1.9	-10.5
1969	-1.6	-16.5
1970	-1.6	-13.9
1971	-1.9	-12.1
1972	-1.5	-10.5
1973	-1.7	-12.2
1974	-1.6	-13.0
1975	-1.4	-6.5
1976	-1.5	-17.6
1977	-1.5	-8.6
1978	-1.7	-13.6
1979	-1.5	-13.5
1980	-1.6	-10.1
1981	-1.5	-13.3
1982	-1.5	-11.8
1983	-1.6	-10.7
1984	-1.5	-15.3
1985	-1.4	-12.1
1986	-1.5	-12.8
1987	-1.2	-19.1
1988	-1.8	-10.3
1989	-1.5	-10.5
1990	-1.4	-7.0
1991	-1.4	-11.8
1992	-1.8	-16.0
1993	-1.5	-15.0
1994	-1.5	-11.0
1995	-1.5	-7.6
Mean	-1.6	-12.3
Minimum	-1.9	-19.1
Maximum	-1.2	-6.5

Table 7-12. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on spawnable widths and dewatered widths during the coho salmon spawning period in the middle Green River, Washington; 1964-1995. Spawnable width and dewatered width values were calculated from transect cross-section and stage-discharge data collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Spawnable Width (ft)					Dewatered Width (ft)				
Year	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project
1964	138.3	138.3	139.6	-1.3	0.0	6.2	6.0	5.3	0.7	-0.2
1965	133.9	133.9	135.2	-1.3	0.0	2.0	2.0	2.2	-0.2	0.0
1966	138.2	138.2	139.4	-1.2	0.0	5.9	6.1	5.9	0.2	0.2
1967	136.7	136.7	138.0	-1.3	0.0	6.0	6.0	6.1	-0.1	0.0
1968	140.0	140.0	141.2	-1.2	0.0	4.4	4.4	4.3	0.1	0.0
1969	134.5	134.5	135.8	-1.3	0.0	1.4	1.4	1.1	0.3	0.0
1970	135.7	135.7	136.9	-1.2	0.0	4.4	4.2	4.3	-0.1	-0.2
1971	138.0	138.0	139.2	-1.2	0.0	3.5	3.5	3.4	0.1	0.0
1972	137.7	137.7	138.9	-1.2	0.0	8.6	9.1	8.2	0.9	0.5
1973	136.6	136.6	137.8	-1.2	0.0	4.1	4.3	4.5	-0.2	0.2
1974	135.9	135.9	137.0	-1.1	0.0	5.4	5.7	5.1	0.6	0.3
1975	142.5	142.5	143.5	-1.0	0.0	8.7	9.1	8.5	0.6	0.4
1976	134.0	134.0	135.3	-1.3	0.0	3.2	3.2	3.4	-0.2	0.0
1977	140.3	140.3	141.5	-1.2	0.0	12.4	12.3	11.5	0.8	-0.1
1978	136.3	136.3	137.5	-1.2	0.0	3.6	3.6	3.5	0.1	0.0
1979	135.0	135.0	136.2	-1.2	0.0	6.2	6.2	6.3	-0.1	0.0
1980	138.0	138.0	139.1	-1.1	0.0	6.5	6.5	6.3	0.2	0.0
1981	135.6	135.6	136.8	-1.2	0.0	3.6	3.7	3.5	0.2	0.1
1982	136.7	136.7	137.9	-1.2	0.0	6.0	6.2	5.9	0.3	0.2
1983	137.8	137.8	138.9	-1.1	0.0	4.8	4.9	4.8	0.1	0.1
1984	135.0	135.0	136.3	-1.3	0.0	1.4	1.4	1.4	0.0	0.0
1985	135.8	135.8	137.1	-1.3	0.0	7.3	7.3	6.9	0.4	0.0
1986	136.2	136.2	137.5	-1.3	0.0	8.8	8.8	7.6	1.2	0.0
1987	131.9	131.9	133.0	-1.1	0.0	5.2	5.2	4.4	0.8	0.0
1988	138.9	138.9	140.0	-1.1	0.0	3.8	3.9	3.4	0.5	0.1
1989	137.4	137.4	138.6	-1.2	0.0	6.5	6.7	6.2	0.5	0.2
1990	141.7	141.7	142.7	-1.0	0.0	8.5	8.6	8.1	0.5	0.1
1991	135.5	135.5	136.5	-1.0	0.0	7.0	7.1	6.9	0.2	0.1
1992	135.6	135.6	136.9	-1.3	0.0	1.9	1.9	1.9	0.0	0.0
1993	134.3	134.3	135.4	-1.1	0.0	4.0	4.0	3.7	0.3	0.0
1994	137.5	137.5	138.6	-1.1	0.0	6.4	6.4	7.0	-0.6	0.0
1995	124.2	124.2	125.1	-0.9	0.0	8.4	8.4	8.4	0.0	0.0
Mean	136.4	136.4	137.6	-1.2	0.0	5.5	5.6	5.3	0.3	0.1
Minimum	124.2	124.2	125.1	-1.3	0.0	1.4	1.4	1.1	-0.6	-0.2
Maximum	142.5	142.5	143.5	-0.9	0.0	12.4	12.3	11.5	1.2	0.5

Table 7-13. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on continuously wetted side channel habitat area (i.e., two-day low flow event) during the coho salmon incubation period (December through mid-April) in the middle Green River, Washington; 1964-1995. Habitat area changes calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Continuously Wetted Side Channel Area due to Water Withdrawals		Change in Continuously Wetted Side Channel Area due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-	-	-	-
1965	-1.9	-18.6	-1.0	-9.7
1966	-1.3	-17.1	0.0	0.0
1967	-1.6	-15.9	-1.2	-11.8
1968	-2.0	-23.2	0.0	0.0
1969	-1.2	-13.9	0.0	0.0
1970	-1.3	-17.0	0.0	0.0
1971	-1.2	-13.4	0.0	0.0
1972	-1.7	-13.5	0.0	0.0
1973	-1.7	-21.5	0.8	10.6
1974	-1.8	-17.3	0.0	-0.1
1975	-1.7	-20.5	0.0	0.0
1976	-1.9	-18.6	-1.3	-12.4
1977	-1.6	-20.4	0.0	0.0
1978	-1.8	-18.1	0.4	4.2
1979	-1.1	-15.2	0.0	0.0
1980	-1.4	-15.8	0.0	0.0
1981	-1.3	-25.1	0.0	0.0
1982	-1.1	-12.2	0.0	0.0
1983	-1.2	-14.7	0.0	0.0
1984	-1.3	-18.9	0.0	0.0
1985	-1.1	-15.2	0.0	0.0
1986	-1.2	-15.5	0.0	0.0
1987	-1.0	-12.1	0.0	0.0
1988	-1.3	-26.3	0.0	0.0
1989	-1.8	-17.5	0.0	0.0
1990	-1.9	-19.1	0.0	0.0
1991	-1.2	-13.2	0.0	0.0
1992	-1.4	-17.6	1.7	21.6
1993	-1.1	-15.8	0.0	0.0
1994	-1.1	-16.0	0.0	0.0
1995	-1.9	-18.4	-0.4	-3.7
Mean	-1.5	-17.3	0.0	0.0

Table 7-14. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on mainstem juvenile rearing habitat for coho salmon in the lower and middle Green River, Washington; 1964-1995. Habitat area values calculated from weighted usable area and flow functions discharge relationships collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Change in Mean Daily Mainstem Habitat Area due to Water Withdrawals				Change in Mean Daily Mainstem Habitat Area due to AWS Project			
	Lower River		Middle River		Lower River		Middle River	
Year	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
1964	5.3	20.2	3.1	11.9	0.3	0.8	0.2	0.8
1965	5.8	14.3	3.3	10.1	0.4	1.0	0.4	1.3
1966	6.4	17.4	3.5	11.6	0.3	0.8	0.4	1.1
1967	5.1	13.8	2.9	9.4	0.8	2.0	0.8	2.3
1968	5.7	18.8	3.3	11.7	-0.1	-0.2	0.1	0.4
1969	6.2	17.0	3.9	12.3	0.6	1.5	0.4	1.1
1970	5.7	14.7	3.2	9.9	0.5	1.2	0.4	1.3
1971	4.4	15.4	2.5	8.8	0.4	1.1	0.4	1.3
1972	4.9	16.3	2.7	9.6	0.1	0.2	0.1	0.2
1973	6.7	15.5	4.1	12.1	-0.1	-0.3	0.1	0.2
1974	4.2	13.3	2.2	7.5	0.1	0.4	0.2	0.7
1975	4.6	15.3	2.7	9.5	0.4	1.1	0.3	1.1
1976	6.8	18.7	4.0	13.1	1.0	2.3	0.8	2.3
1977	7.2	17.7	4.3	13.4	-0.2	-0.4	0.0	-0.1
1978	7.4	19.0	4.4	13.8	0.4	0.8	0.3	0.7
1979	5.1	11.6	2.6	7.5	0.2	0.5	0.3	0.7
1980	5.5	14.7	3.3	10.3	0.1	0.3	0.2	0.5
1981	6.3	17.3	3.9	12.3	0.1	0.2	0.1	0.4
1982	5.8	16.2	3.4	11.2	0.5	1.2	0.6	1.6
1983	6.7	18.1	4.1	13.2	-0.3	-0.7	0.0	-0.1
1984	5.1	16.1	2.7	9.1	0.3	0.9	0.3	0.9
1985	6.0	14.4	3.5	10.7	0.3	0.6	0.4	1.0
1986	5.9	14.7	3.3	10.2	-0.1	-0.2	-0.1	-0.2
1987	4.6	9.5	2.7	7.4	0.0	0.1	0.2	0.4
1988	4.9	13.4	2.5	8.0	0.2	0.4	0.1	0.4
1989	4.2	10.5	2.6	8.0	-0.1	-0.3	0.1	0.3
1990	3.5	11.9	1.8	6.3	-0.2	-0.6	0.0	-0.2
1991	4.2	11.2	2.5	7.9	0.1	0.3	0.2	0.7
1992	6.1	13.2	3.5	10.0	-0.3	-0.5	0.1	0.3
1993	6.5	16.5	3.7	11.7	0.3	0.6	0.2	0.5
1994	5.3	13.0	2.9	9.1	-0.5	-1.0	-0.2	-0.5
1995	4.6	12.2	2.8	8.9	0.0	0.0	0.3	0.8
Mean	5.5	15.1	3.2	10.2	0.2	0.4	0.2	0.7

Table 7-15. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on the area of side channels during the rearing period (year-round) of coho salmon juveniles in the middle Green River, Washington; 1964-1995. Surface area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Mean Side Channel Habitat Area due to Water Withdrawals		Change in Mean Side Channel Habitat Area due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-1.9	-10.6	0.0	0.0
1965	-1.6	-12.8	0.0	0.2
1966	-1.7	-13.1	0.0	0.2
1967	-1.6	-11.5	0.1	0.6
1968	-1.7	-12.1	0.0	-0.1
1969	-1.6	-12.9	0.0	-0.1
1970	-1.7	-13.7	0.1	0.8
1971	-1.8	-10.8	-0.1	-0.6
1972	-1.6	-8.9	0.0	0.2
1973	-1.6	-14.8	0.0	0.1
1974	-1.7	-9.7	0.0	-0.1
1975	-1.6	-9.4	0.0	-0.1
1976	-1.7	-12.7	0.0	0.2
1977	-1.5	-12.8	0.0	0.1
1978	-1.6	-15.4	0.0	0.5
1979	-1.5	-13.2	0.1	0.9
1980	-1.7	-12.5	0.0	0.0
1981	-1.6	-13.3	0.0	0.0
1982	-1.6	-11.8	0.1	0.8
1983	-1.7	-13.4	0.0	0.1
1984	-1.7	-12.3	0.1	0.5
1985	-1.5	-13.2	0.1	0.9
1986	-1.6	-13.7	0.0	-0.3
1987	-1.5	-15.3	0.0	0.5
1988	-1.7	-12.0	0.1	0.7
1989	-1.6	-12.4	0.0	0.2
1990	-1.8	-10.4	0.0	-0.2
1991	-1.6	-11.4	0.0	0.1
1992	-1.6	-16.0	0.0	0.2
1993	-1.7	-15.0	0.0	0.4
1994	-1.6	-13.3	0.0	-0.1
1995	-1.5	-11.2	0.0	0.1
Mean	-1.6	-12.6	0.0	0.2

7.4 Effects of Water Withdrawal and Habitat Conservation Measures on Sockeye Salmon *(Oncorhynchus nerka)*

This section describes the potential effects of Tacoma's water withdrawal activities on sockeye salmon and the potential benefits resulting from habitat conservation measures. Unlike other anadromous salmonids, sockeye salmon juveniles characteristically rear in lakes for 1 to 3 years before migrating to the ocean. Prior to completion of HHD in 1962, there were no large lakes or other lentic environments in the Green River basin accessible to anadromous fish. Although the observation of sockeye adults in a river system without lakes is atypical, there have been other reports of small numbers of adult sockeye in other western Washington river systems that do not contain lakes (Gustafson et al. 1997).

In general, data and information concerning the abundance and status of sockeye salmon populations in the Green River is sketchy, largely limited to several years of spawning ground survey data compiled by Egan (1977, 1995, 1997) as reported in Gustafson et al. (1997). The data that do exist suggest that the number of sockeye salmon using the Green River watershed is low. The spawning ground survey data were compiled for two separate segments of the Green River corresponding to a segment of the middle Green River below the Gorge extending from RM 33.0-44.0 (11 years of data collected during period 1953-96), and a segment below the Headworks from RM 56.0-61.0 (3 years of data collected during period 1976-90). The numbers of adult fish observed during those two periods ranged from one to 16 in the segment below the Gorge, to one to two below the Headworks. In addition to those data sets, MIT harvest records of sockeye salmon have ranged from 0 in 1987 to 278 in 1984 (Hoines 1995 as reported in Gustafson et al. 1997). The most recent observations of sockeye salmon use in the Green River were provided via personal observation. These have been made by Eric Warner of MIT (as reported in Gustafson et al. 1997), and Phil Hilgert of R2 Resource Consultants (one of the authors of this report) who has observed small numbers (fewer than 100) of sockeye adults during other fishery investigations on the Green River.

Sockeye were reportedly stocked in the Green River over a 6-year period extending from 1925 to 1931. During that time, the Washington Department of Game (1928, 1930, and 1932) (as reported in Gustafson et al. 1997) apparently released over 392,050 sockeye salmon fry into the Green River drainage, although the specific location of release sites were not provided. This period pre-dates the construction of HHD but is after construction and operation of the Headworks. The general absence of any data or information on sockeye for the decades following those plants indicates they were largely unsuccessful in establishing a sizable run of sockeye in the Green River. Nevertheless, the adult fish that have been observed in the river could be remnants of those initial plants and could reflect a riverine stock. On the other hand, according to the WDFW, the possibility exists that the sockeye that have been found in the Green River are strays from Lake Washington (Michael 1998). If that is the case, then the Green River sockeye are actually a lake rather than riverine variety. However, this should be balanced with the knowledge that the riverine stocks of sockeye found in other rivers in Washington have not been shown (based on scale pattern analysis) to be of either Lake Washington or Baker Lake origin (Michael 1998). To date, NMFS has not completed genetic testing of tissue samples from Green River sockeye to determine stock origin. Such information and data gaps apparently factored into the NMFS Biological Review Team's (BRT) conclusion that there was insufficient evidence available to "determine whether sockeye salmon seen in rivers without lake-rearing habitat in Washington were distinct populations" (Gustafson et al. 1997). As a result, NMFS did not designate a specific ESU for riverine-spawning sockeye salmon.

For purposes of this HCP and the following analysis, the question of specific stock origin of Green River sockeye salmon remains unanswered. There has been no detailed information collected on sockeye salmon in the Green River relative to the PHABSIM and instream flow modeling (as has been done for other salmonid species such as chinook salmon, chum salmon, and steelhead). To the extent there are similarities in periodicity and life stage habitat requirements between sockeye salmon and species for which quantitative data are available, the analysis completed and conclusions reached for those species have been applied to sockeye on a qualitative basis in this analysis.

Because of the uncertainty as to whether sockeye in the Green River are of a river or lake-type rearing stock, there are no plans to introduce sockeye above HHD. Indeed, the introduction of a lake-type rearing stock of sockeye (with its proclivity to rear in a lacustrine environment for 1 to 2 years) above HHD would not be compatible with Howard Hanson reservoir's primary purpose of flood control management. Attempts to establish sockeye runs above HHD may result in the loss of juvenile fish (because of their proclivity to rear in lacustrine environments for 1 to 2 years) during reservoir drawdown in the fall (October) and throughout the period when the reservoir is maintained at minimum pool elevation (to mid-February) for flood control storage space. For that reason, the analysis of the effects of Tacoma's operations on and benefits of the habitat conservation measures to sockeye salmon is restricted to the middle and lower reaches of the Green River.

The potential effects of Tacoma's covered activities and conservation measures described in this document depend on the distribution of fish and wildlife species within the Green River basin. Anadromous fish species were blocked from accessing the watershed above Tacoma's Headworks since the early 1900s, and several major conservation measures of this HCP address the reintroduction of anadromous fish to the upper watershed. Determining which stocks and which species should be considered for reintroduction to the upper watershed is a fish management decision that is beyond the responsibility of Tacoma Water. The WDFW and MIT are co-managers of Green River fish and wildlife resources and together with the NMFS and USFWS will evaluate reintroduction of anadromous fish into the upper watershed. However, in order to evaluate potential effects of the HCP, assumptions regarding the distribution and potential for reintroduction above HHD were defined for each species potentially covered by the ITP. These assumptions were made for planning purposes only and do not represent suggestions by the City of Tacoma regarding fish restoration opportunities.

7.4.1 Sockeye Upstream Migration

7.4.1.1 Upper Watershed

It is assumed that sockeye salmon will not be introduced into the upper Green River watershed (for reasons noted in Chapter 7.4) and therefore Tacoma's water withdrawal and watershed management activities, and associated conservation measures, will not affect sockeye salmon in that segment of the river.

7.4.1.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Upstream Migration

Water Withdrawal. Analysis of transect data (Caldwell and Hirschey 1989) collected in the middle Green River indicated that passage of chinook salmon should not be impeded when flows are greater than 225 cfs (assuming a minimum passage depth of 1.0 feet). As noted above, the minimum passage depth of sockeye salmon is less (0.6 feet) than for chinook and, therefore, passage through the middle Green River at flows greater than 225 cfs should not be impeded.

With respect to holding habitat, the water quality conditions in the middle Green River should be better than those in the lower river during the entire period (June through August) in which sockeye are entering and holding within the system. This is because the upper portions of the middle river are more proximal to HHD and therefore still benefit from the cooler water releases from the HHD Reservoir. In addition, the relatively steep gradients and coarse substrate typical of the channel in the Green River Gorge increase surface turbulence and promote aeration of the water. Thus, there should be no water quality-related impacts on holding adult sockeye salmon, nor delays in their migration resulting from Tacoma's water withdrawals.

The minimum flows specified under the MIT/TPU Agreement satisfy the upstream passage requirements of chinook salmon and therefore will also satisfy the upstream passage needs of sockeye salmon.

The AWS project provision of an optional annual storage of up to 5,000 ac-ft for fisheries purposes, which could be used for freshets in the late summer and early fall (as described for chinook [Chapter 7.1.1.1] and coho salmon [Chapter 7.3.1.1]), will also provide some benefits to sockeye salmon.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect sockeye upstream migration in the middle watershed.

7.4.1.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Upstream Migration

Water Withdrawal. According to Gustafson et al. (1997), Puget Sound sockeye enter streams beginning in mid-June through August, although the actual timing when sockeye enter the Green River is unknown. Adult sockeye that enter the system early (e.g., in June/early July) will likely migrate upstream until they find suitable pools and pocket water, where they may hold for several months until ready to spawn. The quantity and quality of flow in the lower Green River in June and July should be conducive to sockeye entering, migrating, and holding within the system. Presumably, fish from the early part of the run migrate upstream to deep pools and holding waters associated with or upstream from the Green River Gorge. Given the proximity to HHD, the presence of a natural riparian zone, and the steep gradient of the channel (resulting in surface turbulence and aeration of the water), the water quality (temperature and DO concentrations) within the area of the Green River Gorge is likely to be much better than conditions in the lower river during the late summer and early fall. Indeed, sockeye entering the lower Green River in late July and August may be subjected to low streamflow and water quality problems related directly to elevated water temperatures and low DO concentrations.

This period partially corresponds to the migration period of chinook salmon, and therefore the analysis completed for chinook (see Chapter 7.1.1.1) has applicability for sockeye in the lower river. Thus, there could be some delay in the initial passage of sockeye salmon into the lower Green River and Duwamish Estuary during periods of low flow and degraded water quality conditions. However, such conditions will likely be transitory, and as noted by Fujioka (1970) for chinook, and not prevent the ultimate migration of sockeye into the system.

With respect to the actual physical ability of sockeye to migrate through the lower Green River, the analysis of transects completed for chinook salmon indicated that suitable passage flows for chinook salmon will be achieved when flows at the Auburn gage exceed 200 cfs (see Chapter 7.1.1.1). Because sockeye are smaller than chinook and able to pass upstream through shallow water, passage conditions suitable for chinook will likewise be sufficient for sockeye. Bell (1986) listed a minimum passage depth of 0.6 feet for upstream migration of sockeye salmon.

As noted for coho (see Chapter 7.3.1.1), under HCM 1-01, Tacoma will guarantee minimum flows of at least 250 cfs at the Auburn gage from 15 July to the end of flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs. Tacoma will not use the SDWR if instream flows at Palmer fall below 300 cfs during the remainder of the year. These minimum instream flow requirements during the fall and early winter migration period for sockeye salmon will result in flows that provide adequate water depths for the upstream passage of sockeye salmon through the lower watershed. Depending on the actual run-timing of Green River sockeye, some delay in migration could occur early in the migration period (late June/early July) during sustained low flows due to poor water quality conditions and lack of migration cues. However, such delays will be transitory and will not result in any mortality to the adult salmon; the delay will likely result in the adult fish remaining in saltwater/estuarine habitats for a longer time until suitable flow conditions occurred in the Green River in which to stimulate upstream migration.

The AWS project provision of an optional annual storage of up to 5,000 ac-ft for fisheries purposes, which could be used for freshets in the late summer and early fall (as described for chinook [Chapter 7.1.1.1] and coho salmon [Chapter 7.3.1.1]), will also provide some benefit to sockeye salmon.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect sockeye upstream migration in the lower watershed.

7.4.2 Sockeye Downstream Migration

7.4.2.1 Upper Watershed

It is assumed that sockeye salmon will not be introduced into the upper Green River watershed (for reasons noted in Chapter 7.4) and therefore Tacoma's water withdrawal, watershed management activities, and associated conservation measures will not affect sockeye salmon in that segment of the river.

7.4.2.2 Middle and Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Downstream Migration

Water Withdrawal. Because sockeye salmon will not be introduced above HHD and adults will not be placed above the Headworks, there is no potential entrainment or impingement of sockeye juveniles at the Headworks diversion.

However, as noted for coho (Chapter 7.3.2.2), the survival of outmigrating sockeye salmon in the middle and lower Green River below the Headworks is assumed to be a function of flow, and thus will be influenced by Tacoma's flow diversions. Because of similarities in outmigration timing of smolts between coho (April through June) and sockeye (April through May) (Table C-5 in Gustafson et al. 1997) the instream migration analysis computed for coho should be applicable for approximating anticipated impacts of water diversions on sockeye downstream migration. The results of that analysis (see Chapter 7.3.2.2) indicated an average annual reduction in coho smolt survival condition of 4.9 percent, with reductions in yearly outmigrant survival values ranging from 1.2 percent to 7.2 percent for the period 1964-1995. Reductions in sockeye outmigration survival condition are anticipated to be similar to coho.

The flow augmentation measures occurring in May and June associated with the implementation of the AWS project will increase survival of outmigrating sockeye salmon in the middle and lower sections of the Green River. The degree of benefit is assumed to be similar to that determined for coho salmon (Chapter 7.3.2.2), an average increase in survival condition of 3.3 percent.

7.4.3 Sockeye Spawning and Incubation

7.4.3.1 Upper Watershed

It is assumed that sockeye salmon will not be introduced into the upper Green River watershed (for reasons noted in Chapter 7.4) and therefore Tacoma's water withdrawal, watershed management activities, and associated conservation measures will not affect sockeye salmon spawning and incubation in that segment of the river.

7.4.3.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Spawning and Incubation

Water Withdrawal. As for coho and chinook, Tacoma's water withdrawals will affect the availability of sockeye spawning habitat in both the mainstem river and side-channel areas of the middle Green River. The effects of such withdrawals on sockeye salmon spawning and incubation can be approximated by using the analysis completed for coho salmon (see Chapter 7.3.3.2), assuming similarity in habitat requirements between the two species. Separate analyses were completed for mainstem and off-channel spawning and incubation habitats.

For the mainstem, the analysis indicated an average increase of potential spawning habitat of over 9 percent when the FDWRC and SDWR withdrawals are operating; the greatest reduction (-3.7 percent) in habitat was predicted to occur under drought conditions in 1987 (see Chapter 7.3.3.2). The increases in habitat ascribed to Tacoma's withdrawal of water are a function of the habitat and flow relationships that have been predicted for coho salmon for that section of the river. The relationships indicate that optimal spawning habitat is provided at flows between 240 and 375 cfs. Because natural flows that occur during the period of coho and sockeye spawning generally exceed those values, the withdrawal of water by Tacoma will result in an overall increase in the amount of potential spawning habitat under those conditions.

The effect of Tacoma's FDWRC and SDWR withdrawals on side-channel spawning habitat for sockeye salmon should be similar to that on coho salmon, since both species have similar spawning periods. The analysis for coho salmon indicated that Tacoma's withdrawals will reduce the total area of side channels in the middle Green River by an average of 1.6 acres during its mid-September through mid-January spawning period (see

Chapter 7.3.3.2). This represents a 12.3 percent reduction in the average wetted area of side channels in the middle Green River during the coho spawning period.

The potential effects of Tacoma's withdrawals on incubating eggs and embryos of sockeye salmon were also assumed to be similar to those on coho salmon (see Chapter 7.3.3.2). For mainstem sections of the middle Green River during the sockeye spawning period, the spawnable width of the river was calculated as 137.6 feet without the withdrawals and 136.4 feet with the withdrawals. The average dewatered spawnable width for those days when redd dewatering was predicted to occur was 5.3 feet without the withdrawals and 5.6 feet with the withdrawals. Thus, the increase in average dewatered spawnable width (i.e., the margin of the channel subject to egg/embryo mortality) due to the withdrawals is 0.3 feet. The protected spawnable width of the channel (i.e., the spawnable width not subject to dewatering) was 132.3 feet without the withdrawals and 130.8 feet with the withdrawals. The withdrawals therefore reduce the protected spawnable width of the channel by 1.5 feet.

The potential effects of the diversions on side-channel incubation (see Chapter 7.3.3.2) indicated an average reduction of 1.5 acres of side-channel habitat over that occurring without the withdrawals. According to Burgner (1991), sockeye salmon tend to utilize spring-fed ponds and side channels for spawning more than any other species of salmon. Therefore, the loss of these side-channel habitats could have more of an effect on sockeye salmon than other salmon species if sockeye are spawning in side channels in the Green River. However, the overall numbers of sockeye using the middle Green River for spawning is low.

Because sockeye salmon will not be introduced into the upper watershed, the effects of Tacoma's water withdrawals on sockeye salmon will not be offset by the increased availability of spawning habitats in the upper basin. However, the combined measures of gravel nourishment (see Chapter 5) and the reconnection and restoration of side-channel habitats at several locations in the middle Green River will benefit sockeye spawning and incubation.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect sockeye salmon spawning incubation in the middle watershed.

7.4.3.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Spawning and Incubation

Because of similarities in spawning and incubation timing and habitat requirements, the same analysis applied to coho salmon (see Chapter 7.3.3.3) should be applicable to sockeye; Tacoma's water withdrawals will increase potential spawning habitat in the lower watershed by an average of 12.2 percent.

The opportunities for improving spawning habitat in the lower Green River are limited due to channel modifications directed toward flood control. Even so, the results of the habitat and flow analysis noted above suggest a potential net increase in the amount of available spawning habitat with Tacoma's water withdrawals.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect sockeye spawning and incubation in the lower watershed.

7.4.4 Sockeye Juvenile Rearing

7.4.4.1 Upper Watershed

It is assumed that sockeye salmon will not be introduced into the upper Green River watershed (for reasons noted in Chapter 7.4) and therefore Tacoma's water withdrawal, watershed management activities, and associated conservation measures will not affect sockeye salmon juvenile rearing in that segment of the river.

7.4.4.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Juvenile Rearing

Water Withdrawal. River-type juvenile sockeye salmon presumably will utilize similar habitat features as coho, including mainstem areas, as well as and perhaps most importantly side-channel and slough habitats. Tacoma's water withdrawals will affect both habitat types. The analysis of such effects on juvenile sockeye rearing habitat was again (absent species specific data and information) based on that for coho salmon, the results of which are summarized below.

Because juvenile fish typically utilize areas of slower water velocities, the results of the habitat:flow modeling completed for coho indicated an overall increase in juvenile habitat (10.2 percent) resulting from Tacoma's water withdrawals compared to a no-diversion condition. This is because flows that are higher than those providing optimal rearing habitats are usually present in the middle watershed. Rearing habitat in mainstem rivers is often associated with channel margins that contain slow velocities and physical cover features (e.g., undercut banks, LWD) conducive to juvenile rearing. The analysis completed for coho suggested that an average of 7.5 feet (3.25 feet per side) (see Chapter 7.3.3.3) of wetted channel will be lost during summer low flow conditions in the middle Green River, which will likely translate to reductions in channel margin habitat.

For the side channels, the coho analysis (see Chapter 7.3.3.3) indicated a 12.6 percent reduction (e.g., 1.6-acre reduction in wetted area) in total wetted area in the side channels located between RM 61.0 and 33.8. That segment of the Green River contains the majority of side channels below HHD.

The conservation measures that will improve juvenile sockeye habitat are the same as those described for chinook and coho salmon (see Chapter 7.1.4.2). These measures include reconnecting and rehabilitation the Signani Slough side channel, and placement of LWD in the river channel. Some additional temperature benefits on juvenile rearing habitat will also likely result from coldwater releases from HHD (see Chapter 7.3.4.2).

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect sockeye juvenile rearing in the middle watershed.

7.4.4.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Sockeye Juvenile Rearing

Water Withdrawal. Based on the juvenile habitat:flow models developed for coho for the lower Green River, Tacoma's water withdrawals were estimated to result in an average increase in juvenile habitat of over 15 percent (see Chapter 7.3.4.3). Because of the channelized nature of sections of the lower Green River (for flood control purposes), reductions in wetted channel widths and off-channel habitats will be small. Water quality problems do exist in the lower Green River (see Chapter 7.1.4.3). However, the effects of HHD and Tacoma's water withdrawal activities will not extend sufficiently far downstream to substantially affect water quality conditions (particularly temperature) in the lower Green and Duwamish rivers.

Conservation measures for juvenile sockeye salmon will focus largely on areas in the middle sections of the Green River. Habitat quality in the lower Green River is generally poor (due to channelization for flood control); therefore, the conservation measures will not affect sockeye juvenile rearing habitat in the lower watershed.

7.5 Effects of Water Withdrawal and Habitat Conservation Measures on Chum Salmon *(Oncorhynchus keta)*

This section describes the potential effects of Tacoma's water withdrawal activities on chum salmon and the potential benefits to this species resulting from habitat conservation measures. Two chum stocks are present in the Green River basin: 1) Duwamish/Green fall chum; and 2) Crisp Creek fall chum. The number of fish observed during chum spawner surveys conducted in the Green River shows the number of fish varying from 0 to 700 fish per year; most of these fish were observed in tributaries and were possible Crisp Creek (Keta) hatchery fish. No escapement data is available for the Duwamish/Green stock, and the status of native chum in the Green River is considered Unknown (WDFW et al. 1994). The fall chum observed in Crisp Creek are likely naturally spawning hatchery fish (also known as Keta Creek chum) (WDFW et al. 1994). The Crisp Creek chum stock is considered healthy (WDFW et al. 1994). The chum salmon ESU for the Puget Sound/Strait of Georgia continues to be impacted by increasing harvest rates. However, increasing trends in escapement of chum in this ESU suggest that chum salmon are abundant and have been increasing in abundance in recent years (see Appendix). For this reason, NMFS has concluded that this ESU is not currently at risk of extinction, nor is it likely to become endangered in the future.

Separate analyses are presented for each of the major life history stages of chum salmon, including upstream migration, downstream migration, spawning and incubation, and juvenile rearing. The methods used in these analyses are the same as those applied to chinook salmon in Chapter 7.1, except for differences in the periodicity of chum salmon life stages and in their habitat requirements (see Appendix). The analysis is further segregated by different segments of the Green River, corresponding to upper watershed, middle watershed, and lower watershed (see Chapter 2).

7.5.1 Chum Upstream Migration

7.5.1.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Upstream Migration

Water Withdrawal. The major spawning areas for chum salmon in the Green River are the braided sections of the mainstem below the Gorge, in side-channel areas of the middle Green River, and in major tributaries to the middle river including Burns, Crisp, and Newaukum creeks (Dunstan 1955; Grette and Salo 1986). Few native chum have been observed upstream of the confluence of Crisp Creek (RM 41.0) (WDFW et al. 1994). The Headworks diversion structure prevents the upstream migration of adult chum salmon above RM 61.0. However, it is unlikely that many chum migrate this far upstream based upon the results of prior studies on the distribution of spawners in the Green River basin.

Upstream passage of adult fish will be provided by a permanent fish collection and transport facility at the Tacoma Headworks. However, this upstream passage facility is not expected to benefit chum salmon, since very few chum are likely to migrate upstream as far as the Headworks facility. The number of adult chum reintroduced into the upper watershed by the fish collection and transport program will not be sufficient to establish a self-sustaining run in the upper watershed. Moreover, survival of any outmigrating chum fry passing downstream through the HHD reservoir will likely be poor.

Watershed Management. Because few chum salmon are expected to be introduced into the upper watershed, Tacoma's forest management activities and associated conservation measures will not affect chum salmon upstream migration in the upper watershed.

7.5.1.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Upstream Migration

Water Withdrawal. Analysis of transect and stage-discharge data collected by Ecology (Caldwell and Hirschey 1989) at shallow riffles in the middle Green River indicate that passage for adult chinook salmon should not be impeded by flows greater than 225 cfs (assuming a minimum passage depth of 1.0 foot). The upstream passage of chum salmon should also not be impeded, since chum can migrate through shallower areas than chinook salmon.

Under HCM 1-01, Tacoma will guarantee minimum flows greater than 225 cfs at the Auburn gage from 15 July to the end of flow augmentation from HHD during all years. The SDWR is conditioned on maintaining a 300-cfs minimum flow at Palmer gage throughout the rest of the chum salmon upstream migration period. Because these minimum flows satisfy the upstream passage requirements of chinook salmon (see Chapter 7.1.1.2), they will also satisfy the upstream passage requirement of chum salmon.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect chum upstream migration in the middle watershed.

7.5.1.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Upstream Migration

Water Withdrawal. Tacoma's water withdrawals will likely have less of an influence on chum salmon than chinook salmon (see Chapter 7.1.1.1), since chum commence upstream migration and spawning almost 2 months later than chinook salmon in the Green River. Chum salmon migrate into the river from early September through late December, and spawn from early November through mid-January (Grette and Salo 1986). Chum migration and spawning occurs during the late fall and early winter when flows in the Green River are often high and upstream passage is less likely to be a problem.

Because water depths in the lower river are sufficient for upstream passage of chinook salmon when flows at the Auburn gage exceed 200 cfs, Tacoma's water withdrawals are not expected to impede the upstream passage of chum salmon in the lower Green River. Chum salmon have the ability to migrate into shallow, low-velocity streams and side channels (Johnson et al. 1997), and therefore have a greater ability to pass upstream through shallow areas than do chinook salmon. Due to their later migration and spawning period, warmwater temperatures and low DO concentrations in the lower Green River will have less of a potential impact on the upstream migration of chum salmon than for chinook salmon.

The minimum instream flow requirements provided under HCM 1-01 during the fall and early winter migration period of chum salmon will provide adequate water depths for upstream passage through the lower watershed (see Chapter 7.3.1.1). Some delay may occur during sustained low flow periods early in the migration season due to poor water quality conditions and lack of migration cues, although these conditions probably occur for a short duration during the late fall and early winter migration period of chum salmon.

The AWS project includes a provision for the optional annual storage of up to 5,000 ac-ft of water to be used for fisheries purposes. Under dry year or drought conditions, any storage targeted to augment flows or provide a freshet in the late summer and early fall for adult chinook salmon migration and holding could benefit chum salmon, though chum are less likely to benefit since they migrate upstream later than chinook.

Watershed Management. Tacoma's forest management activities and conservation measures will not affect chum upstream migration in the lower watershed.

7.5.2 Chum Downstream Migration

7.5.2.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Downstream Migration

Water Withdrawal. Tacoma's water withdrawals will primarily affect the downstream passage of juvenile chum salmon in the Green River below the Headworks diversion facility. Tacoma's water supply diversions will probably have little impact on the downstream migration of chum salmon fry from the upper watershed, since few fry will be produced in the upper watershed.

As mentioned previously, Tacoma will be the local sponsor of the downstream fish passage facility to be installed at HHD. The operation of this facility is important to maintain high survival levels of coho salmon, chinook salmon, and steelhead smolt passing downstream through Howard Hanson Reservoir and Dam following the reintroduction of these species into the upper Green River. However, this downstream fish passage facility will provide little tangible benefit to chum salmon because it is unlikely that this species will become established in the upper watershed.

Watershed Management. Because few chum salmon are expected to be introduced into the upper watershed, Tacoma's forest management activities and associated conservation measures will not affect chum salmon downstream migration in the upper watershed.

7.5.2.2 Middle and Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Downstream Migration

Water Withdrawal. The number of chum fry passing downstream through the Headworks diversion pool that could be potentially impinged on the existing screens or entrained into the water intake at the diversion is likely to be very small, since few if any chum will be produced in the upper Green River watershed. However, reduced flows resulting from Tacoma's FDWRC and SDWR withdrawals are expected to result in decreased conditions of outmigrant survival for chum salmon fry in the Green River below Headworks at RM 61.0. As is the case for chinook salmon (see Chapter 7.1.2.2), the survival of downstream migrating chum salmon is assumed to be a function of flow, with survival increasing as river discharge increases.

In order to quantify the impact of Tacoma's diversions on the survival of outmigrating chum salmon, daily estimates of the condition of instream migration were calculated for Green River flows under the HCP flows (Green River flows **with** the AWS project and **with** Tacoma withdrawals) compared to Green River flows **without** the AWS project and **without** Tacoma withdrawals. The survival condition of outmigrating chum fry under each flow regime was calculated on a daily basis during the chum outmigration period (16 February through 31 May) using the same method applied to chinook salmon fry (see Chapter 7.1.2.2).

The results of this analysis indicate that the flow reductions caused by Tacoma's water withdrawals under the FDWRC and SDWR could result in an average reduction in chum salmon fry outmigrant survival condition of 5.0 percent (Table 7-16). Predicted reductions in yearly chum outmigrant survival values caused by these water withdrawals ranged from 2.4 percent to 7.2 percent for the 1964-1995 period.

As described earlier, Tacoma will install a downstream fish bypass facility at the Headworks at RM 61.0 that includes a 220-by-24-foot conventional screen. This conservation measure will significantly improve the survival of outmigrating juvenile coho salmon, chinook salmon, and steelhead, but will not provide tangible benefits to chum salmon because very few chum fry are expected to be produced in the upper watershed.

Flows in the Green River below HHD **with** the AWS project (i.e., early reservoir refill) will be reduced during March and April compared to the flows occurring **without** the

AWS project. Water stored in the reservoir during this period will be used to augment flows in May and June under the AWS project. Analysis of AWS project impacts on downstream migration of anadromous salmonids suggests that chum salmon are the primary salmonid species directly impacted by the early storage of water. Chum salmon are more likely to be affected by the AWS project flow measures because their peak outmigration period (March and April) coincides with the period when river flows will be reduced by these measures.

The effects of the AWS project flow measures on chum salmon outmigrant survival condition were calculated using the same method used for juvenile chinook salmon (see Chapter 7.1.2.2). The AWS project flow measures were predicted to result in an average reduction in yearly survival of 0.3 percent (Table 7-16). The greatest reduction in yearly survival condition values caused by the AWS project flow measures were predicted during 1978 (-2.9 percent), while survival was predicted to be improved slightly during 1992 (1.9 percent). Flows in the Green River are relatively high during April and May, and the reductions in flow during this period resulting from the AWS project were not great enough to significantly reduce the survival of chum outmigrants.

These losses may be partially mitigated by increased survival of hatchery-reared chum fry. Assuming artificial freshets are released from HHD to maintain a flow of 2,500 cfs at Auburn for a 38-hour period during the chum outmigration period, hatchery managers could benefit instream migration conditions of hatchery-reared chum fry by releasing the fry during the planned freshets. Between 1992 and 1996, an average of 732,000 chum fry were released into the Green River from hatcheries. During this period, hatchery-reared chum fry have been released into the Green River at an average flow of 1,473 cfs, measured at Auburn. The size of fish and the date of release are dictated by considerations such as growth rate, available hatchery rearing space, general health of the fingerlings, and instream conditions during release. However, assuming that chum fry could be released during a planned freshet, the survival condition of chum fry will increase by 24.3 percent compared to 1992-1996 release conditions.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect chum downstream migration in the middle and lower watershed.

7.5.3 Chum Spawning and Incubation

7.5.3.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Spawning and Incubation

Because few if any chum adults are expected to be introduced into the upper Green River watershed via the trap-and-haul facility at Headworks, Tacoma's water withdrawals, watershed management activities, and the associated conservation measures will have no significant effects on chum spawning and incubation in the upper watershed.

7.5.3.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals will affect the availability of chum salmon spawning habitat in both the mainstem river and side-channel areas of the middle Green River. The side channels in the middle Green River are probably more important to chum salmon spawning than any other anadromous fish species present in the basin. Chum salmon are more likely to spawn in shallow, low-velocity streams and side channels than other salmon species (Johnson et al. 1997). Muckleshoot Tribal biologists surveying the Green River during 1996 reported significant numbers of chum spawning in side channels of the middle Green River. The majority of chum salmon in the Green River watershed may be produced in side channels and tributaries including Newaukum, Crisp, and Burns creeks (Dunstan 1955; WDFW et al. 1994). Chum spawning and incubating in the tributaries will not be directly affected by Tacoma's withdrawals.

Flow reductions caused by Tacoma's FDWRC and SDWR withdrawals could increase the susceptibility of chum salmon redds to dewatering in the mainstem and side-channel areas of the middle Green River. The potential effects of Tacoma's withdrawals on mainstem chum salmon spawning habitat in the middle Green River were quantified using the same method applied to chinook salmon (i.e., based upon Ecology's Green River IFIM study; see Chapter 2.1.3.2). Daily potential chum salmon spawning habitat values were calculated for Green River flows **with** Tacoma withdrawals, and Green River flows **without** Tacoma withdrawals, using habitat and flow functions developed for Green River chum salmon by Ecology (Caldwell and Hirschey 1989). Based on this analysis, potential chum salmon spawning habitat in the main channel of the middle Green River was predicted to be improved by an average of 17.8 percent during the chum salmon spawning period (1 November through 15 January) by exercise of the FDWRC and SDWR (Table 7-17). The only decrease in chum spawning habitat resulting from municipal water withdrawals (-4.3 percent) was predicted during 1987, a drought year. In contrast, the water withdrawals were predicted to result in an 29.0 percent increase in potential spawning habitat area during 1984, an average year.

Results of Ecology's IFIM study (Caldwell and Hirschey 1989) predicted that flows between 260 and 450 cfs provide optimal spawning habitat conditions for chum salmon in the middle Green River. Because flows in the Green River exceed this optimum range throughout much of the early November through mid-January spawning period of chum salmon, Tacoma's withdrawals are predicted to result in an overall improvement in spawning conditions in the mainstem middle Green River.

As mentioned earlier, the side channels of the middle Green River may be more important than the main channel to chum salmon spawning. The potential effects of Tacoma's water withdrawals on chum salmon spawning habitat area in the side channels of the middle Green River were quantified using wetted side-channel area and discharge relationships. Chum salmon spawning habitat in the side channels was quantified using the same procedure applied to chinook salmon (see Chapter 7.1.3.2). Side-channel habitat area values were calculated on a daily basis during the chum salmon spawning period for a 32-year period (1964-1995). The results of this analysis indicates that Tacoma's water withdrawals will reduce the wetted area of side channels in the middle Green River by an average of 10.6 percent during the chum spawning period (Table 7-18). This represents a 1.7-acre reduction in the average wetted area of side channels in the middle Green River during the chum spawning period.

The potential impacts of Tacoma's diversions on chum salmon incubation were assessed by calculating the width of the channel subject to dewatering (i.e., dewatered spawnable width) using the same method applied to chinook salmon (see Chapter 7.1.3.2 and Chapter 7.3.3.2). Dewatered channel widths were calculated on a daily basis for the chum salmon spawning period, and assumed a 90-day incubation period (i.e., time from egg deposition to fry emergence). The average spawnable width of the main river channel during the chum spawning period was predicted to be 139.8 feet without Tacoma's water withdrawals, and 138.6 feet with the water withdrawals (based upon cross-section and rating curve data obtained at Transect 4 of the Nealy Bridge IFIM site) (Table 7-19). For days when redd dewatering was predicted to occur, the dewatered spawnable width of the channel averaged 5.5 feet without Tacoma's water withdrawals and 5.8 feet with the water withdrawals. Thus, the water withdrawals are predicted to result in an average increase of 0.3 feet in the dewatered width of the channel during those days when redd dewatering is predicted to occur (Table 7-19). This represents a very small portion of the total width of the channel (i.e., 0.14 percent) within which chum salmon can potentially spawn. The protected spawnable width of the channel (i.e., the spawnable width not subject to dewatering) was 134.3 feet without the withdrawals and 132.8 feet with the withdrawals. The withdrawals therefore reduce the protected spawnable width of the channel by 1.5 feet. The water withdrawals were not found to increase the frequency of dewatering during the 75-day incubation period chum salmon. Dewatering of some portion of the spawnable width of the channel is predicted to occur for an average of 31 days both without and with the withdrawals (i.e., 41 percent of the days in the spawning period).

The potential impacts of Tacoma's water withdrawals on chum salmon incubation in the side channels of the middle Green River were analyzed using the side-channel habitat area and discharge curves developed by the USACE (1998). Effects of the diversions on incubation in the side channels were quantified on a daily basis for a 32-year period (1964-1995) using the same method applied to chinook salmon incubation (see Chapter 7.1.3.2). Tacoma's FDWRC and SDWR withdrawals are predicted to reduce the total area of the side channels during 2-day low flow events (i.e., the event most likely to result in redd dewatering) by an average of 1.5 acres (loss of 17.3 percent) from that occurring without the water withdrawals during the incubation period of chum salmon (Table 7-20).

The gravel nourishment conservation measure (see Chapter 5) will benefit chum salmon spawning habitat in the middle Green River by augmenting gravel recruitment lost from the upper watershed due to HHD. Reconnection and restoration of side channels will also improve spawning habitat conditions by providing up to 3.4 acres of additional side channel habitat in the middle Green River, an increase of approximately 22 percent over the total existing area of side-channel habitat potentially available to spawning chum salmon.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have little effect on chum spawning habitat in the main channel and side channels. These flow measures will only modify the flow regime of the Green River between 1 March and 30 June, which is after the November through January spawning period of chum salmon. The AWS project early refill flow measures in the main channel of the middle Green River are minor, as the average increase in dewatered spawnable width predicted to result from these flow measures is 0.1 feet for days when redd dewatering is predicted to occur (Table 7-19). The AWS project early refill measure will not result in a change in the frequency of days when dewatering occurs.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect chum spawning and incubation in the middle watershed.

7.5.3.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Spawning and Incubation

Water Withdrawal. Due to extensive channelization, spawning habitat for chum salmon, like that for coho and chinook salmon, is relatively poor in the lower Green River watershed compared to that in the middle watershed. Potential chum salmon spawning habitat and discharge relationships obtained for the lower Green River from Ecology's instream flow study (Caldwell and Hirschey 1989) were used to quantify the impacts of FDWRC and SDWR water withdrawals on chum salmon spawning habitat in the lower Green River. Tacoma's water withdrawals are predicted to increase potential chum spawning habitat in the lower Green River by an average of 16.2 percent for the November through January spawning period (Table 7-17). This estimate applies to main channel habitat only, since there are few side channels of significant size in the lower Green River.

The opportunities for improving spawning habitat in the lower Green River are very limited due to the disturbed condition of the river channel, which has been extensively modified for flood control purposes. For this reason, those conservation measures that will result in improvements in chum salmon spawning habitat and incubation (e.g., reconnection and restoration of side channels) focus mainly on the middle section of the Green River.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have little effect on chum spawning habitat and incubation in the lower Green River for the same reasons previously described for the middle Green River (see Chapter 7.5.3.2). Impacts of the AWS project on chum salmon incubation in the lower Green River are expected to be fewer than those in the middle Green River (i.e., average 0.1 feet increase in dewatered spawnable width).

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect chum spawning and incubation in the lower watershed.

7.5.4 Chum Juvenile Rearing

7.5.4.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Juvenile Rearing

Tacoma's water withdrawals, watershed management activities, and associated conservation measures will not affect juvenile chum habitat in the upper Green River, since few if any chum spawners are expected to be introduced into the upper watershed as a result of the trap-and-haul program at the Headworks.

7.5.4.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals potentially affect juvenile chum salmon habitat in the middle Green River by reducing flows below Headworks by up to 213 cfs on a daily basis. The withdrawals likely will have a similar effect on chum salmon as they do on chinook salmon (see Chapter 7.1.4.2), because both species have an ocean-type life cycle (i.e., juveniles reside in the river for less than 1 year before migrating to the ocean). Chum salmon fry are present in the Green River from mid-March through mid-July, though most fry outmigrate to the ocean by the end of May. Chum salmon juveniles are typically not present in the drainage during the remainder of the year.

Tacoma's FDWRC and SDWR withdrawals potentially affect chum salmon rearing in both the main river channel, as well as in the side channels present along the middle Green River. The side-channel areas are important to chum salmon fry, which prefer low velocity off-channel habitat areas within which to rear during their relatively short period of residency in the Green River prior to migrating to estuary areas of the Duwamish River and Elliott Bay.

The effects of Tacoma's withdrawals on chum salmon fry habitat were quantified using IFIM potential habitat area and flow functions developed for the middle Green River by Ecology. Habitat area and flow functions were not developed for chum fry as part of

Ecology's instream flow study. For this reason, the functions developed by Ecology for chinook salmon juveniles in the middle Green River were used to quantify the effects of the municipal water withdrawals on chum salmon. Chinook salmon juveniles can hold in slightly faster and deeper water than chum salmon fry, so they serve as a conservative surrogate for estimating the potential influence of Tacoma's water withdrawals on this life stage.

Daily habitat values for chum fry occurring under HCP conditions (Green River flows **with** the AWS project and **with** Tacoma withdrawals) were compared with those occurring under Green River flows **without** the AWS project and **without** Tacoma withdrawals for the period when chum salmon fry are present in the river (mid-February through mid-June) (see Chapter 7.1.3.2 for a description of the methods used for this habitat analysis). The analysis indicated that Tacoma's withdrawals will result in an average 11.4 percent increase in chum salmon fry habitat in the mainstem sections of the middle Green River (Table 7-21). Flows in the middle Green River are usually higher than those considered to be optimal for juvenile chinook salmon by the Ecology instream flow study (Caldwell and Hirschey 1989); this relationship applies to chum salmon fry to an even greater extent since they prefer lower velocity waters. Consequently, Tacoma's withdrawals are expected to have a positive net effect on chum salmon rearing habitat in the main channel of the middle Green River.

As in the case of coho salmon, Tacoma's water withdrawals will likely reduce the amount of margin habitat available to chum salmon fry along the main channel of the Green River (see Chapter 7.3.4.2). The reductions in margin habitat area are likely to pose less of an impact to chum salmon fry in the middle Green River, since they remain in the mainstem channel for a relatively short period of time, after which they migrate to side-channel areas or the estuary areas of the Duwamish River and Elliott Bay.

The potential effects of Tacoma's water withdrawals on chum salmon rearing habitat in the side channels of the middle Green River were quantified using the same wetted side-channel area versus discharge relationships applied to chinook salmon fry (see Chapter 7.1.4.2). Changes in the availability of side-channel area were calculated for the chum salmon rearing period in the Green River (mid-February through mid-June). The results of this modeling effort predicted an average 18.4 percent loss in the total wetted area of side channels in the middle Green River resulting from Tacoma's water withdrawals during the chum salmon rearing period (Table 7-22). This represents a 1.4-acre reduction in the wetted area of side channels in the middle Green River during the chum salmon rearing period.

The habitat conservation measures intended to improve juvenile chum salmon habitat are the same as those designed to improve juvenile chinook habitat in the middle Green River (see Chapter 7.1.4.2). These measures include reconnecting and rehabilitation the Signani Slough side channel, and placement of LWD in the river channel downstream of Tacoma's Headworks. These measures will improve chum salmon rearing habitat in the middle Green River by providing up to 3.4 acres of additional off-channel habitat to chum salmon fry and increasing the number and quality of pools associated by increasing LWD loadings. These mitigation measures will be very beneficial to chum salmon fry, which may require the low-velocity areas provided by off-channel habitat during their late winter and early spring rearing period. Flows in the main channel of the Green River are relatively high during this period, which likely results in poor rearing habitat conditions for chum salmon fry in these areas.

As described for chinook salmon, some benefits will also be realized for several miles of the Green River below HHD by improving (decreasing) water temperatures for salmonids. Temperature modeling results indicated that the natural inflow to HHD exceeds the state Class "AA" temperature standard of 61ºF (16.0ºC) in most years. However, any temperature benefits to chum salmon fry are likely to be insignificant, since most chum fry are only present in the Green River during cooler periods of the year (i.e., late winter through spring).

Watershed Management. Tacoma's forest management activities and conservation measures will not affect chum juvenile rearing in the middle watershed.

7.5.4.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Chum Juvenile Rearing

Water Withdrawal. As with the middle Green River, flow reductions resulting from the FDWRC and SDWR are predicted to improve mainstem habitat conditions for chum salmon fry in the lower Green River, but will also reduce the availability of side-channel habitats. Habitat values were calculated on a daily basis for the chum salmon rearing period to quantify the effects of Tacoma's water withdrawals on chum salmon fry in the lower Green River (the same method used for chinook salmon fry were applied to chum salmon; see Chapter 7.2.4.2). The results of this analysis indicate that Tacoma's water withdrawals will increase mainstem habitat for chum salmon fry by 19 percent on average (Table 7-21). Improvements to chum fry condition in the mainstem river due to the water withdrawals occur because flows in the Green River during the rearing period are usually considerably higher than the range of flows considered to be optimal for chum fry.

Since there is little off-channel habitat in the lower Green River due to extensive channelization for flood control, impacts of the municipal water withdrawals on off-channel habitat conditions for chum salmon will be small.

As described for chinook salmon (see Chapter 7.1.4.3), water quality problems within the lower Green River include water temperature, DO, nutrient enrichment, and a variety of pollutants. However, the effects of HHD and Tacoma's water withdrawal activities will not extend sufficiently far downstream to significantly affect water quality conditions (particularly temperature) in the lower Green and Duwamish rivers.

Habitat for juvenile chum salmon is generally poor in the lower Green River as a result of channelization for flood control, especially because most side channels in this section of the river have been eliminated. Most chum salmon in the lower Green River rear in the estuary areas of the Duwamish River, or migrate into the shallows of Elliott Bay. For this reason, mitigation measures for juvenile chum salmon, like chinook salmon, focus on habitat enhancement of the upper and middle Green River.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect chum juvenile rearing in the lower watershed.

Table 7-16. Comparison of the effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and the AWS project on an index of outmigrant survival conditions for chum salmon fry in the Green River, Washington, 1964-1995.

	Total Daily Difference in Survival Values (percent)	
Year	Effects of Water Withdrawals	Effects of AWS Project
1964	-4.26	-0.42
1965	-5.18	-1.35
1966	-4.61	0.72
1967	-6.22	-2.25
1968	-6.07	0.42
1969	-3.93	-2.27
1970	-5.78	-0.36
1971	-4.48	-1.05
1972	-2.46	0.46
1973	-7.15	1.31
1974	-2.35	-0.59
1975	-5.48	0.08
1976	-4.85	-1.77
1977	-6.77	-0.18
1978	-7.07	-2.89
1979	-4.91	-0.47
1980	-4.35	-0.63
1981	-5.53	0.70
1982	-5.62	-0.63
1983	-6.28	-0.69
1984	-4.54	0.00
1985	-4.91	-0.18
1986	-5.82	0.67
1987	-5.01	-0.67
1988	-3.48	0.83
1989	-3.49	0.16
1990	-3.86	0.25
1991	-4.41	1.02
1992	-6.14	1.89
1993	-4.60	-0.87
1994	-5.63	0.11
1995	-6.11	-1.72
Mean	-5.04	-0.33
Minimum	-7.15	-2.89
Maximum	-2.35	1.89

Table 7-17. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on mainstem spawning habitat for chum salmon in the lower and middle Green River, Washington; 1964-1995. Potential habitat area values calculated from weighted usable area and flow functions developed by Ecology (Caldwell and Hirschey 1989).

	Change in Mean Daily Potential Mainstem Spawning Habitat Area			
	Lower River		Middle River	
Year	Acres	Percent	Acres	Percent
1964	4.8	14.5	12.6	23.0
1965	2.5	4.4	15.9	19.1
1966	4.3	15.6	7.7	16.0
1967	5.4	12.5	15.1	26.2
1968	5.7	25.7	8.5	19.2
1969	4.4	8.2	16.7	21.1
1970	6.4	14.5	14.6	22.9
1971	6.3	33.5	4.5	12.0
1972	4.0	9.8	12.6	19.9
1973	6.5	22.3	10.0	19.8
1974	3.5	9.1	8.6	13.0
1975	2.2	21.4	1.2	3.3
1976	3.2	5.2	21.0	26.4
1977	6.2	26.6	8.3	18.7
1978	5.9	14.7	12.8	22.3
1979	4.3	9.7	6.9	8.8
1980	5.4	22.9	8.1	17.7
1981	5.6	12.2	15.1	21.9
1982	5.9	14.4	14.8	24.5
1983	5.6	23.7	7.3	16.3
1984	9.9	20.7	17.8	29.0
1985	4.2	7.8	17.3	22.3
1986	7.8	18.6	16.6	28.4
1987	1.3	2.1	-4.7	-4.3
1988	4.4	27.8	3.7	9.8
1989	5.6	18.6	7.6	15.1
1990	3.7	21.4	5.0	12.1
1991	4.4	10.5	10.1	15.7
1992	8.2	19.0	13.5	24.2
1993	2.8	5.8	7.6	9.1
1994	8.8	28.5	10.9	24.6
1995	3.0	17.6	4.1	10.2
Mean	5.1	16.2	10.4	17.8

Table 7-18. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on side channel habitat area during the chum salmon spawning period (November through January) in the middle Green River, Washington; 1964-1995. Habitat area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Mean Daily Side Channel Habitat Area Due to Water Withdrawals	
Year	Acres	Percent
1964	-1.8	-9.6
1965	-1.6	-14.7
1966	-1.7	-7.9
1967	-1.8	-11.8
1968	-2.0	-9.2
1969	-1.7	-15.7
1970	-1.7	-12.2
1971	-2.2	-10.7
1972	-1.5	-8.6
1973	-1.9	-10.1
1974	-1.8	-11.0
1975	-1.4	-5.0
1976	-1.7	-16.6
1977	-1.4	-6.0
1978	-1.9	-12.3
1979	-1.6	-11.2
1980	-1.8	-8.4
1981	-1.6	-12.2
1982	-1.6	-9.9
1983	-1.9	-9.1
1984	-1.7	-13.8
1985	-1.5	-11.5
1986	-1.7	-10.7
1987	-1.3	-17.3
1988	-2.1	-9.0
1989	-1.7	-8.4
1990	-1.3	-5.2
1991	-1.6	-10.3
1992	-1.9	-14.6
1993	-1.6	-12.9
1994	-1.7	-9.3
1995	-1.4	-5.5
Mean	-1.7	-10.6
Minimum	-2.2	-17.3
Maximum	-1.3	-5.0

Table 7-19. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on spawnable widths and dewatered widths during the chum salmon spawning period in the middle Green River, Washington; 1964-1995. Spawnable width and dewatered width values were calculated from transect cross-section and stage-discharge data collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Spawnable Width (ft)					Dewatered Width (ft)				
Year	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project
1964	140.0	140.0	141.2	-1.2	0.0	6.6	6.4	5.7	0.7	-0.2
1965	135.3	135.3	136.6	-1.3	0.0	2.0	2.0	2.2	-0.2	0.0
1966	141.6	141.6	142.7	-1.1	0.0	6.3	6.5	6.4	0.1	0.2
1967	138.8	138.8	140.1	-1.3	0.0	6.0	6.0	6.4	-0.4	0.0
1968	141.4	141.4	142.5	-1.1	0.0	5.0	5.0	4.8	0.2	0.0
1969	135.4	135.4	136.7	-1.3	0.0	1.4	1.4	1.1	0.3	0.0
1970	137.7	137.7	138.9	-1.2	0.0	4.4	4.2	4.3	-0.1	-0.2
1971	141.1	141.1	142.2	-1.1	0.0	3.5	3.5	3.5	0.0	0.0
1972	140.2	140.2	141.5	-1.3	0.0	9.6	10.4	9.2	1.2	0.8
1973	139.8	139.8	141.0	-1.2	0.0	4.1	4.3	4.5	-0.2	0.2
1974	138.5	138.5	139.6	-1.1	0.0	5.4	5.7	5.1	0.6	0.3
1975	147.6	147.6	148.4	-0.8	0.0	9.1	9.5	8.9	0.6	0.4
1976	135.0	135.0	136.5	-1.5	0.0	3.2	3.2	3.4	-0.2	0.0
1977	144.9	144.9	145.9	-1.0	0.0	12.6	12.5	11.7	0.8	-0.1
1978	138.1	138.1	139.3	-1.2	0.0	3.7	3.7	3.6	0.1	0.0
1979	137.4	137.4	138.5	-1.1	0.0	6.2	6.2	6.3	-0.1	0.0
1980	141.7	141.7	142.8	-1.1	0.0	6.5	6.5	6.3	0.2	0.0
1981	137.0	137.0	138.2	-1.2	0.0	4.2	4.4	4.0	0.4	0.2
1982	139.0	139.0	140.3	-1.3	0.0	6.1	6.3	6.0	0.3	0.2
1983	141.3	141.3	142.4	-1.1	0.0	4.8	4.9	4.8	0.1	0.1
1984	136.6	136.6	137.9	-1.3	0.0	1.4	1.4	1.4	0.0	0.0
1985	136.7	136.7	138.0	-1.3	0.0	7.1	7.1	6.8	0.3	0.0
1986	138.9	138.9	140.2	-1.3	0.0	8.8	8.8	7.6	1.2	0.0
1987	132.6	132.6	133.8	-1.2	0.0	5.2	5.2	4.4	0.8	0.0
1988	142.0	142.0	143.1	-1.1	0.0	3.6	3.7	3.2	0.5	0.1
1989	141.6	141.5	142.6	-1.1	-0.1	6.5	6.7	6.2	0.5	0.2
1990	145.6	145.6	146.5	-0.9	0.0	9.7	9.8	9.5	0.3	0.1
1991	138.6	138.6	139.8	-1.2	0.0	7.0	7.1	6.9	0.2	0.1
1992	137.4	137.4	138.6	-1.2	0.0	1.9	1.9	1.8	0.1	0.0
1993	136.1	136.1	137.3	-1.2	0.0	4.0	4.0	3.7	0.3	0.0
1994	140.7	140.7	141.8	-1.1	0.0	6.3	6.3	6.9	-0.6	0.0
1995	117.9	117.9	118.6	-1.0	0.0	9.9	9.9	9.6	0.3	0.0
Mean	138.6	138.6	139.8	-1.2	0.0	5.7	5.8	5.5	0.3	0.1
Minimum	117.9	117.9	118.6	-1.5	-0.1	1.4	1.4	1.1	-0.6	-0.2
Maximum	147.6	147.6	148.4	-0.8	0.0	12.6	12.5	11.7	1.2	0.8

Table 7-20. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on continuously wetted side channel habitat area (i.e., two-day low flow event) during the chum salmon incubation period (December through mid-April) in the middle Green River, Washington; 1964-1995. Habitat area changes calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Continuously Wetted Side Channel Area due to Water Withdrawals		Change in Continuously Wetted Side Channel Area due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-	-	-	-
1965	-1.9	-18.6	-1.0	-9.7
1966	-1.3	-17.1	0.0	0.0
1967	-1.6	-15.9	-1.2	-11.8
1968	-2.0	-23.2	0.0	0.0
1969	-1.2	-13.9	0.0	0.0
1970	-1.3	-17.0	0.0	0.0
1971	-1.2	-13.4	0.0	0.0
1972	-1.7	-13.5	0.0	0.0
1973	-1.7	-21.5	0.8	10.6
1974	-1.8	-17.3	0.0	-0.1
1975	-1.7	-20.5	0.0	0.0
1976	-1.9	-18.6	-1.3	-12.4
1977	-1.6	-20.4	0.0	0.0
1978	-1.8	-18.1	0.4	4.2
1979	-1.1	-15.2	0.0	0.0
1980	-1.4	-15.8	0.0	0.0
1981	-1.3	-25.1	0.0	0.0
1982	-1.1	-12.2	0.0	0.0
1983	-1.2	-14.7	0.0	0.0
1984	-1.3	-18.9	0.0	0.0
1985	-1.1	-15.2	0.0	0.0
1986	-1.2	-15.5	0.0	0.0
1987	-1.0	-12.1	0.0	0.0
1988	-1.3	-26.3	0.0	0.0
1989	-1.8	-17.5	0.0	0.0
1990	-1.9	-19.1	0.0	0.0
1991	-1.2	-13.2	0.0	0.0
1992	-1.4	-17.6	1.7	21.6
1993	-1.1	-15.8	0.0	0.0
1994	-1.1	-16.0	0.0	0.0
1995	-1.9	-18.4	-0.4	-3.7
Mean	-1.5	-17.3	0.0	0.0

Table 7-21. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on mainstem juvenile rearing habitat for chum salmon in the lower and middle Green River, Washington; 1964-1995. Habitat area values calculated from weighted usable area and flow functions discharge relationships collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Change in Mean Daily Mainstem Habitat Area Due to Water Withdrawals				Change in Mean Daily Mainstem Habitat Area Due to AWS Project			
	Lower River		Middle River		Lower River		Middle River	
Year	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
1964	2.3	13.6	1.3	5.6	0.6	3.2	0.6	2.5
1965	4.6	19.1	2.7	10.7	1.1	3.9	1.1	4.0
1966	6.7	24.6	4.0	15.2	0.8	2.4	0.9	3.1
1967	5.4	21.4	3.6	13.5	2.0	6.9	1.9	6.7
1968	5.9	23.0	3.6	14.0	-0.1	-0.4	0.3	1.0
1969	4.4	18.5	2.9	10.9	1.5	5.6	0.9	3.3
1970	5.2	21.1	3.1	11.9	1.3	4.4	1.1	3.9
1971	2.4	14.2	1.5	6.6	0.9	4.9	0.9	3.9
1972	1.5	9.5	0.7	3.1	0.2	1.0	0.1	0.5
1973	9.4	24.4	6.2	20.0	-0.3	-0.7	0.2	0.5
1974	1.0	6.8	0.7	2.9	0.4	2.3	0.5	2.4
1975	4.0	19.7	2.6	10.8	0.9	4.1	0.8	3.1
1976	5.2	22.2	3.2	12.6	2.3	8.9	1.8	6.9
1977	8.5	23.9	5.0	17.2	-0.3	-0.7	0.0	0.1
1978	8.2	24.6	5.3	18.2	0.8	2.1	0.6	1.8
1979	4.5	16.7	2.5	9.3	0.6	1.9	0.6	2.2
1980	5.3	19.6	3.3	12.4	0.3	0.9	0.5	1.5
1981	5.3	20.2	3.4	12.5	0.2	0.7	0.3	1.1
1982	4.6	20.5	2.9	11.4	1.2	4.6	1.3	5.0
1983	7.2	22.3	4.6	16.1	-0.7	-1.7	-0.1	-0.2
1984	3.0	16.6	1.9	8.0	0.8	3.8	0.7	2.8
1985	5.8	20.1	3.3	12.2	0.7	2.2	0.9	2.9
1986	5.6	19.3	3.2	11.7	-0.2	-0.7	-0.2	-0.7
1987	5.0	17.0	2.9	10.5	0.1	0.3	0.4	1.3
1988	4.4	19.1	2.3	9.3	0.4	1.6	0.3	1.2
1989	5.2	19.7	3.4	12.7	-0.4	-1.1	0.3	0.9
1990	2.6	14.6	1.3	5.5	-0.5	-2.2	-0.1	-0.5
1991	4.2	19.7	2.8	11.3	0.3	1.1	0.6	2.1
1992	6.6	15.1	4.0	11.7	-0.6	-1.2	0.3	0.7
1993	5.2	22.1	2.9	11.5	0.7	2.4	0.5	1.7
1994	6.6	20.2	3.9	13.6	-1.1	-2.8	-0.5	-1.4
1995	5.9	18.2	3.8	12.8	0.0	-0.1	0.6	1.9
Mean	5.0	19.0	3.1	11.4	0.4	1.8	0.6	2.1

Table 7-22. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on the area of side channels during the rearing period (mid-February through June) of chum salmon fry in the middle Green River, Washington; 1964-1995. Surface area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Continuously Wetted Side Channel Area Due to Water Withdrawals		Change in Continuously Wetted Side Channel Area Due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-1.8	-17.5	-0.7	-7.0
1965	-1.2	-17.8	-0.1	-1.9
1966	-2.0	-23.1	-0.4	-4.6
1967	-1.1	-16.5	-0.5	-7.5
1968	-1.3	-16.0	0.0	0.0
1969	-1.7	-19.9	-1.0	-12.3
1970	-1.3	-17.5	0.0	0.0
1971	-1.8	-15.7	-0.1	-1.1
1972	-1.8	-14.9	-0.5	-3.9
1973	-1.5	-20.0	0.5	7.3
1974	-1.7	-13.5	-0.6	-4.6
1975	-1.9	-19.1	-1.1	-11.2
1976	-2.0	-22.8	-0.2	-2.4
1977	-1.2	-19.1	-0.1	-2.1
1978	-1.1	-17.3	0.0	0.0
1979	-1.2	-19.9	-0.9	-14.1
1980	-1.1	-16.6	-0.6	-9.0
1981	-1.1	-14.5	0.0	0.0
1982	-1.3	-17.1	-0.1	-1.6
1983	-1.1	-17.4	0.7	10.4
1984	-1.8	-17.2	-0.5	-4.6
1985	-1.2	-17.2	0.0	0.0
1986	-1.2	-20.0	0.0	0.0
1987	-1.3	-24.5	0.0	0.0
1988	-1.1	-16.3	0.0	0.0
1989	-1.2	-18.2	-0.1	-1.2
1990	-1.9	-19.1	0.0	0.0
1991	-1.8	-20.5	0.0	0.5
1992	-1.3	-25.9	0.0	0.0
1993	-1.1	-14.0	0.0	0.0
1994	-1.2	-18.7	0.5	7.4
1995	-1.2	-19.8	0.1	2.0
Mean	-1.4	-18.4	-0.2	-1.9

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7.6 Effects of Water Withdrawal and Habitat Conservation Measures on Pink Salmon *(Oncorhynchus gorbuscha)*

Runs of pink salmon were historically present in the Green River during odd years prior to the 1930s (Grette and Salo 1986). However, these runs are no longer present in this river. Pink salmon occasionally stray into the Green River from the Puyallup River; however, the presence of these incidental fish does not imply that a run is present (Grette and Salo 1986). The greatest number of pink salmon observed in a single year in the Green River over last few decades is 13 fish (Hard et al. 1996). Pink salmon populations in the nearby Puyallup and Nisqually rivers are designated as healthy (WDFW et al. 1994). The NMFS recently completed a status review of pink salmon in the Pacific Northwest, and divided these fish into even- and odd-year ESUs. Neither ESU is considered warranted for listing under the ESA at this time (Hard et al. 1996).

7.6.1 Pink Salmon Upstream Migration

Potential Effects of Covered Activities and Conservation Measures on Pink Salmon Upstream Migration

Water Withdrawal. Pink salmon spawn from August through November, which coincides with the chinook salmon migration period. Pink salmon can pass through shallower water than fall chinook salmon because of their smaller size. Because water depths in the lower river are sufficient for upstream passage of chinook salmon when flows at the Auburn gage exceed 200 cfs, Tacoma's water withdrawals are not expected to impede the upstream passage of pink salmon in the lower Green River (see Chapter 7.2.1.1).

Under HCM 1-01, Tacoma will guarantee minimum flows of at least 250 cfs at the Auburn gage from 15 July to the end of low flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs. Tacoma will not use the SDWR if instream flows at Palmer fall below 300 cfs during the remainder of the year. These minimum instream flow requirements provide adequate water depths for the upstream passage of pink salmon. Some delay to anadromous forms may occur during sustained low flow periods early in the migration period due to poor water quality conditions and lack of migration cues in the lower river.

Upstream passage of adult fish will be provided by a permanent fish collection and transport facility at the Headworks. However, pink salmon, like chum salmon, are not expected to be introduced into the upper Green River watershed because they are not likely to migrate upstream as far as the Headworks diversion (RM 61.5). Pink salmon generally spawn in the lower reaches of streams and rivers, and have difficulty migrating upstream through large rapids and over waterfalls (Heard 1991). For this reason, pink salmon spawning should be limited to the lower and middle Green River downstream of the Green River Gorge.

Watershed Management. Because pink salmon are not expected to be introduced into the upper watershed, Tacoma's forest management activities and associated conservation measures will not affect pink salmon upstream migration.

7.6.2 Pink Salmon Downstream Migration

Potential Effects of Covered Activities and Conservation Measures on Pink Salmon Downstream Migration

Water Withdrawal. During the spring, pink salmon fry outmigrate to the ocean. Like chum salmon, pink salmon have an "ocean-type" life cycle, and migrate downstream shortly after emerging from gravels. The outmigration period of pink salmon fry in the Green River is probably similar to that of chum salmon (early March through late May). Impacts of the withdrawals are expected to be similar to those of chum salmon fry, a 5.0 percent reduction in survival condition compared to that occurring without the withdrawals (see Chapter 7.5.2.1).

As described earlier, Tacoma will install a downstream fish bypass facility at the Headworks that will significantly improve the survival of outmigrating juvenile coho salmon, chinook salmon, and steelhead. However, the benefits provided by this facility will not apply to pink salmon because this species is unlikely to spawn in the upper watershed.

The AWS project flow measures are predicted to result in an average reduction in yearly survival condition of chum fry outmigrants of 0.3 percent (see Chapter 7.5.2.2). The impact of these measures on the downstream survival of pink salmon fry should be similar, because pink outmigrate at the same time and same size as chum salmon. Flows in the Green River are relatively high during April and May, which limits the effects of the reservoir refill on downstream flow fluctuations.

Watershed Management. Because pink salmon are not expected to be introduced into the upper watershed, Tacoma's forest management activities and associated conservation measures will not affect pink salmon downstream migration.

7.6.3 Pink Salmon Spawning and Incubation

Potential Effects of Covered Activities and Conservation Measures on Pink Salmon Spawning and Incubation

Water Withdrawal. Pink salmon are unlikely to spawn in the upper Green River watershed, since very few fish are expected to migrate upstream as far as the trap-and-haul facility at the Headworks. Mainstem spawning habitat of pink salmon in the middle and lower reaches should be impacted by Tacoma's withdrawals to a lesser extent than chinook (see Chapter 7.1.3.2), because pink salmon spawn in shallower areas and at lower velocities than chinook salmon. Chinook salmon spawning habitat in the main channel of the middle Green River was predicted to be reduced by an average of 11.1 percent in the middle Green River by the FDWRC and SDWR withdrawals, and by an average of 15.5 percent in the lower Green River watershed by these withdrawals.

The redds constructed by pink salmon are potentially more vulnerable to dewatering than those of chinook salmon because pink salmon spawn in shallower water than do chinook. The effect of Tacoma's water withdrawals on pink salmon were calculated using the same method as for chinook salmon (see Chapter 7.1.3.2), except that a 0.5-feet minimum spawning depth was applied to pink salmon. Based upon this analysis, the average spawnable width of the main river channel during the pink salmon spawning period was predicted to be 138.1 feet without Tacoma's water withdrawals and 136.9 feet with the water withdrawals (Table 7-23). For days when dewatering was predicted to occur, the dewatered spawnable width of the channel averaged 4.1 feet without Tacoma's water withdrawals and 4.4 feet with the water withdrawals. Thus, the water withdrawals were predicted to result in an average increase of 0.3 feet in the dewatered width of the channel for those days when dewatering was predicted to occur during the pink salmon spawning and incubation period. This represents a very small portion of the total width of the channel (i.e., 0.22 percent) within which pink salmon can potentially spawn.

Because pink salmon spawn during the same period of the year as chinook salmon, the impacts of Tacoma's withdrawals on spawning and incubation habitat area in the side channels of the middle Green River should be similar to those for chinook salmon (see Chapter 7.1.3.2). Tacoma's withdrawals were predicted to reduce the wetted area of side channels in the middle Green River during the pink salmon spawning period by an average of 1.5 acres, which represents a 16 percent reduction during the 1964-1995 period. Effects of the water withdrawals on pink salmon incubation were quantified by comparing continuously wetted side-channel habitat for the lowest 2-day flow event

Table 7-23. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on spawnable widths and dewatered widths during the pink salmon spawning period in the middle Green River, Washington; 1964-1995. Spawnable width and dewatered width values were calculated from transect cross-section and stage-discharge data collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Spawnable Width (ft)					Dewatered Width (ft)				
Year	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project
1964	138.7	138.7	140.2	-1.5	0.0	5.0	5.0	4.9	0.1	0.0
1965	134.5	134.5	135.9	-1.4	0.0	1.6	1.6	1.7	-0.1	0.0
1966	136.3	136.3	137.6	-1.3	0.0	3.2	3.2	2.7	0.5	0.0
1967	136.3	136.3	137.6	-1.3	0.0	4.2	4.2	3.7	0.5	0.0
1968	140.6	140.6	141.9	-1.3	0.0	4.4	4.4	4.0	0.4	0.0
1969	135.5	135.5	136.9	-1.4	0.0	1.3	1.3	1.2	0.1	0.0
1970	136.0	136.0	137.2	-1.2	0.0	3.5	3.5	3.4	0.1	0.0
1971	137.8	137.8	139.0	-1.2	0.0	2.6	2.6	2.4	0.2	0.0
1972	136.2	136.2	137.5	-1.3	0.0	3.2	3.2	2.7	0.5	0.0
1973	135.5	135.5	136.8	-1.3	0.0	2.7	2.7	2.5	0.2	0.0
1974	134.9	134.9	136.1	-1.2	0.0	2.8	2.8	3.0	-0.2	0.0
1975	139.5	139.5	140.7	-1.2	0.0	5.8	5.8	5.6	0.2	0.0
1976	135.4	135.4	136.8	-1.4	0.0	0.8	0.8	0.9	-0.1	0.0
1977	139.0	139.0	140.4	-1.4	0.0	7.0	7.0	6.2	0.8	0.0
1978	136.9	136.9	138.2	-1.3	0.0	3.5	3.5	3.0	0.5	0.0
1979	133.7	133.7	134.8	-1.1	0.0	0.2	0.2	0.7	-0.5	0.0
1980	136.8	136.8	138.0	-1.2	0.0	5.5	5.5	4.6	0.9	0.0
1981	135.7	135.7	136.9	-1.2	0.0	1.5	1.5	1.6	-0.1	0.0
1982	136.1	136.1	137.4	-1.3	0.0	2.3	2.3	1.9	0.4	0.0
1983	137.9	137.9	139.1	-1.2	0.0	5.4	5.4	4.9	0.5	0.0
1984	136.4	136.4	137.7	-1.3	0.0	1.7	1.7	1.9	-0.2	0.0
1985	138.2	138.2	139.4	-1.2	0.0	7.7	7.7	7.5	0.2	0.0
1986	137.6	137.6	138.8	-1.2	0.0	10.9	10.9	9.1	1.8	0.0
1987	132.9	132.9	134.1	-1.2	0.0	0.0	0.0	0.0	0.0	0.0
1988	138.8	138.8	139.9	-1.1	0.0	5.9	5.9	5.4	0.5	0.0
1989	136.2	136.2	137.4	-1.2	0.0	5.5	5.5	5.3	0.1	-0.1
1990	142.6	142.6	143.6	-1.0	0.0	11.0	11.0	10.9	0.1	0.0
1991	134.9	134.9	135.9	-1.0	0.0	6.2	6.2	5.7	0.5	0.0
1992	136.8	136.8	138.1	-1.3	0.0	3.9	3.9	3.8	0.1	0.0
1993	134.0	134.0	135.2	-1.2	0.0	6.1	6.1	6.2	-0.1	0.0
1994	136.6	136.6	137.9	-1.3	0.0	6.2	6.2	6.9	-0.7	0.0
1995	141.1	141.1	142.2	-1.1	0.0	8.3	8.3	7.9	0.4	0.0
Mean	136.9	136.9	138.1	-1.2	0.0	4.4	4.4	4.1	0.3	0.1
Minimum	132.9	132.9	134.1	-1.5	0.0	0.0	0.0	0.0	-0.7	-0.1
Maximum	142.6	142.6	143.6	-1.0	0.0	11.0	11.0	10.9	1.8	0.0

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during the pink salmon incubation period. Tacoma's water withdrawals were predicted to potentially reduce side-channel area during the incubation period of pink salmon by 1.5 acres, which represents a 16 percent reduction in the amount of area occurring without the withdrawals.

The gravel nourishment conservation measure (see Chapter 5) will benefit spawning habitat conditions in the middle Green River by augmenting gravel recruitment lost from the upper watershed due to HHD. The target base flows and freshets proposed as part of the AWS project will have minimal benefit to pink spawning and incubation, since these flow augmentation measures primarily affect flows in the Green River only after pink salmon and incubation is complete. Reconnection and rehabilitation of Signani Slough side channel (RM 59.6) and addition of LWD below the Headworks will not benefit pink salmon spawning. Pink salmon are not expected to migrate upstream to the vicinity of the Headworks.

Watershed Management. Because pink salmon are not expected to be introduced into the upper watershed, Tacoma's forest management activities and conservation measures will not affect pink salmon spawning and incubation.

7.6.4 Pink Salmon Juvenile Rearing

Potential Effects of Covered Activities and Conservation Measures on Pink Salmon Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals will only affect pink salmon juvenile habitat in the lower and middle Green River, since pink salmon are not expected to be introduced into the upper watershed as a result of the trap-and-haul program at the Headworks.

Tacoma's water withdrawals potentially affect pink salmon habitat in the middle Green River by reducing flows by up to 213 cfs on a daily basis. These withdrawals will have a similar effect on pink salmon as on chum salmon (see Chapter 7.5.4.2), because both species have an ocean-type life cycle (i.e., juveniles reside in the river for days to weeks prior to migrating to the ocean). Pink salmon fry are likely present in the Green River from early March through June, the same as chum salmon. The analysis of mainstem rearing habitat for chum salmon predicted that Tacoma's withdrawals potentially result in an average 11.4 percent increase in chum fry habitat in the middle Green River (see Chapter 7.5.4.2), and an average 19.0 percent increase in the lower Green River (see Chapter 7.5.4.3). The same values are assumed to be applicable to pink salmon fry.

The effects of Tacoma's water withdrawals on pink salmon rearing habitat in the side channels of the middle Green River were quantified using the same wetted side-channel area versus discharge relationships applied to chum salmon fry (see Chapter 7.5.4.2). The results of the habitat modeling predict an average 1.4-acre reduction (18.4 percent loss) in the total wetted area of side channels in the middle Green River resulting from Tacoma's water withdrawals during the pink salmon fry rearing period. There is little side channel habitat in the lower Green River due to extensive channelization for flood control, thus impacts of the municipal water withdrawals on off-channel habitat conditions for pink salmon are expected to be small.

Many of the habitat conservation measures intended to improve pink salmon fry rearing habitat are the same as those designed to improve juvenile chum habitat in the middle Green River (see Chapter 7.1.4.2). These measures include the release of freshets and placement of LWD in the river channel. Large woody debris transported to the middle of the Green River will create localized low-velocity areas conducive to pink salmon rearing. As for chum salmon, this mitigation measure will be beneficial to pink salmon fry, which require low-velocity areas such as those provided by the side channels during their rearing period.

Habitat for pink salmon rearing is generally poor in the lower Green River as a result of channelization for flood control, especially because most side channels in this section of the river have been eliminated. For this reason, the mitigation projects will be targeted to improving salmonid rearing habitat conditions in the middle section of the Green River, and will not affect pink salmon rearing habitat in the lower watershed.

Watershed Management. Because pink salmon are not expected to be introduced into the upper watershed, Tacoma's forest management activities and conservation measures will not affect pink salmon juvenile rearing.

7.7 Effects of Water Withdrawal and Habitat Conservation Measures on Steelhead *(Oncorhynchus mykiss)*

This section describes the potential effects of Tacoma's water withdrawal activities on steelhead, and the potential benefits to this fish species resulting from habitat conservation measures. Three steelhead stocks are present in the Green River basin: a summer and winter stock of hatchery origin, and a naturally reproducing native winter run stock. The two hatchery stocks are managed by the MIT and WDFW and have no escapement goal. Approximately 70,000 summer steelhead smolts are released into the Green River system annually (WDFW et al. 1994). The summer stock (hatchery origin) is considered to be healthy (WDFW et al. 1994), and ranks second in the state in the number of steelhead caught per unit of fishing effort (King County Department of Planning 1978).

Naturally spawning (wild) winter run steelhead are managed for an escapement goal of 2,000 fish for the river drainage. Interbreeding between this native stock and winter run fish of hatchery origin (Chambers Creek stock) has been minimal due to differences in the timing of spawning (WDFW et al. 1994). Annual spawner escapement has averaged 1,915 fish between 1978 and 1992. The run size of native spawners has ranged from 1,350 to 3,464 during this same time period.

Due to the abundance and overall stability of native winter run steelhead populations in the Green River drainage, this stock is considered to be healthy (WDFW et al. 1994). A recent downward trend in run sizes has been a concern, and this stock will be closely monitored by Tribal and state fisheries resource managers in the future (WDFW et al. 1994). There has been a widespread decline in the abundance of steelhead throughout the Pacific Coast, Columbia River drainage, and Strait of Juan de Fuca. The NMFS has concluded at this time that the Puget Sound ESU is not threatened, though future population declines may warrant reconsideration of this stock for listing under the ESA (Busby et al. 1996).

Separate analyses are presented for each of the major life history stages of steelhead, including upstream migration, downstream migration, spawning and incubation, and juvenile rearing. The methods used in these analyses are the same as those applied to chinook salmon in Chapter 7.1, except for differences in the periodicity of steelhead life stages (see Appendix A), and in the habitat and flow requirements of these life stages. The analysis is further segregated by different segments of the Green River, corresponding to upper watershed, middle watershed, and lower watershed (see Chapter 2).

7.7.1 Steelhead Upstream Migration

7.7.1.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Upstream Migration

Water Withdrawal. As for other anadromous fish species, the Headworks diversion structure prevents the upstream migration of adult steelhead above RM 61.0. Additionally, HHD at RM 64.5 represents a second barrier to the upstream migration of anadromous fish into the upper Green River watershed since its construction in the early 1960s. Like coho salmon, steelhead are mainstem and tributary spawners. However, steelhead can spawn in higher gradient tributaries than coho salmon, so there is more habitat in the upper watershed within which steelhead can potentially spawn. There are approximately 66 miles of mainstem and tributary habitat in the upper Green River watershed (above HHD) that are suitable for steelhead spawning (i.e., total mileage for all stream and mainstem sections of 5 percent or less gradient) (USACE 1998, Appendix F1).

Tacoma has been trapping adult steelhead at Headworks since 1992 using a temporary trap-and-haul facility. Between 70 and 130 steelhead have been trapped each year to date, with native adults released into the upper watershed. In addition, native winter stock steelhead fry have been outplanted into tributaries of the upper Green River since 1982 by the WDFW. The number of steelhead fry outplanted into the upper watershed has ranged from approximately 30,000 to 55,000 fish per year.

Native adult steelhead will continue to be reintroduced into the upper Green River watershed above HHD following the installation of a permanent fish collection and transport facility at the Headworks. Steelhead will be reintroduced into the upper Green River watershed using the same methods applied to chinook and coho salmon. Restoring anadromous fish access to the upper watershed significantly increases the availability of suitable habitat to steelhead in the Green River basin. Comparing the upper watershed adult steelhead escapement goal, estimated by the USACE (1998, Appendix F1), to the Tribal and state escapement goals for the middle and lower Green River and Newaukum Creek (WDFW et al. 1994) suggests that 66 miles of habitat in the upper watershed represents about 40 percent of the winter steelhead habitat potentially available in the Green/Duwamish basin.

Watershed Management. Implementation of upland forest and riparian conservation measures will have a positive effect on steelhead upstream migration in the Upper HCP Area. Mass-wasting prescriptions developed through watershed analysis are expected to reduce management-related contributions of coarse sediment. Over the long term, this could reduce the extent of aggraded reaches that consistently experience subsurface flows during dry summers. Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will increase shade, moderating elevated summer temperatures caused by lack of adequate shade. Increasing the proportion of riparian stands greater than 50 years of age from 27 to 100 percent will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming deep pools in larger channels. Tacoma's ownership encompasses most of the mainstem and large tributary habitat preferred as holding habitat by large-bodied salmonids such as steelhead, thus temperature reductions and increased LWD inputs resulting from development of mature coniferous riparian forests on Tacoma's lands are expected to be especially beneficial for upstream migrating steelhead.

Stream-crossing culverts on Tacoma's land will be inventoried, and repaired or replaced as required within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure will increase the amount of habitat that is accessible to upstream migrating steelhead, although the magnitude of that increase cannot be estimated until the inventory is complete.

7.7.1.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Upstream Migration

Water Withdrawal. Tacoma's water withdrawals will likely have little effect on the upstream migration of adult native winter steelhead. Unlike chinook and coho salmon, which migrate up the Green River during the late summer and fall, native winter steelhead do not commence their upstream migration until the winter months (i.e., January). The upstream migration period of native winter steelhead coincides with the period of high seasonal flows in the Green River. Because water depths in the lower river were determined to be sufficient for upstream passage of chinook salmon when flows at the Auburn gage exceed 200 cfs, Tacoma's water withdrawals should have no impact on the upstream passage of native steelhead in the middle Green River since flows are substantially higher than 200 cfs throughout the steelhead migration period.

During the native steelhead winter and spring migration period, water temperatures in the middle Green River are cool and DO concentrations high. Consequently, the upstream migration of adult native steelhead should not be impeded by water quality conditions in the middle river. Since water withdrawal will not affect flow or water quality during the steelhead upstream migration period, no conservation measures are necessary to improve the upstream migration of adult steelhead.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect steelhead upstream migration in the middle watershed.

7.7.1.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Upstream Migration

As in the case of the middle Green River, Tacoma's water withdrawals and forest management activities are expected to have no effect on the upstream migration of native steelhead in the lower watershed; therefore, no conservation measures are necessary.

7.7.2 Steelhead Downstream Migration

7.7.2.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Downstream Migration

Water Withdrawal. Tacoma's water withdrawals will primarily affect the downstream passage of juvenile steelhead in the Green River below the Headworks diversion facility (including the diversion dam and pool). Consequently, Tacoma's water supply diversions will have little direct impact on downstream migration in the upper watershed. Effects of water storage are addressed as a USACE activity under Section 7 of the ESA.

Since active pumping of the North Fork well field will reduce surface flow in the North Fork of the Green River above HHD (see Figure 2.2), groundwater withdrawals could affect the downstream migration of juvenile steelhead. The North Fork well field is used during periods of high turbidity in the mainstem Green River, which typically occur during the winter, coincident with high surface flows in the North Fork. Use of the well field is assumed to have minimal effects on outmigrating steelhead smolts, since they outmigrate during April through June.

While the USACE is responsible for the effects of water storage and release at HHD, Tacoma will be the local sponsor of the downstream fish passage facility to be installed at HHD. The operation of this facility is important to maintain high levels of steelhead smolt survival through Howard Hanson Reservoir and Dam following the reintroduction of adult spawners into the upper Green River. The estimated survival index of steelhead smolts for combined reservoir and dam passage resulting under operation of the HHD fish passage facility is 90 percent, compared to a survival index of 8.7 percent under pre-AWS project conditions (USACE 1998, Appendix F1, Section 8E).

Watershed Management. Extensive harvest of forest stands at elevations that commonly develop a snowpack but also frequently experience heavy, warm winter rains may increase the magnitude of peak flows (WFPB 1997). However, in the Pacific Northwest, the majority of such events occur during late November and February, prior to the period when juvenile salmonids begin to move downstream. Since watershed management prescriptions contain provisions to restrict the potential for increased peak flows to less than 10 percent, and forestry activities are not expected to influence flows during the salmonid outmigration season (April through June in the Green River basin), neither Tacoma's forest management activities or conservation measures will affect steelhead downstream migration.

7.7.2.2 Middle and Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Downstream Migration

Water Withdrawal. Tacoma's water withdrawals could have two impacts on the survival of outmigrating juvenile steelhead. First, some of the smolts outmigrating through the Headworks diversion pool could be impinged on the existing screens or entrained into the water intake at the diversion. Fish impinged on the screens or entrained into the water supply system are assumed to ultimately perish. The survival of outmigrating steelhead smolts passing through the Headworks reach should be higher than that of juvenile coho salmon even though both species outmigrate during the same time of the year (early April through June). Steelhead typically reside in fresh water for 2 to 3 years prior to smolting and are typically larger than coho smolts, which have a shorter freshwater residency. The larger size of steelhead smolts makes them less vulnerable to entrainment and impingement. Existing screens at the Headworks do not meet current NMFS design criteria; however, data on existing outmigrant entrainment and survival at Tacoma's Headworks are not available.

Second, the survival of outmigrating steelhead smolts in the middle and lower Green River channel below the Headworks is probably influenced by flow, as with chinook salmon (see Chapter 7.1.2.2). Tacoma's FDWRC and SDWR withdrawals are expected to result in decreased outmigrant survival values of steelhead by reducing flows in the Green River below Headworks. In order to assess the impact of Tacoma's water withdrawals on the survival of outmigrating steelhead smolts, daily estimates of survival condition were calculated for Green River flows under the HCP (Green River flows **with** the AWS project and **with** Tacoma withdrawals) and compared to Green River flows **without** the AWS project and **without** Tacoma withdrawals. Steelhead smolt survival condition was calculated for each of these flow conditions using the same method used for chinook salmon (see Chapter 7.1.2.2). These daily survival rates were calculated for the steelhead salmon outmigration period (1 April through 30 June), and were weighted according to the estimated percentage of smolts outmigrating down the river on a daily basis (based upon the outmigration periodicity distribution developed by Grette and Salo, 1986).

The analysis of flow changes on outmigrant survival condition was based on experiments conducted by University of Washington researchers (Wetherall 1971). Their experiments were conducted using hatchery-reared chinook juveniles that averaged 3.1 inches (80 mm) in length. Steelhead juveniles outmigrate after spending 1 to 3 years rearing in the stream environment and are often 6 inches (150 mm) or more in length. Many researchers believe that larger outmigrants exhibit increased survival relative to smaller outmigrating salmonids during outmigration, possibly due to faster swimming speeds (Chapman et al. 1994) or lower susceptibility to predation by sculpin. The actual effects of Tacoma's water withdrawals on steelhead outmigrant survival are expected to be less than the average 4.9 percent reduction in survival condition obtained through modeling. Steelhead smolt survival is expected to be less influenced by flow changes than the small chinook smolts due to the larger size and vigorous nature of the steelhead.

The results of this analysis indicate that the flow reductions in the Green River channel caused by exercise of the FDWRC and SDWR result in an average reduction in steelhead smolt outmigrant survival condition of 4.9 percent (Table 7-24). Potential reductions in yearly outmigrant survival values ranged from 1.2 to 7.2 percent for the 1964-1995 period.

As described earlier, Tacoma will install a downstream fish bypass facility at the Headworks at RM 61.0 that includes a 220-by-24-foot conventional screen. This conservation measure will improve the survival of outmigrating steelhead smolts passing Tacoma's Headworks by preventing fish from being impinged or entrained into the water supply intake. Upgrading the existing Headworks screens to meet NMFS design criteria is assumed to improve steelhead smolt survival.

Flow augmentation in May and June resulting from implementation of the AWS project will also improve the survival of outmigrating steelhead smolts in the Green River. Because the period of spring flow augmentation under the AWS project occurs during the peak outmigration period of steelhead (i.e., 1 May through 31 May), this measure is expected to improve smolt outmigrant survival. The benefits to steelhead migrants provided by AWS project spring flow augmentation measures were calculated using the same method used for juvenile chinook salmon (see Chapter 7.1.2.2). The average predicted improvement in steelhead smolt survival condition resulting from the AWS project is 3.3 percent (Table 7-24). Estimated increases in yearly survival values resulting from the implementation of flow augmentation range from 0.5 percent to 5.7 percent for the 1964-1995 period.

Watershed Management. Tacoma's watershed management activities and conservation measures will not affect steelhead downstream migration in the middle and lower watershed.

7.7.3 Steelhead Spawning and Incubation

7.7.3.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals at the Headworks will not affect spawning habitat and incubation of steelhead in the upper Green River basin above HHD. Pumping of groundwater from the North Fork well field could have a minor effect on steelhead spawning and incubation in the North Fork of the Green River. However, pumping is unlikely to significantly reduce surface flows during the spring high flow period when steelhead spawn.

As described earlier, Tacoma has trapped and hauled native adult steelhead from the Headworks diversion into the upper Green River watershed since 1992 using a temporary capture facility. Between 7 and 133 native adult steelhead have been captured at this facility, and have either been reintroduced into the upper watershed or used as brood stock for the fry outplanting program. The permanent trap-and-haul facility at the Headworks will have the capability of substantially increasing the number of native steelhead spawners introduced into the upper watershed.

Steelhead are expected to spawn in low and moderate gradient reaches (5 percent or less) in mainstem and tributary within the upper watershed (USACE 1998, Appendix F1, Section 2). The USACE estimated there are 66 miles of mainstem and tributary spawning habitat in the upper Green River watershed that are accessible to upstream migrant steelhead and that have channel gradients of 5 percent and less (USACE 1998, Appendix F1, Section 2).

Watershed Management. The potential effects of Tacoma's forest management activities on spawning and incubation in the upper watershed are similar to those described for chinook in Chapter 7. Implementation of watershed management conservation measures will have a positive effect on salmonid spawning and incubation in the Upper HCP Area.

Implementation of mass-wasting prescriptions and the RSRP developed through watershed analysis is expected to reduce management-related contributions of fine sediment to less than 50 percent over background. This may result in a decrease in the proportion of fine sediment contained by spawning gravels, and could result in increased survival to emergence.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. In addition, the increased abundance of late-seral stands is expected to ensure that at least some of the LWD that enters the stream system is large enough to function as key pieces, which are especially important for forming stable flow obstructions in larger channels. The net result should be an increase in in-channel LWD and an associated increase in the availability of spawning gravel, especially in moderate gradient (2-5 percent) tributary streams preferred by steelhead. Steelhead will benefit from increased spawning gravel availability in both mainstem and moderate to high gradient tributaries.

7.7.3.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals will influence the availability of steelhead spawning habitat in both the mainstem river and side-channel areas of the middle Green River. Reduced flows caused by these withdrawals may also increase the susceptibility of steelhead redds to dewatering by exposing mainstem and side-channel areas during the incubation period.

Compared to salmon, steelhead are more likely to spawn in the mainstem sections of the river rather than in the side-channel sections. The effects of Tacoma's withdrawals on mainstem steelhead spawning habitat in the middle Green River were quantified using the same method applied to chinook salmon (i.e., based upon Ecology's Green River IFIM study; see Chapter 2.1.3.2). The daily potential habitat values occurring during the spawning period of steelhead under Green River flows **with** Tacoma withdrawals and Green River flows **without** Tacoma withdrawals were calculated using potential habitat and flow functions developed for the Green River for this species by Ecology (Caldwell and Hirschey 1989). Based upon this analysis, steelhead spawning habitat in the main channel of the middle Green River will be improved by an average of 8.7 percent by exercise of the FDWRC and SDWR water withdrawals (Table 7-25). The only decrease in spawning habitat caused by the withdrawals (-4.2 percent) was predicted during 1992, a dry year. In contrast, the diversions resulted in a 12.8 percent increase in potential spawning habitat area during 1993. The Ecology instream flow study predicted that flow between 550 and 650 cfs provides optimal spawning habitat for steelhead in the middle Green River. Because flows in the Green River typically exceed this optimal range of flows throughout the spawning period of steelhead (early April to late June), Tacoma's withdrawals are predicted to result in an overall improvement in spawning conditions for this species in the mainstem middle Green River.

The effects of Tacoma's water withdrawals on steelhead spawning habitat area in the side channels of the middle Green River were quantified using wetted side-channel area versus discharge relationships. The same method used for estimating chinook salmon spawning habitat area in the side channels (see Chapter 7.1.3.2) was applied to steelhead. Values of side-channel habitat were calculated on a daily basis for the steelhead spawning period (1 April through 30 June). The results of these analyses indicate that Tacoma's withdrawals will reduce the wetted area of side channels in the middle Green River by an average of 12.6 percent during the steelhead spawning period (Table 7-26). This represents a 1.9-acre reduction in the average wetted area provided by side channels in the middle Green River during this period.

The impacts of Tacoma's FDWRC and SDWR withdrawals on steelhead incubation were assessed by calculating the width of the channel subject to redd dewatering (i.e., dewatered spawnable width) using the same method applied to chinook salmon (see Chapter 7.1.3.2). Spawnable and dewatered channel widths were calculated on a daily basis for the steelhead spawning period. Dewatered spawnable widths were calculated from transect and rating curve data obtained from Nealy Bridge Transect 6 (Ecology instream flow study), and were determined assuming a 50-day incubation period (i.e., time from redd deposition to fry emergence). These widths were weighted according to the percentage of steelhead redds present in the mainstem Green River on a daily basis throughout the March through June spawning period (see Table A1, Appendix A). The Nealy Bridge Transect 6 was selected by Caldwell (1992) for the purpose of analyzing the effects of river stage reductions on steelhead spawning habitat. Although steelhead spawning was observed to be heavy in the vicinity of this transect, the width of this transect is less sensitive to changes in flow that some of the transects established at other sites during Ecology's Green River instream flow study. Consequently, the width calculations obtained for this transect may underestimate the impacts of the water withdrawals if extrapolated to the entire river.

The assumption that embryonic development from fertilization to emergence lasts 50 days is a modeling simplification. The time required for egg incubation and alevin development to the emergent fry stage is dependent upon the accumulation of Fahrenheit

Temperature Units (FTUs), which in turn is a function of water temperature. Seattle Water Department researchers found that winter steelhead fry emerge from the gravel in the Cedar River after accumulating between 1045 and 1284 mean FTUs, with mean emergence at about 1165 FTUs. Green River water temperatures during the incubation period range from about 7ºC (45ºF) in early March to about 17ºC (62ºF) in mid-August. In the Green River, the number of days required to accumulate 1165 FTUs from March through June varies between from 40 to 45 days for eggs fertilized near the end of June to from 75 to 80 days for eggs fertilized in early March. For this analysis, 50 days was selected as the time between fertilization to emergence for modeling purposes. Based on the 50-day assumption, the steelhead spawning and incubation model developed for this analysis projected that fry will emerge from the gravel between 20 April (early March spawn) and 19 August (late June spawn). In reality, 50 days underestimates development time for eggs fertilized in March through the first 2 weeks in May, and overestimates development time for eggs fertilized during the last 2 weeks in June. Fifty days is a good estimate for eggs fertilized during the last 2 weeks in May through the first 2 weeks in June.

The average weighted spawnable width of the main river channel during the steelhead spawning period was predicted to be 145.4 feet without Tacoma's water withdrawals and 144.4 feet with the water withdrawals. For days when redd dewatering was predicted to occur, the dewatered spawnable width of the channel averaged 1.5 feet without Tacoma's water withdrawals and 1.9 feet with the water withdrawals. Thus, the water withdrawals are predicted to result in an average increase of 0.4 feet in the dewatered width of the channel for days when redd dewatering is predicted to occur (Table 7-27). This represents a very small portion of the total width of the channel (i.e., 0.03 percent) within which steelhead can potentially spawn. The protected spawnable width of the channel (i.e., the spawnable width not subject to dewatering calculated by subtracting dewatered width from spawnable width) was 143.9 feet without the withdrawals and 142.5 feet with the withdrawals. The withdrawals therefore reduce the protected spawnable width of the channel by 1.4 feet. The water withdrawals were found to increase the frequency of dewatering by an average of 1 day during the 120-day steelhead spawning period. Dewatering of some portion of the spawnable width of the channel is predicted to occur for an average of 28 days with the withdrawals and 27 days without the withdrawals. Steelhead redds were historically probably dewatered in some years even without Tacoma's diversions. The modeled natural flow data indicate that the average 7-day low flow between 1 April and 30 May for the period of 1964 to 1995 was 982 cfs (Table 7-1). However, modeled natural 7-day low flows as low as 270 cfs occurred during April and May (Table 7-1), and were less than 550 cfs in five of the 32 years of record. The results of this analysis indicate that Tacoma's water diversions will have a minor impact on the survival of steelhead eggs and embryos in mainstem sections of the middle Green River.

The impacts of Tacoma's water withdrawals on steelhead incubation habitat in the side channels of the middle Green River were assessed using the side-channel habitat area versus discharge curves developed by the USACE (1998). Effects of the diversions on steelhead incubation habitat were quantified using the same method applied to chinook salmon (see Chapter 7.1.3.2). The results of this analysis indicated that Tacoma's withdrawals will reduce the area of side channels in the middle Green River during 2-day low flow events (i.e., the flow event most likely to dewater redds) by an average of 1.4 acres (i.e., 23.0 percent reduction) from that occurring without the withdrawals (Table 7-28) during the steelhead incubation period (1 May through 31 July).

The gravel nourishment conservation measure (see Chapter 5) will benefit steelhead spawning habitat in the middle Green River by augmenting the gravel recruitment lost from the upper watershed due to HHD. Reconnection and restoration of side channels will also improve spawning habitat conditions by providing up to 3.4 acres of additional side-channel habitat in the middle Green River. This measure will provide up to a 25 percent increase in the total area of side-channel habitat potentially available to spawning steelhead (based upon the average side-channel area occurring without the HCP mitigation measures during the steelhead spawning period).

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will affect the spawning conditions for steelhead, because the spawning period of this species (1 March to 30 June) coincides with the early refill and flow augmentation period. (Note: These flow measures have been targeted to mainstem steelhead production by providing higher sustained baseflows during their incubation period.) The early refill, flow augmentation, and freshet measures will increase the average weighted spawnable width of the mainstem river channel from 144.0 feet (without AWS project) to 144.4 feet (Table 7-27). The AWS project flow measures will result in an overall improvement in steelhead incubation by reducing the frequency of low flow events during the late spring, which are most likely to dewater redds. The AWS project flow measures include two 36-hour freshets, which slightly increase the average value of dewatered spawnable width (1.9 feet) from that occurring without the flow measures (1.5 feet) (Table 7-27). Thus, these freshets increase the average dewatered width for days when dewatering occurs by 0.4 feet. However, this value may not represent an actual impact to steelhead since the freshets are probably too short in duration (36 hours) for a steelhead to construct a redd and complete spawning.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect steelhead spawning and incubation in the middle watershed.

7.7.3.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Spawning and Incubation

Water Withdrawal. Spawning habitat for steelhead, like that for the salmon species, is relatively poor in the lower Green River watershed compared to that in the middle watershed due to extensive channelization. Potential steelhead spawning habitat versus discharge relationships obtained for the lower Green River from Ecology's instream flow study (Caldwell and Hirschey 1989) were used to quantify the impacts of the FDWRC and SDWR water withdrawals on the spawning habitat of this species in the lower Green River. Tacoma's water withdrawals are predicted to increase potential steelhead spawning habitat in the lower Green River by an average of 8.9 percent for the March through June spawning period (Table 7-25). This estimate applies to main channel habitat only, since there are few side channels of significant size in the lower Green River. Impacts to steelhead incubation in the lower river are expected to be less than those in the middle river (i.e., 0.4-foot increase in average dewatered width for days in which dewatering occurs), since the lower river is substantially narrower due to channelization.

The opportunities for improving spawning habitat in the lower Green River are very limited due to the disturbed condition of the river channel, which has been extensively modified for flood control purposes. For this reason, those conservation measures that will result in improvements in steelhead spawning habitat and incubation (e.g., gravel seeding) focus mainly on the middle section of the Green River, and will not affect habitat in the lower watershed.

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project flow measures will have the same overall beneficial effect on steelhead spawning and incubation in the lower Green River as they do in the middle river (see Chapter 7.7.3.2), although these benefits will be diminished due to the channelized nature of the lower river.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect steelhead spawning and incubation in the lower watershed.

7.7.4 Steelhead Juvenile Rearing

7.7.4.1 Upper Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals will primarily affect juvenile steelhead habitat in the lower and middle Green River (i.e., below Headworks). Pumping of groundwater from the North Fork well field is expected to have a minor effect on steelhead rearing in the North Fork Green River since well field pumping primarily occurs during high flow periods during the late fall, winter and early spring (these high flow periods are largely responsible for the elevated turbidity levels that necessitate the use of the groundwater pumping facility). Pumping during the summer and early fall, though rare, is expected to have a negative effect on steelhead rearing habitat in the North Fork once this species is reintroduced into the upper watershed. Most juvenile steelhead rear in the upper watershed for at least 2 years, and will be expected to reside in the North Fork throughout the entire year.

The trap-and-haul facility to be built by Tacoma will allow more of the adult steelhead (native winter run) that reach the Headworks diversion structure to be captured and then released into the upper watershed above HHD than current conditions. In addition to reconnecting the upper watershed to the lower watershed using the trap-and-haul and downstream fish passage facilities, habitat rehabilitation projects will also be implemented by Tacoma and the USACE in the upper watershed during Phase I of the AWS project. As described in Chapter 7.1.4.1, the rehabilitation projects to be implemented as part of the AWS project restoration and mitigation activities will provide increased rearing and overwintering habitat for anadromous and resident salmonids, including juvenile steelhead. These projects include constructing an additional 3.9 acres of off-channel habitat, which will provide important overwintering habitat for juvenile steelhead in the upper watershed. Large woody debris will be introduced into the new off-channel areas and approximately 18 miles of mainstem and tributary habitat, increasing channel complexity and the number of pools associated with wood, thereby increasing the quantity and quality of rearing habitat available to juvenile steelhead.

Watershed Management. The potential effects of Tacoma's forest management activities on steelhead juvenile rearing habitat are similar to those described for chinook in Chapter 7.1.4. Implementation of watershed management conservation measures will have a positive effect on juvenile rearing in the Upper HCP Area. Mass-wasting prescriptions are expected to reduce the frequency of landslides that deliver sediment and initiate dam-break floods. These measures are expected to result in a decrease in embeddedness, which will be especially beneficial to species such as steelhead that overwinter in interstitial spaces.

Reestablishment of riparian forests dominated by coniferous trees greater than 50 years old will result in a gradual increase in the recruitment of LWD. As in-channel LWD increases, the frequency of pools is also expected to increase. Pool cover will improve as a result of the additional LWD. The net result should be an increase in the quality and quantity of pool habitat used for juvenile steelhead summer and winter rearing. As riparian stands mature, the number of large conifers capable of acting as barrier tress during dam-break floods will increase. The increased abundance of barrier trees, combined with the decreased frequency of mass wasting is expected to reduce the risk of dam-break floods that can kill or injure juvenile steelhead overwintering in the substrate.

Stream-crossing culverts on Tacoma's lands will be inventoried and repaired or replaced as required within 5 years of issuance of the ITP. Stream crossings will be maintained in passable condition for the duration of the ITP. This measure will increase the amount of tributary and off-channel habitat that is accessible to steelhead for use as off-channel rearing habitat, although steelhead are less likely to utilize such habitat than salmon. The magnitude of that increase cannot be estimated until the inventory is complete.

7.7.4.2 Middle Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals will affect steelhead rearing habitat by reducing flows in the Green River below the Headworks up to 213 cfs on a daily basis. The withdrawals potentially have a greater effect on steelhead than on chinook salmon (see Chapter 7.1.4.2) and coho salmon (see Chapter 7.5.4.2), since most steelhead juveniles reside in the Green River basin for a least 2 years prior to migrating to the ocean. Tacoma's FDWRC and SDWR withdrawals will affect steelhead rearing in the main river channel as well as in the side channels present along the middle Green River. The side-channel habitat areas may be less important to juvenile steelhead than juvenile coho, chinook, and chum salmon, since juvenile steelhead are widely distributed throughout the pools, runs, and riffles of the mainstem Green River.

The effects of Tacoma's withdrawals were quantified using IFIM habitat area and flow functions developed for juvenile steelhead in the middle Green River by Ecology. Daily habitat values occurring under HCP conditions (Green River flows **with** the AWS project and **with** Tacoma withdrawals) were compared to those occurring under Green River flows **without** the AWS project and **without** Tacoma withdrawals (see Chapter 7.1.3.2 for a description of the methods used for this habitat analysis). The analysis indicates that Tacoma's withdrawals (both FDWRC and SDWR) will result in an average 7.9 percent increase in juvenile steelhead habitat in the mainstem middle Green River (Table 7-29) during their year-round rearing period. Flows in the middle Green River are typically higher than those considered to be optimal for juvenile steelhead (350 to 400 cfs) by Ecology's instream flow study (Caldwell and Hirschey 1989), except during low flow periods in the late summer and early fall. During these low flow periods, juvenile steelhead habitat values are sustained at relatively high levels (i.e., > 90 percent of optimal) by the minimum flow measures that have been established by the MIT/TPU Agreement.

A comparison of the HCP flow regime to flow conditions in the absence of Tacoma withdrawals and HHD (natural or unregulated) indicates that average monthly flows are somewhat lower during the primary steelhead juvenile growth season (June through September). The HCP flow regime provides flows closer to the maximum habitat condition indicated by Ecology's instream flow study in June and July but slightly lower habitat values in August and September. Lower average habitat conditions in August and September are somewhat offset by flow augmentation that prevents extreme 7-day low flows from dropping to historic levels.

Selected hydrologic characteristics of flows (cfs) in the Green River under the modeled unregulated and HCP flow regimes for the period 1964 to 1995 (Source: CH2M Hill 1997).

Average Monthly Flow (cfs)	Unregulated	HCP
June	1,208	1,024
July	586	466
August	364	335
September	401	371
Low Flow 15 July to 15 September		
Average 7-day Low Flow	290	294
Minimum 7-day Low Flow	203	250

The effects of Tacoma's water withdrawals on steelhead rearing habitat in the side channels of the middle Green River were quantified using the same wetted side-channel area versus discharge relationships employed in the chinook salmon analysis (see Chapter 7.1.4.2). Changes in availability of side-channel area were calculated on a year-round basis, since most juvenile steelhead reside in the Green River for 2 years. The results of analysis predict an average 12.6 percent loss in total wetted area for the side channels located between RM 61.0 and RM 33.8 (i.e., the majority of side channels in the Green River below HHD) during the year-round rearing period of steelhead (Table 7-30). This represents a 1.6-acre average reduction in the total area of side channels in the middle Green River during the year-round steelhead rearing period.

The conservation measures designed to improve juvenile steelhead habitat are the same as those described to improve juvenile chinook habitat in the middle Green River (see Chapter 7.1.4.2). These measures include reconnecting and restoring the Signani Slough side channel, and placement of LWD in the river channel. These measures will improve steelhead rearing habitat by providing up to 3.4 acres of additional off-channel habitat, which is important for overwintering, and by increasing the structural complexity of main channel habitats.

As described for chinook and coho salmon, some benefits will also be realized for several miles of the Green River below HHD by improving (decreasing) water temperatures for rearing salmonid fish, including steelhead. As described in Chapter 7.1.4.2, the operation of HHD provides temperature benefits to rearing salmonids by significantly reducing water temperatures in sections of the river immediately downstream of the dam during warm periods of the year. However, this benefit diminishes downstream of Palmer due to progressive warming of the river as it approaches equilibrium with air temperatures.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect steelhead juvenile rearing in the middle watershed.

7.7.4.3 Lower Watershed

Potential Effects of Covered Activities and Conservation Measures on Steelhead Juvenile Rearing

Water Withdrawal. As with the middle Green River, flow reductions resulting from exercise of the FDWRC and SDWR will improve mainstem habitat conditions for steelhead in the lower Green River but will reduce the availability of side-channel habitats. Municipal water withdrawals modeled using daily flows from 1964-1995 for the lower river result in an average 6.7 percent increase in mainstem habitat for juvenile steelhead (Table 7-29) during their year-round rearing period. Since there is little off-channel habitat in the lower Green River due to channelization and flood control, impacts of municipal water withdrawals to off-channel habitat will be small.

As described for chinook salmon (see Chapter 7.1.4.3), water quality problems within the lower Green River include water temperature, DO, nutrient enrichment, and a variety of pollutants. However, the effects of HHD and Tacoma's water withdrawal activities will not extend sufficiently far downstream to significantly affect water quality conditions (particularly temperature) in the lower Green and Duwamish rivers. The implementation of freshets during fall low flow conditions, if included as part of the optional storage of 5,000 ac-ft for low flow augmentation, could potentially provide short-term improvements in water quality conditions in the lower Green River to induce and improve upstream passage of adult coho and chinook salmon. However, these freshets will not be sufficient in duration to provide tangible benefits to rearing steelhead.

Juvenile steelhead habitat is generally poor in the mainstem lower Green River as a result of channelization for flood control. For this reason, mitigation measures for juvenile steelhead focus on habitat enhancement of the upper and middle Green River, and will not affect steelhead juvenile rearing habitat in the lower watershed.

Table 7-24. Comparison of the effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and the AWS project on an index of outmigrant survival conditions for steelhead juveniles in the Green River, Washington, 1964-1995.

	Total of Daily Difference in Survival Values (percent)	
Year	Effects of Water Withdrawals	Effects of ASW Project
1964	-1.99	3.04
1965	-5.01	3.97
1966	-5.45	3.62
1967	-4.92	3.64
1968	-6.31	3.97
1969	-3.05	2.30
1970	-5.19	4.23
1971	-2.93	1.37
1972	-2.54	1.10
1973	-7.17	3.21
1974	-1.20	1.80
1975	-3.38	1.30
1976	-4.60	1.73
1977	-7.05	3.46
1978	-6.43	3.57
1979	-5.27	3.72
1980	-5.45	3.62
1981	-5.67	0.54
1982	-5.27	3.70
1983	-6.54	5.70
1984	-3.89	3.24
1985	-4.80	4.49
1986	-5.71	4.10
1987	-5.08	3.41
1988	-5.12	2.88
1989	-5.13	3.78
1990	-4.50	3.81
1991	-5.50	3.72
1992	-5.74	2.99
1993	-5.33	2.19
1994	-6.03	5.36
1995	-5.80	5.48
Mean	-4.94	3.28
Minimum	-7.17	0.54
Maximum	-1.20	5.70

Table 7-25. Effects of Tacoma's First Diversion Water Right Claim and Second Diversion Water Right on mainstem spawning habitat for steelhead in the lower and middle Green River, Washington; 1964-1995. Potential habitat area values calculated from weighted usable area and flow functions developed by Ecology (Caldwell and Hirschey 1989).

	Change in Mean Daily Mainstem Spawning Habitat Area			
	Lower River		Middle River	
Year	Acres	Percent	Acres	Percent
1964	6.4	12.3	7.1	9.7
1965	6.2	8.7	8.8	9.3
1966	6.6	9.9	9.7	11.0
1967	5.2	6.5	6.5	5.9
1968	7.4	8.9	13.0	11.8
1969	6.0	11.9	4.9	6.6
1970	7.9	11.0	11.1	11.7
1971	7.1	12.7	8.8	11.0
1972	5.4	10.9	6.5	8.6
1973	0.2	0.2	4.2	3.1
1974	4.8	12.3	2.7	4.1
1975	6.4	9.5	8.9	9.4
1976	6.6	10.5	8.3	9.5
1977	5.3	5.9	11.2	9.7
1978	4.6	5.1	8.3	6.9
1979	6.8	9.8	9.6	10.4
1980	5.1	7.6	6.6	6.9
1981	7.2	9.2	10.8	10.4
1982	7.2	9.6	9.1	9.1
1983	3.4	3.7	8.0	6.4
1984	8.3	14.0	9.9	12.0
1985	6.7	10.5	8.3	9.8
1986	6.2	7.6	10.4	9.8
1987	6.0	8.2	8.7	8.9
1988	6.9	12.3	8.4	10.5
1989	5.6	9.4	7.6	9.0
1990	8.4	14.4	9.5	12.3
1991	8.0	12.3	11.2	12.7
1992	-4.0	-4.2	-5.7	-4.2
1993	8.6	14.1	10.7	12.8
1994	4.5	5.5	8.1	7.4
1995	3.3	3.6	7.0	5.7
Mean	5.8	8.9	8.1	8.7

Table 7-26. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on side channel habitat area during the steelhead spawning period (April through June) in the middle Green River, Washington; 1964-1995. Habitat area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Mean Daily Side Channel Habitat Area Due to Water Withdrawals		Change in Mean Daily Side Channel Habitat Area Due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-1.9	-8.4	0.0	0.2
1965	-1.9	-13.3	0.1	1.2
1966	-1.8	-11.6	0.1	0.7
1967	-1.8	-13.5	0.3	2.3
1968	-1.7	-13.7	0.0	0.2
1969	-2.0	-10.4	0.0	-0.3
1970	-2.0	-13.6	0.3	2.4
1971	-2.1	-11.0	-0.2	-1.2
1972	-1.7	-6.7	0.1	0.5
1973	-1.6	-16.6	0.1	0.8
1974	-2.0	-7.7	0.0	0.0
1975	-1.8	-10.1	0.0	-0.2
1976	-1.9	-11.8	0.1	0.8
1977	-1.7	-15.2	0.0	0.1
1978	-1.7	-15.5	0.1	1.6
1979	-1.9	-12.5	0.3	2.4
1980	-1.9	-12.9	0.0	0.3
1981	-1.9	-13.8	0.0	0.4
1982	-2.0	-13.0	0.4	2.8
1983	-1.6	-14.3	0.1	1.0
1984	-2.2	-12.0	0.2	1.5
1985	-1.8	-11.8	0.3	2.3
1986	-1.9	-14.5	-0.1	-0.5
1987	-1.8	-12.5	0.1	1.1
1988	-2.0	-11.0	0.3	2.0
1989	-1.9	-11.4	0.1	0.6
1990	-2.4	-12.5	0.0	-0.2
1991	-2.1	-13.3	0.1	0.8
1992	-1.4	-17.4	0.1	1.3
1993	-2.3	-13.3	0.1	0.9
1994	-1.8	-14.1	0.0	0.4
1995	-1.6	-14.9	0.1	1.4
Mean	-1.9	-12.6	0.1	0.9
Minimum	-2.4	-17.4	-0.2	-1.2
Maximum	-1.4	-6.7	0.4	2.8

Table 7-27. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on spawnable widths and dewatered widths during the steelhead spawning period in the middle Green River, Washington; 1964-1995. Spawnable width and dewatered width values were calculated from transect cross-section and stage-discharge data collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Spawnable Width (ft)					Dewatered Width (ft)				
Year	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project	Without AWS Project	With Withdrawals	Without Withdrawals	Change due to Withdrawals	Change due to AWS Project
1964	146.7	147.1	147.7	-0.6	0.4	3.0	2.8	2.3	0.5	-0.2
1965	144.5	144.7	145.7	-1.0	0.2	1.0	1.4	1.2	0.2	0.4
1966	144.9	145.4	146.2	-0.8	0.5	1.4	2.1	1.7	0.4	0.7
1967	143.1	143.2	144.4	-1.2	0.1	2.2	2.6	2.3	0.3	0.4
1968	142.8	143.4	144.6	-1.2	0.6	2.8	1.8	2.0	-0.2	-1.0
1969	145.0	145.2	145.8	-0.6	0.2	2.0	2.4	1.8	0.6	0.4
1970	144.1	144.6	145.5	-0.9	0.5	2.1	2.2	1.8	0.4	0.1
1971	146.1	146.3	147.0	-0.7	0.2	1.7	1.5	1.0	0.5	-0.2
1972	147.0	147.3	147.9	-0.6	0.3	1.9	2.1	1.6	0.5	0.2
1973	139.5	140.6	142.3	-1.7	1.1	0.2	0.1	0.0	0.1	-0.1
1974	147.6	147.8	148.3	-0.5	0.2	3.3	3.0	2.4	0.6	-0.3
1975	145.0	145.3	146.2	-0.9	0.3	2.9	3.3	2.6	0.7	0.4
1976	145.6	145.7	146.6	-0.9	0.1	1.3	2.1	1.6	0.5	0.8
1977	142.1	142.7	144.0	-1.3	0.6	1.0	0.9	0.7	0.2	-0.1
1978	142.1	142.1	143.6	-1.5	0.0	1.1	1.8	1.9	-0.1	0.7
1979	144.4	144.7	145.7	-1.0	0.3	1.5	2.8	2.4	0.4	1.3
1980	144.4	144.7	145.8	-1.1	0.3	1.7	2.3	1.8	0.5	0.6
1981	143.6	143.8	144.9	-1.1	0.2	1.7	1.7	1.4	0.3	0.0
1982	143.8	144.0	145.1	-1.1	0.2	1.6	2.1	1.7	0.4	0.5
1983	141.2	141.9	143.3	-1.4	0.7	1.3	2.1	1.7	0.4	0.8
1984	145.5	145.9	146.6	-0.7	0.4	1.7	1.5	1.2	0.3	-0.2
1985	145.1	145.5	146.3	-0.8	0.4	2.0	2.0	1.7	0.3	0.0
1986	142.7	143.3	144.5	-1.2	0.6	1.6	1.8	1.5	0.3	0.2
1987	143.7	144.0	145.0	-1.0	0.3	1.3	2.2	1.8	0.4	0.9
1988	145.9	146.2	147.0	-0.8	0.3	1.4	1.6	1.6	0.0	0.2
1989	145.4	145.8	146.6	-0.8	0.4	0.8	1.4	1.2	0.2	0.6
1990	145.5	145.9	146.7	-0.8	0.4	2.5	2.3	1.8	0.5	-0.2
1991	144.8	145.3	146.1	-0.8	0.5	0.6	0.8	0.7	0.1	0.2
1992	136.7	138.7	140.7	-2.0	2.0	0.0	1.6	1.1	0.5	1.6
1993	145.3	145.5	146.4	-0.9	0.2	0.7	1.1	0.8	0.3	0.4
1994	141.5	142.6	143.9	-1.3	1.1	1.0	1.0	1.0	0.0	0.0
1995	141.5	141.9	143.3	-1.4	0.4	0.0	1.4	1.2	0.2	1.4
Mean	144.0	144.4	145.4	-1.0	0.4	1.5	1.9	1.5	0.4	0.3
Minimum	136.7	138.7	140.7	-2.0	0.0	0.0	0.1	0.0	-0.2	-1.0
Maximum	147.6	147.8	148.3	-0.5	2.0	3.3	3.3	2.6	0.7	1.6

Table 7-28. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project on continuously wetted side channel habitat area (i.e., two-day low flow event) during the steelhead incubation period (March through August) in the middle Green River, Washington; 1964-1995. Habitat area changes calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Continuously Wetted Side Channel Area Due to Water Withdrawals		Change in Continuously Wetted Side Channel Area Due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-2.1	-26.3	0.0	0.0
1965	-1.2	-22.3	0.0	0.0
1966	-1.2	-20.0	0.0	0.0
1967	-1.2	-22.4	0.0	0.0
1968	-1.2	-20.8	0.0	0.0
1969	-1.2	-19.9	0.0	0.0
1970	-1.3	-25.7	0.0	0.0
1971	-1.7	-23.8	0.0	-0.1
1972	-2.1	-26.9	0.0	0.0
1973	-1.2	-21.6	0.0	0.0
1974	-2.1	-26.3	0.0	0.0
1975	-1.2	-19.6	0.0	0.0
1976	-1.2	-19.5	0.0	0.0
1977	-1.3	-25.1	0.0	0.4
1978	-1.3	-22.6	0.0	0.1
1979	-1.3	-25.9	0.0	0.0
1980	-1.2	-22.3	0.0	0.0
1981	-1.3	-25.1	0.0	0.0
1982	-1.2	-21.0	0.0	0.0
1983	-1.2	-18.6	0.5	7.3
1984	-1.2	-20.0	0.0	0.0
1985	-1.3	-25.7	0.0	0.0
1986	-1.2	-22.3	0.0	0.0
1987	-1.3	-25.9	0.0	0.0
1988	-1.2	-22.5	0.0	0.0
1989	-1.3	-25.3	0.0	0.7
1990	-1.2	-20.5	0.0	0.0
1991	-1.2	-21.7	0.0	0.0
1992	-1.3	-25.9	0.0	0.0
1993	-2.0	-23.6	0.0	0.0
1994	-1.2	-21.6	0.2	4.2
1995	-1.3	-25.5	0.0	0.0
Mean	-1.4	-23.0	0.0	0.4

Table 7-29. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on mainstem juvenile rearing habitat for steelhead in the lower and middle Green River, Washington; 1964-1995. Habitat area values calculated from weighted usable area and flow functions discharge relationships collected by Ecology during its instream flow study (Caldwell and Hirschey 1989).

	Change in Mean Daily Mainstem Habitat Area Due to Water Withdrawals				Change in Mean Daily Mainstem Habitat Area Due to AWS Project			
	Lower River		Middle River		Lower River		Middle River	
Year	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
1964	5.0	9.8	6.2	11.1	0.2	0.4	0.5	0.9
1965	3.8	5.7	3.8	6.8	-0.3	-0.6	0.4	0.6
1966	5.0	7.6	5.8	10.3	-0.2	-0.4	0.3	0.5
1967	3.5	5.6	3.7	6.6	0.1	0.3	1.1	1.7
1968	6.2	10.6	6.6	11.8	-0.1	-0.2	-0.2	-0.3
1969	4.5	6.9	5.5	9.9	0.7	1.2	1.0	1.6
1970	4.3	6.6	4.5	8.0	0.0	-0.1	0.6	1.0
1971	4.8	9.2	4.3	7.7	0.9	1.7	1.0	1.6
1972	3.9	7.2	4.2	7.6	0.1	0.1	0.2	0.3
1973	3.8	5.3	5.0	8.9	0.0	0.1	0.3	0.5
1974	3.2	5.9	2.8	5.1	0.4	0.7	0.6	0.9
1975	4.2	7.8	4.4	7.9	0.3	0.6	0.7	1.1
1976	4.6	7.1	5.9	10.5	0.6	1.1	1.4	2.3
1977	4.4	6.2	5.7	10.2	0.0	0.0	-0.1	-0.2
1978	5.3	7.5	7.3	13.1	0.1	0.1	0.5	0.8
1979	2.9	4.3	1.9	3.4	-0.3	-0.6	0.1	0.2
1980	4.2	6.7	4.3	7.7	0.2	0.3	0.1	0.2
1981	5.3	8.0	5.9	10.6	0.0	0.0	0.1	0.2
1982	4.5	7.1	5.1	9.1	-0.2	-0.3	0.7	1.1
1983	4.9	7.4	6.2	11.1	0.0	0.0	0.0	0.1
1984	5.7	9.7	4.9	8.8	0.4	0.8	0.6	1.0
1985	3.8	5.4	4.1	7.4	-0.4	-0.8	0.2	0.4
1986	4.4	6.5	4.6	8.2	-0.5	-0.9	-0.4	-0.7
1987	2.7	3.7	1.3	2.3	-0.3	-0.6	0.0	0.0
1988	3.8	6.3	3.1	5.6	-0.2	-0.4	0.1	0.2
1989	3.0	4.8	2.3	4.1	-0.1	-0.1	0.1	0.2
1990	3.6	7.0	2.6	4.7	-0.3	-0.5	-0.2	-0.3
1991	3.6	5.8	3.3	6.0	-0.4	-0.8	0.2	0.3
1992	3.5	4.8	3.1	5.6	0.3	0.5	0.9	1.4
1993	4.7	6.9	5.4	9.6	0.2	0.3	0.5	0.8
1994	4.1	6.2	3.6	6.5	0.4	0.7	0.3	0.6
1995	4.0	6.3	3.6	6.4	-0.1	-0.2	0.2	0.3
Mean	4.2	6.7	4.4	7.9	0.0	0.1	0.4	0.6

Table 7-30. Effects of Tacoma's First Diversion Water Right Claim, Second Diversion Water Right, and AWS project spring flow augmentation (Phase I) on the area of side channels during the rearing period (year-round) of steelhead juveniles in the middle Green River, Washington; 1964-1995. Surface area values calculated from side channel area and flow functions developed in support of the AWS project (USACE 1998, Appendix F1).

	Change in Mean Side Channel Habitat Area due to Water Withdrawals		Change in Mean Side Channel Habitat Area Due to AWS Project	
Year	Acres	Percent	Acres	Percent
1964	-1.9	-10.6	0.0	0.0
1965	-1.6	-12.8	0.0	0.2
1966	-1.7	-13.1	0.0	0.2
1967	-1.6	-11.5	0.1	0.6
1968	-1.7	-12.1	0.0	-0.1
1969	-1.6	-12.9	0.0	-0.1
1970	-1.7	-13.7	0.1	0.8
1971	-1.8	-10.8	-0.1	-0.6
1972	-1.6	-8.9	0.0	0.2
1973	-1.6	-14.8	0.0	0.1
1974	-1.7	-9.7	0.0	-0.1
1975	-1.6	-9.4	0.0	-0.1
1976	-1.7	-12.7	0.0	0.2
1977	-1.5	-12.8	0.0	0.1
1978	-1.6	-15.4	0.0	0.5
1979	-1.5	-13.2	0.1	0.9
1980	-1.7	-12.5	0.0	0.0
1981	-1.6	-13.3	0.0	0.0
1982	-1.6	-11.8	0.1	0.8
1983	-1.7	-13.4	0.0	0.1
1984	-1.7	-12.3	0.1	0.5
1985	-1.5	-13.2	0.1	0.9
1986	-1.6	-13.7	0.0	-0.3
1987	-1.5	-15.3	0.0	0.5
1988	-1.7	-12.0	0.1	0.7
1989	-1.6	-12.4	0.0	0.2
1990	-1.8	-10.4	0.0	-0.2
1991	-1.6	-11.4	0.0	0.1
1992	-1.6	-16.0	0.0	0.2
1993	-1.7	-15.0	0.0	0.4
1994	-1.6	-13.3	0.0	-0.1
1995	-1.5	-11.2	0.0	0.1
Mean	-1.6	-12.6	0.0	0.2

7.8 Effects of Water Withdrawal and Habitat Conservation Measures on Coastal Cutthroat Trout *(Oncorhynchus clarki clarki)*

The mainstem and all major tributaries of the upper Green River support cutthroat and rainbow trout (USFS 1996). Some of the cutthroat trout inhabiting the upper Green River watershed may have been derived from sea-run forms, although this has yet to be confirmed. Cutthroat trout have also been planted in lakes of the upper Green River watershed by the WDFW (USFS 1996). Results of fish sampling indicate that resident cutthroat trout are more abundant than other salmonid fish (including resident rainbow trout, outplanted juvenile steelhead, eastern brook trout, and mountain whitefish) in most streams of the upper Green River watershed (Wunderlich and Toal 1992). Cutthroat trout are also more widely distributed in the upper Green River watershed than other fish (USFS 1996). Both stream-rearing (fluvial) and lake-rearing (adfluvial) forms of cutthroat trout are believed to be present in the upper Green River (Wunderlich and Toal 1992). The adfluvial forms (large fish up to 20 inches in length) are thought to reside in Howard Hanson reservoir prior to migrating to the tributaries to spawn.

An anadromous cutthroat trout population is present in the Green River below HHD, although little information is available on its status (Grette and Salo 1986). Coastal cutthroat trout in Washington State have not been proposed for listing under the ESA. The NMFS received a petition to list coastal sea-run cutthroat trout and designate critical habitat throughout their range in California, Oregon, and Washington on 18 December 1997 (63 FR 13832). The NMFS determined that the petitioned action may be warranted, and will continue to evaluate the status of this species.

7.8.1 Coastal Cutthroat Trout Upstream Migration

Potential Effects of Covered Activities and Conservation Measures on Cutthroat Trout Upstream Migration

Water Withdrawal. Sea-run cutthroat trout spawn from mid-February to mid-May in the Green River (Grette and Salo 1986) and the timing of their upstream migration is a little earlier than winter-run steelhead. As for steelhead, Tacoma's water withdrawals will likely have little effect on the upstream migration of adult cutthroat trout. The migration and spawning period of sea-run cutthroat trout coincides with the period of high seasonal flows in the Green River; median monthly flows at Auburn range from 1,000 to 1,400 cfs from February through May. Water depths were determined to be sufficient for the upstream passage of chinook salmon when flows at the Auburn gage exceed 200 cfs (see Chapter 7.1.1). Tacoma's water withdrawals should have no impact on the upstream passage of sea-run cutthroat trout in the lower and middle Green River, since flows are substantially higher than this value throughout their migration period. The upstream migration of adult sea-run cutthroat trout should not be impeded by water quality conditions in the lower and middle river; water temperatures are cool and DO levels are high during their spring migration period.

Since 1913, Tacoma's Headworks diversion structure at RM 61.0 has prevented the upstream migration of anadromous fish, including sea-run cutthroat. Additionally, HHD (RM 64.5) has been a barrier to the upstream migration of anadromous fish since its construction in the early 1960s. Blockage of migration into the upper watershed prevents access to approximately 40 percent of potential anadromous fish habitat in the basin. Sea-run cutthroat trout could potentially spawn in 66 miles of mainstem and tributary habitat in the upper Green River watershed, assuming that they use the same range of stream gradients as steelhead (i.e., 5 percent or less; see Chapter 7.7.1.3).

All coastal cutthroat trout captured at the permanent fish collection facility at Tacoma's Headworks will be transported and released into the upper Green River watershed. This measure will provide an additional 66 miles of potential spawning habitat to sea-run cutthroat trout over that occurring in the Green River basin below HHD. The number of adult sea-run cutthroat trout that are ultimately reintroduced into the upper watershed is likely small. Sea-run cutthroat trout generally spawn in low gradient reaches of small tributaries, and in the lower regions of streams and rivers (Trotter 1997). For this reason, the number of cutthroat trout spawners that migrate to the Headworks diversion will probably be low.

Watershed Management. The impacts of Tacoma's forest management activities and associated conservation measures on cutthroat trout will be the same as those described for steelhead upstream migration in Chapter 7.7.1.

7.8.2 Coastal Cutthroat Trout Downstream Migration

Potential Effects of Covered Activities and Conservation Measures on Cutthroat Trout Downstream Migration

Water Withdrawal. Tacoma's water withdrawals primarily affect the downstream passage of juvenile cutthroat trout in the Green River at, and below, the Headworks diversion facility (including the diversion dam and pool). Consequently, Tacoma's water withdrawals will have little direct impact on downstream migration in the upper watershed.

Provided that sea-run cutthroat trout spawning in the upper water is restored by the trap-and-haul measures, some of the outmigrating cutthroat trout smolts passing from the upper watershed through the Headworks diversion pool could be exposed to injury when passing by the existing screens. The mortality rate of outmigrating cutthroat trout passing by the Headworks diversion is unknown.

The survival of outmigrating cutthroat trout in the middle and lower Green River below the Headworks is probably influenced by flow (see Chapter 7.1.2.2). Tacoma's FDWRC and SDWR withdrawals are expected to reduce survival rates of cutthroat trout outmigrants by reducing flows in the Green River below the Headworks. Again, the effects of the withdrawals on outmigrating cutthroat trout are expected to be similar to that of steelhead smolts (see Chapter 7.7.2.2). Tacoma's exercise of the FDWRC and SDWR is expected to result in an average reduction in cutthroat trout outmigrant survival index of 4.9 percent annually in the middle and lower river.

While the USACE is responsible for the effects of water storage and release at HHD, Tacoma will be the local sponsor of the downstream fish passage facility to be installed at HHD. The operation of this facility is important to maintain high levels of salmon and steelhead survival through Howard Hanson Reservoir and Dam following the reintroduction of adult spawners into the upper Green River. Cutthroat trout smolts are assumed to have the same survival rate as steelhead smolts for combined reservoir and dam passage resulting under operation of the HHD fish passage (see Chapter 7.7.2.1). The survival rate of steelhead through the HHD project was estimated by the USACE to be 90 percent with the HHD downstream fish passage facility, compared to an estimated survival rate of 8.7 percent under pre-AWS project conditions (USACE 1998, Appendix F1, Section 8E).

Tacoma will install a downstream fish bypass facility at the Headworks at RM 61.0 that includes a 220-by-24-foot conventional screen. This conservation measure will improve the survival of outmigrating cutthroat trout juveniles passing Tacoma's Headworks by minimizing impingement or entrainment into the water supply intake.

Flow augmentation in May and June resulting from implementation of the AWS project will also improve the survival of outmigrating cutthroat trout smolts in the Green River for the same reasons described for steelhead smolts (see Chapter 7.7.2.2). Using the same values applied to steelhead, the AWS project flow measures are predicted to increase the average survival condition of cutthroat trout outmigrants by 3.3 percent over that occurring without these measures.

Watershed Management. Tacoma's forest management activities and associated conservation measures will not affect cutthroat trout downstream migration.

7.8.3 Coastal Cutthroat Trout Spawning and Incubation

Potential Effects of Covered Activities and Conservation Measures on Cutthroat Trout Spawning and Incubation

Water Withdrawal. Tacoma's water withdrawals at the Headworks will not affect spawning habitat and incubation of sea-run and resident cutthroat trout in the upper Green River basin above HHD. Pumping of groundwater from the North Fork well field could affect cutthroat trout spawning and incubation in the North Fork of the Green River. However, pumping is unlikely to significantly reduce surface flows during the spring high flow period when cutthroat trout spawn.

Tacoma's water withdrawals will influence cutthroat trout spawning habitat in both the mainstem river and side-channel areas of the middle Green River. Reduced flows caused by these withdrawals may also increase the susceptibility of cutthroat trout redds to dewatering by exposing the margins of mainstem and side-channel areas during the incubation period. Tacoma's water withdrawals will likely affect the spawning and incubation of cutthroat trout to a lesser extent than steelhead (see Chapter 7.7.3.2), since cutthroat trout are more likely than steelhead to spawn in tributaries of the lower and middle Green River (i.e., habitat not affected by the water withdrawals) than in the main channel sections.

For steelhead, Tacoma's water withdrawals are predicted to improve potential spawning habitat in the mainstem of the middle Green River by an average of 8.7 percent (see Chapter 7.7.3.2) during the steelhead spawning period. Tacoma's water withdrawals were also predicted to increase potential steelhead spawning habitat in the mainstem of the lower Green River by an average of 8.7 percent during their spawning period. Tacoma's FDWRC and SDWR withdrawals are expected to have a similar effect on cutthroat trout spawning habitat in the mainstem sections of the lower and middle Green River.

The potential effects of Tacoma's water withdrawals on cutthroat trout spawning habitat area in the side channels of the middle Green River is also be expected to be similar to that of steelhead (see Chapter 7.7.3.2). Given this assumption, Tacoma's withdrawals are predicted to reduce the wetted area of side channels in the middle Green River by an average of 12.6 percent during the cutthroat trout spawning period. This represents a 1.9-

acre reduction in the average wetted area provided by side channels in the middle Green River during this period.

The impacts of Tacoma's exercise of its FDWRC and SDWR on cutthroat trout incubation in the mainstem river were also assumed to be similar to that of steelhead, since the velocity, depth, and substrates used by these two species for spawning is similar. Given this assumption, Tacoma's water withdrawals are predicted to result in a small increase in the width of the channel susceptible to dewatering during the incubation period of cutthroat trout (average increase of 0.4 feet in the dewatered width of the channel for those days when redd dewatering was predicted to occur; see Chapter 7.7.3.2). This represents a very small portion of the total width of the channel (i.e., 0.03 percent) within which cutthroat trout can potentially spawn.

The impacts of Tacoma's water withdrawals on cutthroat trout habitat in the side channels of the middle Green River were assessed using the side-channel habitat area versus discharge curves developed by the USACE (1998). Effects of the FDWRC and SDWR on cutthroat trout incubation habitat were determined using the same values derived for steelhead (see Chapter 7.7.3.2). Tacoma's withdrawals are predicted to reduce the area of side channels in the middle Green River during 2-day low flow events (i.e., the flow event most likely to dewater redds) by an average of 1.4 acres (i.e., 23.0 percent loss) from that occurring without the withdrawals during the cutthroat trout incubation period.

The trap-and-haul facility could result in the reintroduction of sea-run cutthroat trout into the upper Green River watershed. The USACE estimated there are 66 miles of mainstem and tributary spawning habitat in the upper Green River watershed that are accessible to upstream migrant steelhead and have channel gradients of 5 percent and less (USACE 1998, Appendix F1, Section 2). A similar amount of habitat will be available to sea-run cutthroat trout spawners. This measure could potentially increase the number of sea-run cutthroat trout juveniles in the upper watershed, though this will likely result in a reduction in the number of resident cutthroat trout juveniles, provided that cutthroat production is rearing limited (resident cutthroat trout are currently the most abundant salmonid fish species in the upper Green River watershed).

The gravel nourishment conservation measure (see Chapter 5) will benefit cutthroat trout spawning habitat in the middle Green River by augmenting the gravel recruitment lost from the upper watershed due to HHD. Reconnection and restoration of side channels will also improve spawning habitat conditions by providing up to 3.4 acres of additional side-channel habitat in the middle Green River. This measure will provide up to a 25 percent increase in the total area of side-channel habitat potentially available to spawning cutthroat trout (based upon the average side-channel area occurring without the HCP mitigation measures).

The early reservoir refill, spring flow augmentation, and freshets proposed as part of the AWS project will have a similar effect on cutthroat trout spawning as they will on steelhead (see Chapter 7.7.3.2). As with steelhead, which also have a spring through early-summer incubation period, the AWS project flow measures will result in an overall improvement in cutthroat trout incubation by reducing the frequency of low flow events during the late spring that are most likely to dewater redds.

Watershed Management. The effects of Tacoma's forest management activities and associated conservation measures on cutthroat trout spawning and incubation in the upper watershed will be the same as those described for steelhead in Chapter 7.7.3. Watershed management will not affect cutthroat trout spawning and incubation in the middle and lower watershed.

7.8.4 Coastal Cutthroat Trout Juvenile Rearing

Potential Effects of Covered Activities and Conservation Measures on Cutthroat Trout Juvenile Rearing

Water Withdrawal. Tacoma's water withdrawals will primarily affect juvenile sea-run cutthroat trout habitat in the lower and middle Green River (i.e., below Headworks). Pumping of groundwater from the North Fork well field is expected to have a minor effect on cutthroat trout rearing in the North Fork Green River, since well field pumping primarily occurs during high flow periods during the late fall, winter and early spring (these high flow periods are largely responsible for the elevated turbidity levels that necessitate the use of the groundwater pumping facility). Pumping during the summer and early fall, though, could reduce cutthroat trout rearing habitat in the North Fork.

Tacoma's water withdrawals will affect cutthroat trout rearing habitat in the middle and lower Green River by reducing flows below the Headworks by up to 213 cfs on a daily basis. The effects of these withdrawals on rearing cutthroat are expected to be similar to those on juvenile steelhead (see Chapter 7.7.4.2), assuming the juveniles of both species have similar habitat requirements. Given this assumption, Tacoma's withdrawals will result in an average 7.9 percent increase in juvenile habitat in the mainstem middle Green River and an average of 6.7 percent increase in juvenile habitat in the mainstem lower Green River. During annual low flow periods (late summer and early fall), juvenile cutthroat trout habitat in the mainstem sections of the lower and middle Green River will be sustained at a relatively high level (i.e., > 90 percent of optimal) by the minimum flow measures that have been established by the MIT/TPU Agreement.

The effects of Tacoma's water withdrawals on cutthroat trout rearing habitat in the side channels of the middle Green River are also assumed to be similar to those on steelhead (see Chapter 7.7.4.2). Tacoma's withdrawals are expected to result in an average 12.6 percent loss in the total wetted area for the side channels during the year-round rearing period of cutthroat trout. This represents a 1.6-acre average reduction in the total area of side channels in the middle Green River during the year-round cutthroat trout rearing period.

The trap-and-haul facility to be built by Tacoma will allow sea-run cutthroat trout that migrate upstream to the Headworks diversion structure to be captured and then released into the upper watershed above HHD. In addition to reconnecting the upper watershed to the lower watershed, habitat rehabilitation projects will also be implemented by Tacoma and the USACE in the upper watershed during Phase I of the AWS project. As described in Chapter 7.1.4.1, the rehabilitation projects to be implemented will improve mainstem and off-channel habitat conditions (especially overwintering habitat) for rearing sea-run cutthroat trout juveniles, as well as juvenile and adult resident cutthroat trout. These rehabilitation projects include construction of an additional 3.9 acres of off-channel habitat, and placement of LWD into the new off-channel areas and approximately 18 miles of mainstem and tributary habitat.

The conservation measures to be implemented in the middle Green River will improve rearing habitat conditions for cutthroat trout in this reach, as well as for that of other salmonids (see Chapter 7.1.4.2). These measures include reconnecting and rehabilitating the Signani Slough side channel, and placement of LWD in the river channel. These measures will improve cutthroat trout rearing habitat by providing up to 3.4 acres of additional off-channel habitat, and by increasing the structural complexity of main channel habitats.

As described for chinook salmon (see Chapter 7.1.4.2), some benefits will also be realized for several miles of the Green River below HHD by improving (cooling) water temperatures for rearing salmonid fish, including cutthroat trout. The operation of HHD provides temperature benefits to rearing salmonids by significantly reducing water temperatures in sections of the river immediately downstream of the dam during warm periods of the year. However, this benefit diminishes downstream of Palmer due to progressive warming of the river as it approaches equilibrium with air temperatures.

The mitigation measures designed to rehabilitate habitat conditions for juvenile cutthroat trout and other rearing salmonids focus on the upper and middle Green River, since habitat conditions in the lower mainstem Green River are generally poor due to extensive channelization. Opportunities for habitat improvement are limited in the lower mainstem Green River due to the flood control measures (e.g., dikes and levees) that are required in this urbanized section of the river, thus the conservation measures will not affect juvenile rearing habitat in the lower watershed.

Watershed Management. The effects of Tacoma's forest management activities and associated conservation measures on cutthroat trout juvenile rearing in the upper watershed will be the same as those described for steelhead in Chapter 7.7.3. Watershed management will not affect cutthroat trout juvenile rearing in the middle and lower watershed.

7.9 Effects of Water Withdrawal and Habitat Conservation Measures on Pacific Lamprey *(Lampetra tridentata)*

The Pacific lamprey, like Pacific salmon, is an anadromous fish that spawns in fresh water, with the majority of growth and adult maturation occurring in salt water. The larvae of this species are called ammocoetes and they may reside in fresh water for up to 7 years before metamorphosing to a juvenile stage that begins to transition to a parasitic lifestyle (see Appendix A). The Pacific lamprey is one of the most primitive fishes found in the Green River below the Headworks. However, the size and health of the existing population of Pacific lamprey is largely unknown, since there have been no detailed quantitative surveys completed in the system. The most recent data on Pacific lamprey were collected as part of the spring side-channel fish surveys conducted by R2 Resource Consultants in 1998, during which numerous lamprey ammocoetes were found (Jeanes and Hilgert 1998). Because little is known about this species in the Green River, the effects of Tacoma's water withdrawals were evaluated based on knowledge of the species periodicity and life history requirements and, where applicable, the results of more detailed habitat modeling for other species and life stages deemed similar to that for Pacific lamprey. Because of their relative obscurity, descriptions of the lamprey's life history characteristics are included in this chapter and in Appendix A.

The upper watershed (above HHD) is currently not accessible to Pacific lamprey. This HCP was developed under the assumption that there are no immediate plans to reintroduce Pacific lamprey into the upper Green River. Although they are a native species, prudent and careful management of the upper watershed dictates that caution be exercised when reintroducing anadromous species into a regulated system. The focus of such introductions will be on salmonid species (e.g., chinook, coho, and steelhead), the success of which can be gauged only by the monitoring of multiple life cycles of each species, from spawning to adult returns. The reintroduction of Pacific lamprey into the upper watershed along with salmon and steelhead may have heretofore unforeseen impacts (e.g., species interactions, impacts to resident salmonid populations) on the success of the salmonid reintroduction program. For that reason, Tacoma has assumed that any reintroduction of Pacific lamprey will be preceded by a thorough evaluation of all risks and potential benefits (e.g., source of nutrients to upper stream systems) to the future salmon and steelhead stocks that may develop in the upper watershed. Tacoma recognizes that this represents a management decision that will ultimately be made by the resource agencies. However, for purposes of this HCP Tacoma has assumed that at least the initial reintroduction of fish into the upper watershed will be limited to salmonid species. Tacoma's water withdrawal, forest management activities, and associated conservation measures will therefore not affect Pacific lamprey in the upper watershed.

7.9.1 Pacific Lamprey Upstream Migration

Pacific lamprey are native anadromous fish that spawn in gravel areas of streams and rivers. The juvenile lamprey rear for up to 7 years in fresh water before migrating to the ocean to begin a parasitic existence. After feeding in the ocean for 2 to 4 years (Kan 1975), they return to their natal streams to spawn. Adult Pacific lamprey enter fresh water between April and June and complete their upstream migration by September (Beamish 1980). Pacific lamprey are considered weak swimmers; their burst swimming speed has been measured at 7 feet per second compared to 22 feet per second for chinook (Bell 1990). While their maximum speed is slow compared to salmonids, they are able to use their buccal funnel (mouth) to cling to rock surfaces and slowly creep upstream in velocities that they would not otherwise be able to surmount. Adult Pacific lamprey move upstream into headwater areas, often through rapids and over waterfalls. Spawning in the uppermost watershed areas allows for maximum usage of suitable stream rearing habitats as the young ammocoetes gradually colonize and relocate downstream. Adult Pacific lamprey have been observed to readily ascend Denil-type fish ladders designed for passage of adult salmonids (Slatick and Basham 1985). During their spawning migration in fresh water, adult lamprey do not feed, but utilize body reserves and may shrink 20 percent in body size from the time of freshwater entry to spawning (Beamish 1980). Adult Pacific lamprey overwinter in deep pool habitat and spawn the following spring.

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on Pacific Lamprey Upstream Migration

Although there have been no analyses specifically targeted to Pacific lamprey passage in the Green River, inference can be made from the results of such studies for other species. In particular, the analysis of passage requirements for salmonid species can be used to assess potential effects of Tacoma's withdrawals on Pacific lamprey passage. As noted in Chapters 7.1 and 7.3, the depth of water required for upstream passage of chinook and smaller coho salmon has been reported to be around 1.0 feet and 0.6 feet respectively. Flow conditions affording passage for chinook and coho should provide suitable conditions for upstream passage of Pacific lamprey. Adult lamprey are relatively poor swimmers but their unique morphology allows them to ascend to the upper reaches of watersheds.

Under HCM 1-01, Tacoma will guarantee minimum flows of at least 250 cfs at the Auburn gage from 15 July to the end of low flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs. Tacoma will not use the SDWR if instream flows at Palmer fall below 300 cfs during the remainder of the year. Such flows should be sufficient to allow adult upstream movement of Pacific lamprey into the lower and middle Green River during the latter portion of their upstream migration period (July through September); flows in the river during the earlier portion of their migration period (April through June) are generally higher than these and should likewise provide suitable passage conditions.

To provide for a future opportunity to reintroduce Pacific lamprey into the upper watershed, the design of the trap-and-haul facility at the Headworks will integrate features that promote their safe capture and transport. Bar spacing in crowders will be designed to potentially collect adult Pacific lamprey. Design parameters will avoid openings or gaps in passage facilities that could potentially lead to death or injury from lamprey becoming wedged or trapped. Design and construction of the trap-and-haul facility at the Headworks will also minimize unnecessary gaps in the fishway. As an example, structures on the floor of the fishway should be flush with the floor (Starke and Dalen 1995).

7.9.2 Pacific Lamprey Downstream Migration

After spending up to seven years as ammocoetes in slow, backwater areas burrowed in the mud, larval lamprey undergo metamorphosis in late summer and fall. The lamprey develop eyes, teeth and a rasping tongue in preparation for their parasitic existence as adults. Metamorphosis occurs over a 6-to-8 week period; after transformation, the lamprey move into areas with faster currents and gravel substrates. The young adults begin outmigrating during the fall, but the majority overwinter and migrate downstream to the ocean in April and May (Beamish and Levings 1991). While there appears to be some variation between river systems, the average size of young adult lamprey when they enter the estuary is approximately 5.5 inches (Beamish 1980).

During their downstream migration, if they are mature enough as they near the estuary, young adult lamprey may attach themselves to salmonid smolts (Parker 1994 *in* Starke and Dalen 1995). During their study of the survival rate of juvenile chinook released from a hatchery into the Green River at RM 32.0 and recaptured several days later in the estuary, Wetherall (1971) observed that between 0.15 percent and 1.5 percent of the juvenile chinook exhibited lamprey wounds. Seven percent of chinook juveniles captured in the Duwamish estuary exhibited lamprey scars in a study by Matsada and others (Matsada et al. 1968). While authors of both of the chinook studies cited the wounds as scars from river lamprey (*Lampetra ayresi*), it is possible that some of the scars were made by young adult Pacific lamprey. Young adult Pacific lamprey have been observed feeding on salmonid smolts in estuarine areas, but the incidence of feeding on salmonid smolts is thought to be low. When young adult Pacific lamprey enter salt water they typically move to water deeper than 230 feet (Beamish 1980).

Young adult Pacific lamprey rely on currents to be carried downstream during their outmigration to the ocean; higher flows appear to initiate downstream movement (Beamish and Levings 1991). Even small increases in flow rate appear sufficient to initiate downstream migration (Beamish and Levings 1991). Based on observations of turbine intakes in the Columbia River system, it appears that most juvenile lamprey outmigrants are carried low in the water column along the thalweg (Starke and Dalen 1995). Since lamprey have no swim bladder, they cannot easily regulate their location in the water column (Hatch and Parker 1996). Their movement low in the water column may help reduce avian predation, but downstream fish passage facilities designed to protect surface-oriented salmonid outmigrants may not be effective in passing outmigrating young adult Pacific lamprey.

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on Pacific Lamprey Downstream Migration

According to Beamish and Levings (1991) the majority of young adult Pacific lamprey outmigrate to the ocean during April and May. This period historically corresponded to the refill period for HHD reservoir (a USACE flood control operation) resulting in reduced flows in the Green River. Reductions in flows during this period could result in the delay of outmigration of young adult Pacific lamprey, and in some instances mortality associated with stranding, trapping and increased predation. Tacoma's water diversions at the Headworks are expected to exacerbate such conditions and further impact the downstream migration of Pacific lamprey.

Should Pacific lamprey be introduced into the upper watershed, there is some question as to the effectiveness of the HHD fish passage facility for passing young adult Pacific lamprey. As noted above, juvenile lamprey outmigrants are generally carried low in the water column. However, the HHD fish passage facility employs a surface-oriented intake, a location selected to attract downstream migrating juvenile salmonids. Thus, the efficiency of the facility for passing juvenile lamprey is unknown.

Under the AWS project, refill of HHD will begin as early as 16 February. This will provide flexibility in the release of water during the spring, as described in the habitat conservation measures in Chapter 5.2.2. In addition, under the Phase I of the AWS project, a maximum of two freshets are proposed for each year during late April and May, with each freshet limited to 2,500 cfs maximum flow for 36 hours at the Auburn gage during normal years, and 1,250 cfs for 36 hours during dry years. These freshets will likely benefit both juvenile salmonids and young adult Pacific lamprey outmigrations through the Green River below HHD.

7.9.3 Pacific Lamprey Spawning and Incubation

After migrating upstream in the summer and fall, adult Pacific lamprey overwinter and spawn the following spring. Pacific lamprey spawning in rivers on the coast of Oregon usually occurs in May when water temperatures are between 10ºC (50ºF) and 15ºC (59ºF) (Close et al. 1995). In the Babine River system in British Columbia, Pacific lamprey were observed spawning from June through the end of July (Farlinger and Beamish 1984). Spawning areas are located in low gradient reaches in mainstem and tributary pool tailouts and riffles. Spawning occurs over predominantly gravel substrates with a mixture of pebbles and sand. Similar to salmonids, incubating lamprey eggs are susceptible to smothering by fine sediments, and increases in suspended sediments can decrease egg survival. Adult lamprey spawn in gravel areas with mean column water velocities of 1.5 to 3.0 feet per second (Kan 1975). Most adult Pacific lamprey die after spawning but there have been observations of repeat spawning (Michael 1984). Similar to salmonids, temperature controls the hatching of eggs. At a water temperature of 14.4ºC (58ºF), Pletcher (1963 *in* Close et al. 1995) observed eggs hatching after 19 days and the larvae left the gravel substrate approximately 2 to 3 weeks after hatching.

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on Pacific Lamprey Spawning and Incubation

As noted above, the general types of habitat used by lamprey for spawning are similar to those used by salmonids. Hence, Tacoma's water withdrawals may result in some reduction in Pacific lamprey spawning habitat. However, there is no information regarding specific locations or timing of Pacific lamprey spawning in the Green River and therefore the degree of impact is unknown. The incubation period of eggs is notably shorter for Pacific lamprey than for salmonids (4 to 5 weeks from egg deposition to emergence at 15ºC [59ºF]). Thus, the period of time in which the eggs/embryos will be vulnerable to subsequent flow reductions and potential dewatering will be shorter than for salmonids. Tacoma's water withdrawals increase potential spawning habitat for steelhead in the mainstem channel by reducing velocities. Since lamprey are weaker swimmers than steelhead, reduced flows associated with Tacoma withdrawals may benefit Pacific lamprey spawning. The combined effects of target baseflows, spring flow augmentation, and restrictions in stage decline may all provide some benefits to Pacific lamprey spawning and incubation.

7.9.4 Pacific Lamprey Juvenile Rearing

Pacific lamprey larvae emerge from the gravel nests approximately 5 to 6 weeks after hatching and drift downstream to settle in slow backwater areas. The larval lamprey, termed ammocoetes, drift into areas of slow current and burrow into mud and sand deposits. The highest densities of ammocoetes are found along the channel margins, where they inhabit burrows in predominantly mud substrate. Higher densities of ammocoetes are also found in lower sections of rivers with low gradients opposed to upper watershed, higher gradient reaches (Richards 1980 *in* Close et al. 1995). As they grow, ammocoetes may find new areas to burrow in, colonizing areas downstream. Movement of ammocoetes occurs primarily at night and most downstream movement occurs in the spring when flows are the highest (Beamish and Levings 1991). The larval stage may extend from 4 to 7 years; during this time the ammocoetes are blind, toothless, sedentary, and feed by filtering detritus, diatoms, algae and other food particles. After metamorphosis in the fall, the young adults hold in cobble and boulder substrates before migrating to the ocean between late fall and spring.

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on Pacific Lamprey Juvenile Rearing

Tacoma's water withdrawals could affect Pacific lamprey rearing habitat by reducing flows in the middle and lower Green River by up to 213 cfs on a daily basis. The results of the analysis of Tacoma's exercise of its FDWRC and SDWR during the steelhead incubation period (1 May through 31 July) indicate that side-channel areas in the middle Green River will be reduced by an average of 1.4 acres (i.e., 23 percent reduction) from that occurring without the withdrawals. Since this analysis is based on changes in side-channel area and does not adjust for differences between fish species, the results should be applicable to lamprey rearing during that same time period. Because larval lamprey may rear in fresh water for extended periods (up to 7 years have been reported), theoretically, they will be more vulnerable to low flow conditions than salmonid species (which have a much shorter freshwater rearing period).

The restoration and reconnection of Signani Slough will likely provide additional spawning and rearing habitat for Pacific lamprey. The provision of instream flows as specified at Auburn and Palmer gages (see Chapters 5.1.1 and 5.1.2) will maintain important rearing habitats in the river during low flow and drought conditions.

7.10 Effects of Water Withdrawal and Habitat Conservation Measures on River Lamprey *(Lampetra ayresi)*

This section discusses the potential effects of Tacoma's water withdrawals in the Green River and the potential benefits resulting from habitat conservation measures on river lamprey. River lamprey, like Pacific lamprey, are an anadromous fish that spawn in fresh water, have a freshwater juvenile rearing phase, and then migrate to the ocean where they grow and mature before returning to fresh water for spawning. Like Pacific lamprey, river lamprey are parasitic and have been known to cause injury and death to juvenile salmon (Beamish 1980). One clear distinction between the two species is that adult Pacific lamprey may reach a length of 30 inches while adult river lamprey reach an average length of only 12 inches (Wydoski and Whitney 1979).

River lamprey have not been extensively studied. The information that does exist suggests a life history pattern similar to that of Pacific lamprey, although river lamprey have a life span several years shorter than Pacific lamprey (Beamish 1980). The larvae of this species are also called ammocoetes, which are blind and toothless and generally feed on algae and microscopic organisms. It is unknown how long river lamprey ammocoetes reside in fresh water before metamorphosing to a juvenile stage and transitioning to a parasitic lifestyle (see Appendix A). The population of river lamprey in the Green River appears to be sympatric with that of the Pacific lamprey. Based on incidental catches of both river lamprey and Pacific lamprey during side-channel surveys conducted in the Green River, the abundance of river lamprey appears to be much lower than Pacific lamprey; ammocoetes of river lamprey were infrequently captured compared to Pacific lamprey (Jeanes and Hilgert 1998). The size and health of the existing population of river lamprey are largely unknown. As a result, the potential effects of Tacoma's water withdrawals were evaluated based on similarity in life stage periodicity and life history requirements to Pacific lamprey (see Chapter 7.9) and, where applicable, the results of more detailed habitat modeling for other species and life stages deemed similar to that for river lamprey.

Like Pacific lamprey, the analysis presented for river lamprey is not presented by river section (e.g., lower Green River, middle Green River, etc.), but rather for the entire reach of river currently utilized by that species. Moreover, as for Pacific lamprey, this HCP makes the assumption that there are no plans to reintroduce (assuming they were historically present) river lamprey into the upper Green River. Therefore, Tacoma's forest management activities and associated conservation measures will not affect river lamprey, and the following discussion is limited to the effect of water withdrawal and its associated conservation measures.

7.10.1 River Lamprey Upstream Migration

According to Beamish (1980) adult river lamprey return from the ocean to fresh water between September and later winter, with the adults apparently holding until the following spring when spawning occurs (April through June). The period of immigration of adult river lamprey into the Green River is unknown. Spawning presumably occurs over gravel areas similar to those used by Pacific lamprey. Adult river lamprey are smaller (about 12 inches) than Pacific lamprey (about 30 inches) (Scott and Crossman 1973; Wydoski and Whitney 1979) and therefore will also likely be weak swimmers (see Chapter 7.9). However, they also have a buccal funnel mouth, enabling them to cling to rock surfaces and slowly work their way upstream. River lamprey die after spawning (Beamish 1980).

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on River Lamprey Upstream Migration

Although there have been no analyses specifically targeted to river lamprey passage in the Green River, inference can be made from the results of such studies for other species. In particular, the analysis of passage requirements for salmonid species can be used to assess potential effects of Tacoma's withdrawals on river lamprey passage. As noted for Pacific lamprey (see Chapter 7.9), because of their unique morphology and ability to utilize their mouth parts to assist in upstream passage, the flow conditions affording passage for chinook should provide suitable conditions for upstream passage of river lamprey.

Under HCM 1-01, Tacoma will guarantee minimum flows of at least 250 cfs at the Auburn gage from 15 July to the end of low flow augmentation from HHD during all but drought years, when minimum flows may be reduced to 225 cfs. Tacoma will not use the SDWR if instream flows at Palmer fall below 300 cfs during the remainder of the year. Such flows should be sufficient to allow adult upstream movement of river lamprey into the lower and middle Green River during their migration periods.

7.10.2 River Lamprey Downstream Migration

After spending up to several years as ammocoetes in slow, backwater areas burrowed in the mud, larval lamprey undergo metamorphosis in late summer and fall. The lamprey develop eyes, teeth and a rasping tongue in preparation for their parasitic existence as adults. River lamprey metamorphosis occurs in later July, with downstream migration occurring the following year from May to July (Beamish 1980). Little is known about the behavior of downstream migrating river lamprey. However, because of similarity in life history patterns to Pacific lamprey, parasitism on juvenile salmonids seems likely as the young adults outmigrate to the ocean (see Chapter 7.9.2).

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on River Lamprey Downstream Migration

According to Beamish (1980) the majority of young adult river lamprey outmigrate to the ocean from May to July. This period generally corresponds to the time of the descending limb of the hydrograph in the Green River. Reductions in flows resulting from Tacoma's operations during this period could result in some delay in the outmigration of young adult river lamprey. This assumes that the downstream movement of young adult lamprey is a passive process, with the fish essentially moving at the same speed as the current.

Should river lamprey be introduced into the upper watershed, there is some question as to the effectiveness of the fish passage facility for passing young adult river lamprey. Assuming that river lamprey have a similar outmigration behavior as Pacific lamprey (i.e., outmigrants generally carried low in the water column), and that the HHD fish passage facility will incorporate a surface intake, the efficiency of the HHD facility for passing juvenile lamprey is unknown.

Under Phase I of the AWS project, up to two freshets are proposed for each year during late April and May, with each freshet limited to 2,500 cfs maximum flow for 38 hours at the Auburn gage during normal years, and 1,250 cfs for 38 hours during dry years. These freshets will likely benefit both juvenile salmonids and young adult river lamprey outmigrations. Maintenance of minimum instream flows during the period of outmigration will provide further assurance of successful downstream migration of river lamprey.

7.10.3 River Lamprey Spawning and Incubation

After migrating upstream between September and late winter, adult river lamprey overwinter and spawn the following spring from April to June (Beamish 1980). Spawning areas are likely similar to those used by Pacific lamprey, which are areas located in low gradient reaches in mainstem and tributary pool tailouts and riffles. Spawning likely occurs over predominantly gravel substrates with a mixture of pebbles and sand. River lamprey die after spawning; there has been no documentation of repeat spawning as for Pacific lamprey. Egg incubation and hatching times are presumed to be similar to those of Pacific lamprey (see Chapter 7.9.3).

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on River Lamprey Spawning and Incubation

As noted above, the general types of habitat used by lamprey for spawning are similar to those used by salmonids. Hence, Tacoma's water withdrawals may result in some reduction in river lamprey spawning habitat. However, there is no information regarding specific locations used by river lamprey for spawning (or the timing of spawning) and therefore the degree of impact is unknown. The incubation period of eggs is assumed to be shorter for lamprey (based on Pacific lamprey information) than for salmonids, and therefore the period of time in which the eggs/embryos will be vulnerable to subsequent flow reductions and potential dewatering will be less than for salmonids.

As for Pacific lamprey, the combined effects of target baseflows in the spring, restrictions in stage decline, and maintenance of minimum flows in the Green River may all provide some benefits to river lamprey spawning and incubation.

7.10.4 River Lamprey Juvenile Rearing

Little is known about the rearing behavior of river lamprey, although it is assumed to be similar to that of Pacific lamprey (see Chapter 7.9). Based on Pacific lamprey data, larvae of river lamprey likely emerge from gravel nests approximately 5 to 6 weeks after hatching and drift downstream to settle in slow backwater areas. The larval lamprey, termed ammocoetes, drift into areas of slow current and burrow into mud and sand deposits. As they grow, ammocoetes may find new areas to burrow in, colonizing areas downstream. The length of the larval stage of river lamprey has not been documented;

Pacific lamprey may remain as ammocoetes for up to 7 years (see Chapter 7.9). After metamorphosis in late July (Beamish 1980), the young adults likely hold in cobble and boulder substrates before migrating to the ocean the following year from May to June.

Potential Effects of Tacoma's Water Withdrawal and Associated Conservation Measures on River Lamprey Juvenile Rearing

Tacoma's water withdrawals may affect river lamprey rearing habitat by reducing flows in the middle and lower Green River by up to 213 cfs on a daily basis. The results of the analysis of Tacoma's exercise of its FDWRC and SDWR during the steelhead incubation period (1 May through 31 July) indicate that side-channel areas in the middle Green River will be reduced by an average of 1.4 acres (i.e., 23 percent reduction) from that occurring without the withdrawals. Since this analysis is based on changes in side-channel areas and does not adjust for differences between fish species, the results should be applicable to lamprey rearing during that same time period. Because larval lamprey may rear in fresh water for extended periods, theoretically they will be more vulnerable to low flow conditions than salmonid species, which have a much shorter freshwater rearing period.

The restoration and reconnection of Signani Slough will likely provide additional spawning and rearing habitat for river lamprey. The provision of instream flows as specified at Auburn and Palmer gages (see Chapter 5.1.1 and 5.1.2) will maintain important rearing habitats in the river during low flow and drought conditions.

7.11 Gray Wolf *(Canis lupus)*

Implementation of the Green River HCP will have a minor positive impact on the gray wolf. Habitat Conservation Plan measures to protect gray wolf dens and "first" rendezvous sites are consistent with USFWS guidelines to avoid incidental take, thereby avoiding any negative impacts to the species while conducting covered activities in the upper portions of the HCP Area. Maintenance of habitat conditions preferred by gray wolf prey (elk and deer) will also benefit the species. However the overall positive effect will be minor because few, if any, gray wolves are likely to occur in the Upper HCP Area, and none are likely to occur downstream of HHD.

Measure HCM 3-04G restricts timber felling, yarding, road construction, blasting, and use of helicopters for timber harvest and silvicultural activities within 1.0 mile of a known active gray wolf den from 15 March through 15 July. These activities are also restricted within 0.25 mile of a "first" rendezvous site from 15 May through 15 July. Additionally, outside the denning season, Tacoma will contact the USFWS prior to conducting harvest activities within 0.25 mile of a known den. The primary function of this measure is to reduce disturbance to denning wolves and to maximize the possibility that wolves will continue to use known den and rendezvous sites in the future. Other measures in the HCP not specific to the gray wolf will provide additional benefits. Road closure and abandonment will provide direct benefits by reducing disturbance. Firearm restrictions will provide direct benefits by decreasing the likelihood of a wolf being shot or harassed. Several of the forest management measures for the upper portion of the HCP Area will improve the quality of habitat for ungulate prey of the gray wolf (deer and elk), and thereby improve conditions for the wolf. Late-seral coniferous forest in the Natural and Conservation Zones and in riparian areas will provide hiding and thermal cover for deer and elk. Long rotations and small harvest unit sizes in the Commercial Zone will provide favorable mixtures of cover and forage for these same ungulates, and the creation of shrub and grass plots will increase forage for deer and elk above levels typical of western Washington forests. Riparian management measures in all forest zones will protect areas of a type known to be important to deer and elk during the calving season and winter (O'Connell et al. 1993).

It is likely the HCP will have only a minor effect or no effect on the overall population of gray wolves in Washington. Although there have been wolves sighted in the upper Green River watershed, the HCP Area is on the fringe of the species' range. If the gray wolf does inhabit any portion of the HCP Area, it will occur only in small numbers in the upper watershed. Should the number of gray wolves in the HCP Area increase in the future, the HCP measures could benefit the species.

7.12 Peregrine Falcon *(Falco peregrinus)*

The Green River HCP will have a positive effect on peregrine falcons by: 1) protecting nest sites and potential nesting cliffs from disturbance; 2) protecting potential hunting habitat in riparian zones; and 3) protecting and improving water quality for water bird prey species. The combined effects of Measures HCM 3-04K and HCM 3-04L will be to avoid any negative impacts to peregrine falcons that might occur while conducting covered activities, and to improve habitat conditions overall in the upper Green River watershed for peregrine falcons and their prey. These species-specific measures will provide seasonal protection during nesting and long-term habitat protection around nest sites in the upper Green River basin. In addition, all potential nest cliffs (> 75 feet high) will be buffered from timber harvest and other habitat alteration. Other measures focused on riparian management, such as no-harvest riparian and wetland buffers and partial-harvest riparian buffers along streams, will provide protection and screening cover for prey species in open aquatic habitats in the upper Green River basin. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation management, erosion control, culvert improvements, stream-crossing improvements and road construction improvements on steep and unstable soils will protect and eventually improve stream and open water habitats, and water quality for water bird populations.

Operation of the water supply project, diversion of water from the Green River, and performance of other covered activities in the upper watershed are not expected to have any negative impact on peregrine falcons in the upper Green River basin. Peregrines are unlikely to inhabit the lower and middle basin areas, so they will not be affected by changes in stream flow on the Green River. Overall, the HCP will benefit any existing falcons that might occur in the upper basin.

7.13 Bald Eagle *(Haliaeetus leucocephalus)*

The HCP will have a positive effect on bald eagles by: 1) increasing the overall amount and quality of late-successional coniferous forest habitat; 2) protecting nest and communal winter night roosts; 3) providing protection of riparian zones along lakes and rivers; and 4) protecting and improving water quality. Negative impacts to bald eagles will be avoided altogether during the performance of covered activities.

Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, hardwood conversion, and snag and green-tree recruitment will improve the amount and quality of late-successional coniferous forest in the Upper HCP Area. Under the HCP, green-tree retention in harvest units will result in larger and greater numbers of residual trees and snags than normally required under Washington Forest Practices Rules and Regulations, thus providing more foraging perches and potential nest sites for bald eagles. Riparian management measures such as no-harvest riparian and wetland buffers and partial-harvest riparian buffers along streams will protect and improve conditions for fish prey species as well as protecting nest and roost trees. Road construction and maintenance measures, including road closures to the public and road abandonment, will reduce human disturbance and improve water quality, thereby improving habitat for bald eagle prey. Species-specific measures (HCM 3-04M and HCM 3-04N) will provide seasonal and long-term protection during nesting and winter roosting in the Green River basin. Restoration of anadromous fish is likely to provide a substantial supply of spawned-out adults in the reservoir and upper tributaries, which will benefit eagles in the upper basin of the Green River.

Operation of the water supply project and diversion of water from the Green River will have no negative effects on bald eagles in the upper basin. Overall, the HCP will benefit the population existing in the upper basin. Bald eagles along the lower and middle basin areas of the Green River will benefit from restoration of salmon spawning habitat in side channels as well as restoration of salmon runs above the dam.

7.14 Marbled Murrelet *(Brachyramphus marmoratus)*

The HCP has the potential to have a positive effect on the marbled murrelet by increasing riparian protection and promoting late-successional forest conditions on approximately 72 percent of the Upper HCP Area (8,349 acres in the Natural Zone, Conservation Zone, UMA and riparian buffers of the Commercial Zone; out of a total of 11,644 acres of forestland in the three zones combined). Marbled murrelets are currently rare in the Green River watershed, however, so any short-term benefits will be negligible. Over the long term, the HCP will provide potential nest sites, should murrelets expand their use of the Upper HCP Area in the future. Negative impacts to marbled murrelets will be avoided by implementing seasonal disturbance buffers around occupied habitats and habitats where occupancy is suspected but undetermined. There are no murrelets known to inhabit the HCP Area, and there will be no potential marbled murrelet habitat harvested in conjunction with any of the covered activities.

7.15 Northern Spotted Owl *(Strix occidentalis caurina)*

The Green River HCP will have a positive effect on spotted owls located in the upper portion of the HCP Area as a result of the seasonal and long-term protection of spotted owl nests; retention of late-successional forest in the Natural and Conservation Zones; 70-year rotation ages in the Commercial Zone; and increased retention of snags, recruitment trees, and logs. Conversely, timber harvest activities in the Commercial Zone may periodically reduce the total amount of foraging habitat within 1.8 miles of one or more existing spotted owl activity centers, and thereby reduces the ability of these areas to successfully support reproducing owls. Overall, positive effects are expected to outweigh negative effects because there will be substantial increases in the overall availability of habitat, compared to minor reductions in habitat near existing activities centers.

The HCP restricts timber felling, yarding, road construction, blasting, and use of helicopters for timber harvest and silvicultural activities within 0.25 mile of known active nests from 1 March through 31 August, unless owls occupying the site have been found, by USFWS protocol surveys, to be non-reproductive or to have failed to reproduce during a given year. Reproductive status will be determined no earlier than 15 May. The HCP restricts timber felling and habitat alteration within 660 feet (31.4 acres) of a known site center occupied by a spotted owl pair or resident single until the site has been found, by USFWS protocol surveys, to be unoccupied for 3 consecutive years. Some measures that are not specific to the spotted owl also provide benefits. Forest management in all zones will result in additional spotted owl habitat. Management in the Natural and Conservation Zones will result in the retention of existing old-growth forest, the preferred habitat of the spotted owl. Management in the Commercial Zone will provide additional habitat as a result of the extended rotation age of 70 years. Snag, green-tree, and log retention measures will ultimately provide habitat for spotted owl prey, which will provide indirect benefits to the owl.

Suitable spotted owl habitat in the Upper HCP Area has been classified by Tacoma as Type A (capable of supporting nesting, roosting and foraging), Type B (capable of supporting roosting and foraging only) and Type C (capable of supporting foraging only). Within the Upper HCP Area there are 1,718.3 acres of Type A, B and C spotted owl habitat that lie within 1.8 miles of one or more known spotted owl activity centers (Table 7-31). This is the habitat potentially used by spotted owls nesting in and near the HCP Area. Of this total, 566.8 acres lie within 0.7 mile of an activity center, and are therefore considered to be potentially important to resident spotted owls (Table 7-32). Some of this habitat will be harvested under the HCP, while most will be protected from harvest.

All suitable habitat in the Natural Zone will be protected under the HCP, including the 792.9 acres that lie within 1.8 miles of one or more activity centers (Table 7-31). All suitable habitat in the Conservation Zone, including the 493.1 acres within 1.8 miles of an activity center, will be managed under an uneven-aged silvicultural system to promote the development of late-seral forest conditions. Periodic commercial thinning in the Conservation Zone may disrupt or displace some resident owls, but over the long term this uneven-aged management will improve habitat conditions for resident spotted owls. Once a stand of forest habitat in the Conservation Zone reaches 100 years of age, no further harvesting will occur and there will be no harvest-related impacts to resident spotted owls.

The Commercial Zone contains 432.3 acres of suitable spotted owl habitat within 1.8 miles of one or more activity centers. Most, but not all, of this will be available for even-aged harvest under the HCP. An estimated 39.0 acres in the Commercial Zone will be retained within UMAs, and another undetermined number of acres will be protected within riparian buffers. This leaves a maximum of 393.3 acres of suitable spotted owl habitat within 1.8 miles of an activity center that could be available for harvest in the

Commercial Zone. Of the 393.3 acres, 61.2 acres are Type A, 165.9 acres are Type B, and 205.2 acres are Type C. An estimated 237.3 of the 393.3 acres lie within 0.7 mile of an activity center (Table 7-32), where they could be important to resident spotted owls.

The effects of habitat loss on individual spotted owl activity centers will be relatively minor. The 16 spotted owl sites in the vicinity of the Upper HCP Area have between 26 percent and 55 percent suitable habitat within 1.8 miles of their activity centers (Table 7-33). All 16 sites have at least as much habitat as Thomas et al. (1990) suggested was necessary to support resident spotted owl pairs in the western Washington Cascades. Seven of these 16 activity centers will experience no loss of habitat as a result of Tacoma's activities under the Green River HCP (Site Numbers 212, 589, 769, 791, 857, 888, and 955). Another eight will experience temporary impacts followed by long-term improvements in habitat as a result of uneven-aged management in the Conservation Zone (Site Numbers 548, 555, 727, 737, 760, 793, 859, and 1153).

Loss of habitat due to even-aged harvest of timber will occur within 1.8 miles of only five activity centers (Site Numbers 555, 727, 760, 762, and 793), four of which will also experience habitat enhancement through uneven-aged management. The amount of habitat removed through even-aged harvest will represent at most 2 percent of the total area within 1.8 miles of only three of these activity centers (Site Numbers 727, 762, and 793). One of these activity centers (Site Number 793) is not a resident owl site and probably is not occupied by spotted owls. The other two (Site Numbers 727 and 762) currently have 45 percent and 53 percent habitat, respectively. These totals will be reduced by no more than 2 percent each under the HCP. No activity center will be reduced to having less than 40 percent suitable habitat within 1.8 miles. Post-harvest conditions will all be within the range of habitat for known reproductive sites in the Washington Cascades (Thomas et al. 1990).

Similar effects will be observed within 0.7 mile of the known activity centers. Only one (Site Number 727) that currently has less than 50 percent suitable habitat within 0.7 mile will be subjected to even-aged harvest. This activity center currently has 48 percent suitable habitat within 0.7 mile, and approximately 1 percent will be harvested under the Green River HCP.

Table 7-31. Suitable spotted owl habitat in the Green River HCP Area within 1.8 miles of known spotted owl activity centers.

Forest Management Zone	Acres of Suitable Spotted Owl Habitat			
	Type A	**Type B**	**Type C**	**TOTAL**
Natural Zone	48.9	561.2	182.8	792.9
Conservation Zone	0.0	194.3	298.8	493.1
Commercial Zone	61.2	165.9	205.2	432.3[1]
Total	**110.1**	**921.4**	**686.8**	**1718.3**

[1] Includes 39.0 acres to be retained in Upland Management Area (UMA).

Table 7-32. Suitable spotted owl habitat in the Green River HCP Area within 0.7 mile of known spotted owl activity centers.

Forest Management Zone	Acres of Suitable Spotted Owl Habitat			
	Type A	**Type B**	**Type C**	**TOTAL**
Natural Zone	40.0	37.5	105.3	182.8
Conservation Zone	0.0	44.0	74.4	118.4
Commercial Zone	61.2	129.2	75.2	265.6[1]
Total	**101.2**	**210.7**	**254.9**	**566.8**

[1] Includes 28.3 acres to be retained in Upland Management Area (UMA).

Table 7-33. Total percent suitable spotted owl habitat available within 0.7 mile and 1.8 miles of known spotted owl activity centers, and percent habitat proposed for harvest under the Green River HCP.

Activity Center I.D. Number	Percent Suitable Spotted Owl Habitat Within 0.7 Mile of Activity Center			Percent Suitable Spotted Owl Habitat Within 1.8 Miles of Activity Center		
	Total Available	Proposed for Even-aged Harvest	Proposed for Uneven-aged Harvest	Total Available [1]	Proposed for Even-aged Harvest	Proposed for Uneven-aged Harvest
212	41	0	0	26	0	0
548	73	0	0	47	0	< 1
555	64	0	< 1	54	< 1	< 1
589	55	0	0	48	0	0
727	48	1	< 1	45	2	< 1
737	47	0	< 1	37	0	0
760	66	< 1	0	48	< 1	2
762	64	< 1	0	53	2	0
769	63	0	0	53	0	0
791	52	0	0	35	0	0
793 [2]	17	2	1	31	2	2
857	38	0	0	35	0	0
859	56	0	0	55	0	3
888	50	0	0	40	0	0
955	60	0	0	51	0	0
1153	83	0	0	43	0	< 1

[1] Based on Washington Department of Natural Resources data of 1 October 1999.

[2] Site does not have resident status.

Overall, the HCP will benefit the population of spotted owls existing in the upper portion of the HCP Area more than the continuance without the HCP. Current Forest Practices Rules and Regulations and federal restrictions on the take of spotted owls restrict harvesting, road construction, and aerial application of pesticides in and around known spotted owl activity centers, but they do not require or even encourage landowners to create new habitat for spotted owls. The HCP will provide slightly less protection for spotted owl activity centers in the Commercial Zone, but considerably more protection in the Natural and Conservation Zones and a significant increase in habitat overall in the

HCP Area. The number of spotted owls successfully nesting in the HCP Area will likely increase over time as a result of the HCP.

7.16 Grizzly Bear *(Ursus arctos)*

The Green River HCP contains specific measures to avoid or reduce disturbance to grizzly bears, but the overall positive effect on this species will be minor because few, if any, grizzly bears are likely to occur in the upper portion of the HCP Area and none are likely to occur in the middle and lower portions of the HCP Area. No negative effects on grizzly bears are anticipated as a result of performing any of the covered activities.

The HCP measures specific to the grizzly bear provide 1.0-mile buffers for known active den sites from 1 October through 31 May, the temporary suspension of management activities and the addition of long-term visual screening along roads following confirmed grizzly bear sightings, and the removal of dump sites that may attract grizzly bears. The HCP will also result in restrictions on firearms in the HCP Area, restrictions on road construction through preferred grizzly bear habitats, and notification of the USFWS before any habitat alteration within 3.0 miles of a known den site. These measures are designed to reduce disturbance to grizzly bears and their preferred habitats and to maximize the possibility that grizzly bears will continue to use known den sites. Other measures in the HCP not specific to the grizzly bear will provide additional benefits. Road closure and abandonment will provide direct benefits by reducing disturbance. Also, some large blocks of roadless habitat (e.g., lower Friday Creek) currently exist within the upper watershed. These areas will be managed as Natural Zones and will remain roadless. Riparian protection will provide direct benefits by increasing the quality of riparian habitat. Grizzly bears use riparian habitats during fish runs and fruiting season (O'Connell et al. 1993). Restoration of salmon runs will improve the prey base for grizzly bears.

Overall, the HCP will have a minor effect or no effect on the overall population of grizzly bears in Washington. Although grizzly bear presence has been documented south of the HCP Area, the HCP Area is on the fringe of the species' range. If the grizzly bear does inhabit any portion of the HCP Area, it will occur only in small numbers in the upper watershed. Should the grizzly bear begin to extend its range into the HCP Area, the HCP could provide a larger benefit. Current Washington Forest Practice Rules and Regulations restrict harvesting, road construction, and site preparation within 1.0 mile of known active dens between 15 March and 30 July, and within 0.25 mile the remainder of the year, but offer no requirements for visual screening, removal of dump sites, restrictions on road building in preferred habitats, or restrictions on firearms. Overall, the

HCP will benefit the population existing in the upper basin more than continuance without the HCP.

7.17 Oregon Spotted Frog *(Rana pretiosa)*

Water withdrawals from the Green River could have negative effects on the Oregon spotted frog by altering water levels in the preferred habitat of this amphibian (calm, shallow, low-elevation sloughs, and side channels) along the middle and lower reaches of the river. Such effects will be minor, however, because such habitat is rare in the Green River drainage, and the frog is even rarer. Measures in this HCP to provide stable summer flows in the Green River for salmonids will minimize any effects of water withdrawal, and restoration of Signani Slough (Measure HCM 2-07) will create new habitat for the Oregon spotted frog to offset any impacts. Again, these effects (both positive and negative) are likely to be minor because there is only a remote possibility the Oregon spotted frog is present in the Green River basin.

7.18 Canada Lynx *(Lynx canadensis)*

The HCP contains measures that are beneficial to the Canada lynx, but the overall positive effect on this species will be minor because few, if any, Canada lynx are likely to occur in the HCP Area. No negative effects are anticipated as a result of the covered activities.

The HCP measure specific to the lynx (HCM 3-04J) restricts timber felling, yarding, road construction, blasting, and silvicultural activities involving the use of helicopters within 0.5 mile of known active den sites or potential lynx denning habitat from 1 May through 31 July. This measure is designed to reduce disturbance to Canada lynx and to maximize the possibility that they will continue to use known den sites. Other measures in the HCP not specific to the Canada lynx will provide additional benefits. Road closure and abandonment will provide direct benefits by reducing disturbance. Limiting clearcut size to 40 acres will decrease the large openings that the lynx avoids. Firearm restrictions will provide benefits by decreasing the likelihood of a Canada lynx being shot. It is likely that the HCP will have little or no effect on the population of Canada lynx in Washington. Although there has been a Canada lynx sighted in the upper Green River watershed, the HCP Area is on the fringe of the species' range. If the Canada lynx does inhabit any portion of the HCP Area, it will occur only in small numbers in the upper watershed. Should the lynx begin to extend its range into the HCP Area, the HCP could provide a larger benefit. Overall, the HCP will benefit the Canada lynx because current

Washington Forest Practices Rules and Regulations have no restrictions on harvesting, road construction, or site preparation near known active lynx dens.

7.19 Cascades Frog *(Rana cascadae)*

The Green River HCP will have positive effects on Cascades frogs by: 1) providing protection of riparian zones and wetlands; and 2) protecting and improving water quality. No negative effects are anticipated, because this species is highly aquatic and relatively insensitive to forest conditions beyond the riparian zone.

Riparian management measures, such as no-harvest and partial-harvest riparian buffers adjacent to streams and wetlands, will protect streamside vegetation, bank stability, instream habitat, and water quality in the upper Green River basin. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation management, erosion control, culvert improvements, stream-crossing improvements and road construction improvements on steep and unstable soils, will protect and eventually improve stream and wetland habitat and improve connectivity of riparian corridors.

Operation of the water supply project and diversion of water from the Green River will have no effect on the Cascades frog because this high elevation species does not occur in the lower and middle basin areas of the Green River, and will not be affected by changes in stream flow on the Green River. Overall, the HCP will benefit the population existing in the upper basin more than continuance without the HCP, since there are no requirements to protect habitat for this species under current state or federal laws.

7.20 Cascade Torrent Salamander *(Rhyacotriton cascadae)*

The HCP will have positive effects on Cascade torrent salamanders (if they occur in the area) by: 1) increasing the overall amount and quality of late-successional coniferous forest habitat near streams; 2) maintaining canopy cover directly adjacent to streams; 3) protecting and improving water quality and instream habitat; and 4) providing protection of talus fields (including all permanently wet talus), all of which are important habitat components for this species. Minimal negative effects are expected because the wide riparian buffers to be implemented under the HCP will maintain cool stream temperatures and ensure no direct impacts of timber harvesting on this highly aquatic species.

Measures HCM 3-02A and HCM 3-02B will provide no-harvest buffers of 50 to 100 feet on all perennial non-fish-bearing streams (WDNR Type 4), the most likely habitat of the species in the Green River basin. When combined with upland forest management measures such as no-harvest in the Natural Zone; uneven-aged management and reduced harvest rate in the Conservation Zone; and extended rotation (70 years), reduced harvest rate and reduced clearcut size in the Commercial Zone; the riparian protection measures will essentially eliminate the effects of timber harvesting on the microclimate of small streams. Mature forest cover is beneficial to the Cascade torrent salamander because it contributes to the cool, moist microclimate required by adults. Riparian management measures will protect shade, bank stability, instream habitat, and water quality in the upper basin of the Green River. These stream functions are critical to the fully aquatic larval Cascade torrent salamanders, which require cold, clear, oxygen-rich water and a cobble substrate. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation, erosion control, culvert improvements, stream-crossing improvements, and road construction improvements on steep and unstable soils, will protect existing water quality and stream habitat and improve connectivity of riparian corridors with closed-canopy riparian forests. Cascade torrent salamanders will also use wet talus with permanent seeps. Species-specific measures designed to protect Larch Mountain salamanders will benefit Cascade torrent salamanders by providing permanent protection of talus slopes in the upper Green River basin.

Operation of the water supply project and diversion of water from the Green River are not expected to have negative impacts on this species in the upper Green River basin, because the small headwater streams (WDNR Types 3 and 4) and seeps it uses will not be affected by changes in stream flow on the Green River. The species is not expected to occur in the lower and middle basin areas.

7.21 Van Dyke's Salamander *(Plethodon vandykei)*

The HCP will have positive effects on Van Dyke's salamanders by: 1) increasing the overall amount and quality of late-successional coniferous forest habitat; 2) providing protection of talus fields; and 3) providing protection of riparian zones along small streams. Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas, and snag recruitment will improve the amount and quality of late-successional coniferous forest. Van Dyke’s salamanders require the moist microclimate provided by extensive mature forest cover, and utilize rotten logs for cover, foraging, and egg laying. Riparian management measures such as no-harvest riparian buffers and partial-harvest riparian buffers will protect shade, bank stability, instream habitat, water quality, and improve connectivity of riparian corridor forests in the upper basin of the Green River. Van Dyke's salamanders are closely associated with the banks of small streams that have a dense canopy cover, and their dispersal is probably reduced in areas of extensive clearcutting. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation management, erosion control, culvert improvements, stream-crossing improvements, road construction improvements on steep and unstable soils, and Watershed Analysis, will protect existing water quality and stream habitat and improve connectivity of riparian corridors. Species-specific measures designed to protect Larch Mountain salamanders will also benefit Van Dyke's salamanders by providing permanent protection of unique habitats (talus slopes), which will directly benefit both species in the upper Green River basin. Van Dyke's salamanders are often found in talus, usually with overhead forest cover or nearby forest cover.

Operation of the water supply project and diversion of water from the Green River are not expected to have negative impacts on the Van Dyke's salamander in the upper Green River basin, because the species only uses small headwater streams (WDNR Types 3 and 4) and these will not be affected by changes in stream flow on the Green River. Currently, the species is known to occur only in the upper basin, but positive impacts in the area could result in the development of a source population, thereby providing recruitment for populations along this northwest limit of the species' range.

7.22 Larch Mountain Salamander *(Plethodon larselli)*

Under the HCP, positive effects on Larch Mountain salamanders will result from: 1) increasing the overall amount and quality of late-successional coniferous forest habitat; and 2) providing protection of habitat occupied by individuals of the species. Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, hardwood conversion, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas, and snag recruitment will improve the amount and quality of late-successional coniferous forest. Larch Mountain salamanders are often associated with mature and old-growth forest cover, where logs and rock talus are used for cover. They prefer coniferous forest, so hardwood conversion will help to improve habitat quality in the future. Road construction and maintenance measures, including road closures to the public and road abandonment, will protect existing habitat and improve connectivity by reducing road barriers. Species-specific measures will provide permanent protection of occupied habitats and are expected to benefit the species directly in the upper Green River basin.

Operation of the water supply project and diversion of water from the Green River are not expected to have negative impacts on Larch Mountain salamanders in any part of the Green River basin, because this is a fully terrestrial, upland species that will not be affected by changes in stream flow. Currently, the species is known to occur only in the upper basin, but positive impacts in the area could result in the development of a source population, thereby providing recruitment for populations along this northwest limit of the species' range. Overall, the HCP will benefit the population existing in the basin, since there are no requirements to protect habitat for this species under current state or federal laws.

7.23 Tailed Frog *(Ascaphus truei)*

The Green River HCP will have positive effects on tailed frogs by: 1) increasing the overall amount and quality of late-successional coniferous forest habitat; 2) providing protection of riparian zones along small streams; and 3) protecting and improving water quality and instream habitat. Negative impacts could occur if riparian buffers are insufficient to completely prevent deleterious increases in stream temperatures after timber harvesting, but the potential for this is low because of the wide buffers and the low overall rate of even-aged harvest (averaging no more than 40 acres per year).

Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas, and snag recruitment will improve the amount and quality of late-successional coniferous forest. Mature forest cover is beneficial since it contributes to the cool, moist microclimate required by adult tailed frogs that forage well into uplands at night. Riparian management measures such as no-harvest riparian buffers and partial-harvest riparian buffers will protect shade, bank stability, instream habitat, water quality, and improve connectivity of riparian corridors with closed-canopy riparian forests. Larval tailed frogs are adapted to very cold water and tailed frog populations can be retained in areas with riparian buffer strips. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation management, erosion control, culvert improvements, stream-crossing improvements and road construction improvements on steep and unstable soils, will protect existing water quality and stream habitat and improve connectivity.

Operation of the water supply project and diversion of water from the Green River are not expected to have negative impacts on the tailed frog in the upper Green River basin, because the species only uses small headwater streams (WDNR Types 3 and 4) and these will not be affected by changes in stream flow on the Green River. Currently, the species is known to occur only in the upper basin, but positive impacts in the area could result in the development of a source population, possibly providing recruitment to small streams entering the middle Green River basin.

7.24 Northwestern Pond Turtle *(Clemmys marmorata)*

The Green River HCP will have positive effects on Northwestern pond turtles by: 1) providing protection of riparian zones and wetlands; 2) providing a future source of LWD to aquatic habitats; and 3) protecting and improving water quality and instream habitat. Negative impacts could rarely occur if pond turtles are present in upland areas (beyond no-harvest riparian buffers) during timber harvest or road construction. Given the rarity of northwestern pond turtles in the HCP Area, both positive and negative impacts are expected to be minor.

Riparian management measures such as no-harvest riparian and wetland buffers and partial-harvest riparian buffers along streams will provide sources of LWD as well as protection of potential aquatic habitats in the upper Green River basin. The riparian buffers will provide for recruitment of future logs for basking sites and cover, and the no-harvest sections will eliminate the use of heavy machinery that could crush turtles and/or their nests in the riparian zone. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation management, erosion control, culvert improvements, stream-crossing improvements and road construction improvements on steep and unstable soils, will protect and eventually improve stream and wetland habitat and water quality. These mitigation measures will decrease wetland habitat fragmentation and protect water quality for the aquatic food chain supporting pond turtles.

Operation of the water supply project and diversion of water from the Green River are not expected to have negative impacts on pond turtles in the upper Green River basin, but if pond turtles are present in the lower and middle basins they could be affected by changes in stream flow on the Green River. Increased side-channel flow downstream of the Headworks will cause water velocity to reach unfavorable levels for pond turtles in some areas, but will also result in the formation of additional acres of pool habitat, backwaters, and ponds, resulting in an overall neutral effect on pond turtle habitat overall. Improvements to Signani Slough (Measure HCM 2-07) could provide additional habitat for the Northwestern pond turtle in the middle Green River basin, where the species is most likely to make use of it in the future.

7.25 Northern Goshawk *(Accipiter gentilis)*

The Green River HCP will have positive effects on northern goshawks by: 1) increasing the overall amount and quality of late-successional coniferous forest habitat; 2) protecting known nest sites; and 3) protecting and improving riparian forests. Negative impacts will include temporal losses of habitat and destruction of unknown nests during timber harvesting in the Conservation and Commercial Zones. Negative impacts are expected to be minimized by the combination of forest management and species-specific management measures in the HCP.

Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management, and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, hardwood conversion, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas, and snag recruitment will improve the amount and quality of late-successional coniferous forest, a preferred habitat of the northern goshawk. Riparian management measures such as no-harvest riparian and wetland buffers, and partial-harvest riparian buffers along streams will protect and improve conditions for riparian-associated prey species. Road construction and maintenance measures, including road closures to the public and road abandonment, will reduce disturbance and habitat fragmentation. Species-specific measures will provide seasonal protection during nesting and long-term habitat protection around known nest sites in the upper Green River basin. Operation of the water supply project and diversion of water from the Green River will have no impact on goshawks in any part of the Green River basin, since the species is not associated with aquatic habitats.

7.26 Olive-Sided Flycatcher *(Contopus cooperi)*

The HCP will have positive effects on olive-sided flycatchers by: 1) increasing the overall amount and quality of late-successional coniferous forest habitat; and 2) protecting and improving forests around open wetlands. Negative impacts could occur as a result of habitat loss and nest destruction during timber harvesting operations in the Commercial Zone where even-aged harvesting may take place in the preferred habitat of this species (upland forest edges).

Olive-sided flycatchers will benefit from an overall increase in habitat that will result from forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, hardwood conversion, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas and snag recruitment. Under the HCP, green-tree retention in harvest units will provide larger and greater numbers of residual trees than normally required under Washington Forest Practices Rules and Regulations, thus providing more foraging perches and potential nest sites for olive-sided flycatchers. Riparian management measures such as no-harvest riparian and wetland buffers, will provide edge habitat between forests and open areas, and tall foraging perches. Negative impacts will be short term and will be limited to even-aged harvesting in the Commercial Zone, which will average no more than 40 acres per year. Such harvesting will ultimately increase the amount of habitat available for the olive-sided flycatcher by creating the forest edge habitat the species seeks for nesting.

Operation of the water supply project and diversion of water from the Green River will have no negative impact on olive-sided flycatchers in any part of the Green River basin. Overall, the HCP will benefit the population existing in the basin, since there are no requirements to protect habitat for this species under current state or federal laws.

7.27 Vaux's Swift *(Chaetura vauxi)*

The Green River HCP will have positive effects on Vaux's swifts by: 1) increasing the overall amount and quality of late-successional coniferous forest; and 2) protecting and improving riparian forests. Negative effects could occur if snags or residual live trees used as nests or roosts are felled or otherwise made unsuitable during timber harvesting operations. The potential for negative impact is considered low.

Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, hardwood conversion, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas, and snag recruitment in harvest units will improve the amount and quality of late-successional coniferous forest. Under the HCP, green-tree and snag retention will provide larger and greater numbers of snags and residual trees (for snag recruitment) than normally required under Forest Practices Rules and Regulations, thus providing more potential foraging, nesting, and roosting sites for Vaux's swifts. Riparian management measures such as no-harvest riparian and wetland buffers and partial-harvest riparian buffers along streams will provide additional late-successional forest. Measure HCM 3-04T will specifically encourage Tacoma to retain snags used by the Vaux's swift if any are found during timber harvest operations.

Operation of the water supply project and diversion of water from the Green River will have no negative impact on Vaux's swifts in any part of the Green River basin. Overall, the HCP will benefit the population existing in the upper basin more than continuance without the HCP, since there are no requirements to protect habitat for this species under current state or federal laws.

7.28 California Wolverine *(Gulo gulo)*

The Green River HCP contains measures that are beneficial to the California wolverine, but the overall positive effect on this species will be minor because few, if any, California wolverines are likely to occur in the HCP Area. No negative impacts are anticipated.

The HCP measure specific to the wolverine restricts timber felling, yarding, road construction, blasting, and silvicultural activities involving the use of helicopters within 0.5 mile of known active den sites from 1 October through 31 May. This measure is designed to reduce disturbance to California wolverines and to maximize the possibility that they will continue to use known den sites. Other measures in the HCP not specific to the California wolverine will provide additional benefits. Road closure and abandonment will provide direct benefits by reducing disturbance. Firearm restrictions will provide benefits by decreasing the likelihood of a wolverine being shot.

It is likely that the HCP will have only a minor effect or no effect on the population of the California wolverine in Washington. Although there have been sightings of California wolverines in the upper Green River watershed and the I-90 Land Exchange Parcel, the HCP Area is on the fringe of the species' range. If the California wolverine does inhabit any portion of the HCP Area, it will occur only in small numbers in the upper watershed. However, should the wolverine begin to extend its range into the HCP Area, the HCP could provide a larger benefit.

7.29 Pacific Fisher *(Martes pennanti)*

The Green River HCP will have positive effects on the Pacific fisher by reducing disturbance to denning fishers, increasing riparian protection, and managing for late-successional forest conditions; but the overall positive effect on this species will be minor because few, if any, fishers are likely to occur in the HCP Area. Negative effects on fishers will occur only if occupied forest habitat or den sites are impacted during timber harvesting, but the potential for this is low.

The HCP measure specific to the fisher restricts timber felling, yarding, road construction, blasting, and silvicultural activities involving the use of helicopters within 0.5 mile of known active den sites from 1 February through 31 July. This measure is designed to reduce disturbance to the Pacific fisher and to maximize the possibility that they will continue to use known den sites. Other measures in the HCP not specific to the Pacific fisher will provide additional benefits. Road closure and abandonment will provide direct benefits by reducing disturbance. Because fishers are known to utilize riparian corridors extensively, increased riparian protection will provide a direct benefit. Management in the Natural and Conservation Zones for late-successional forest conditions will provide direct benefits as a result of greater amounts of available down woody debris, a habitat component important to the fisher. Snag, green recruitment tree and log retention following harvest will also result in direct benefits. Firearm restrictions provide benefits by decreasing the likelihood of a fisher being shot.

It is likely the Green River HCP will have only a minor effect or no effect on the population of the Pacific fisher in Washington. Although there has been a sighting of a fisher in the upper Green River watershed, it is unlikely that the fisher population in the HCP Area is large. If the Pacific fisher does inhabit any portion of the HCP Area, it will occur only in small numbers in the upper watershed.

7.30 Common Loon *(Gavia immer)*

The HCP will have positive effects on common loons by: 1) providing protection of riparian zones along lakes and rivers; 2) restoring anadromous fish to Howard Hanson Reservoir; 3) reducing road construction and use; and 4) protecting and improving water quality in the reservoir. Negative effects may occur during fluctuations in the level of Howard Hanson Reservoir, but management of the reservoir is under the jurisdiction of the USACE, and not a covered activity under this HCP. No other negative effects on loons are anticipated as a result of water supply activities in the Green River basin.

Riparian management measures such as no-harvest riparian and wetland buffers and partial-harvest riparian buffers along streams will provide protection and screening cover of potential open aquatic habitats in the upper Green River basin. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation management, erosion control, culvert improvements, stream-crossing improvements, and road construction improvements on steep and unstable soils, will protect and eventually improve stream and open water habitats and water quality. Restoration of anadromous fish is likely to provide a substantial supply of fingerlings and smolts in the reservoir, which will benefit loons.

Operation of the water supply project and diversion of water from the Green River are not expected to have negative impacts on loons in the upper Green River basin because they are generally restricted to Eagle Lake and Howard Hanson Reservoir. Loons are unlikely to inhabit the lower and middle basin areas, so they will not be affected by changes in stream flow on the Green River.

7.31 Pileated Woodpecker *(Dryocopus pileatus)*

The HCP will have positive effects on pileated woodpeckers by: 1) increasing the overall amount and quality of late-successional coniferous forest; and 2) protecting and improving riparian forests. Foraging and nesting habitat for this species may be periodically impacted through timber harvesting in the Commercial Zone, but the rate of harvest will be very low (averaging 40 acres or less per year). Foraging and nesting habitat may also be negatively affected during timber harvesting in the Conservation Zone, but the overall objective of this harvesting will be to increase habitat for this and other late-successional coniferous forest species in the long term.

Upland forest management measures such as no-harvest in the Natural Zone, uneven-aged management and reduced harvest rate in the Conservation Zone, extended rotation (70 years) and reduced harvest rate in the Commercial Zone, hardwood conversion, reduced clearcut size, reforestation, reduced burning, reduced clearcut size in salvage areas, and snag recruitment, will improve the amount and quality of late-successional coniferous forest in the HCP Area. Green-tree and snag retention during harvesting in the Commercial Zone will provide larger and greater numbers of snags and residual trees (for snag recruitment) than normally required under Washington State Forest Practices Rules and Regulations, thus providing more potential foraging, nesting, and roosting sites for pileated woodpeckers. For a maximum population density (100 percent) of pileated woodpeckers, snag models suggest a density of 0.04 suitable snags (> 25 inches diameter at breast height [dbh]) per acre (Neitro et al. 1985). The HCP will result in the retention of all safe snags and at least four green recruitment trees per acre of harvest in the Commercial Zone. One of the recruitment trees will be at least 20 inches dbh and another will be at least 16 inches dbh. These numbers are well in excess of the habitat requirements of pileated woodpeckers. Riparian management measures such as no-harvest riparian and wetland buffers and partial-harvest riparian buffers along streams will provide additional late-successional forest (including snags) and connectivity between upland patches of forest.

Operation of the water supply project and diversion of water from the Green River will have no negative impact on pileated woodpeckers in any part of the Green River basin. Overall, the HCP will benefit the population existing in the upper basin, since there are minimal requirements to protect habitat for this species under current state and federal laws.

Literature Cited

References cited in this chapter are provided in Chapter 10 of the HCP

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8. Costs, Funding, and Implementation Schedule of the Conservation, Monitoring, and Research Measures

8.1 Estimated Costs of the Habitat Conservation Measures

The City of Tacoma's (Tacoma) Green River Habitat Conservation Plan (HCP) brings together the results of over 20 years of research, evaluation, discussions, negotiation and legal proceedings regarding Tacoma's water supply operations and watershed management and protection in the Green River basin. As a result of those efforts a variety of permits, agreements, and memorandas of understanding have been developed to gain approval for the continued use of Tacoma's First Diversion Water Right claim (FDWRC) and exercise its Second Diversion Water Right (SDWR). As a result of such discussions, Tacoma has taken an active part in identifying impacts related to its operations and activities, and developing measures to avoid, minimize, or otherwise mitigate such impacts. Over the years, Tacoma entered into agreements to constrain its water withdrawals to protect fish and wildlife resources and to provide a variety of mitigation measures totaling millions of dollars.

In view of the recent listing of Pacific Northwest species such as the chinook salmon, and the potential for future listings under the Endangered Species Act (ESA), Tacoma re-evaluated its water supply and watershed protection activities. Tacoma prepared this HCP to support its application for an Incidental Take Permit (ITP) in order to gain certainty over its ability to meet the current and future water demands of its customers. In many cases, water supply restrictions and mitigation efforts developed through other proceedings served to satisfy requirements of the ESA. In other cases, new habitat conservation measures were developed to ensure that Tacoma's activities are in compliance with the ESA.

The habitat conservation measures identified in Chapter 5 represent Tacoma's best efforts to avoid, minimize, or otherwise mitigate impacts associated with water supply and watershed protection activities. The estimated cost of the habitat conservation measures, including measures developed as part of prior agreements and conservation measures developed specifically as part of this HCP, total approximately $57,000,000 (Table 8-1). The majority of the costs of the habitat conservation measures represent commitments made by Tacoma as part of agreements reached for the Second Supply Project (SSP), the 1995 Muckleshoot Indian Tribe/Tacoma Public Utilities (MIT/TPU) Settlement Agreement and as local sponsor for the U.S. Army Corps of Engineers' (USACE)

Table 8-1. Estimated Costs of Habitat Conservation Measures identified in Tacoma's Green River Habitat Conservation Plan (cost in 1997 dollars x $1,000 for 50 year term of the Incidental Take Permit)

Measure	Description	Joint (Tacoma/USACE/other) Funding Estimate [1]	Tacoma Only Funding Estimate	Total
HCM 1-01	Minimum Instream Flows	$0	100%	[2]
HCM 1-02	Seasonal Restrictions on SDWR	$0	100%	[2]
HCM 1-03	Tacoma Headworks Upstream Fish Passage Facility	$0	$2,530	$2,530
HCM 1-04	Tacoma Headworks Downstream Fish Bypass Facility	$0	$3,060	$3,060
HCM 1-05	Tacoma Headworks Large Woody Debris (LWD)/Rootwad Placement	$0	10	10
HCM 2-01	HHD Downstream Fish Passage Facility	$34,000	$0	$34,000
HCM 2-02	HHD Non-Dedicated Storage and Flow Management Strategy	$125	$0	$125
HCM 2-03	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures	$1,099	$0	$1,099
HCM 2-04	Standing Timber Retention	$0	$1,090[5]	$1,090
HCM 2-05	Juvenile Salmonid Transport and Release [3]	$0	$287	$287
HCM 2-06	Low Flow Augmentation [4]	$0	$400	$400
HCM 2-07	Side Channel Re-connection Signani Slough	$947	$0	$947
HCM 2-08	Woody Debris Management Program	$500	$500[5]	$1,000
HCM 2-09	Mainstem Gravel Nourishment	$4,700	$0	$4,700
HCM 2-10	Headwater Stream Rehabilitation	$341	$0	$341
HCM 2-11	Snowpack and Precipitation Monitoring	$71	$0	$71
HCM 3-01	Upland Forest Management Measures	$0	$2,129[5]	$2,129
HCM 3-02	Riparian Management Measures	$0	$3,000[5]	$3,000
HCM 3-03	Road Construction and Maintenance Measures	$0	$1,714	$1,714
HCM 3-04	Species-specific Management Measures	$0	$741	$741
TOTAL ESTIMATED COST		**$41,783**	**$15,461**	**$57,244**

1 The Joint Funding estimate represents a cost-share arrangement between Tacoma, the USACE, and other potential partners. The cost-share percentages are subject to change in the Water Resource Development Act, other Congressional initiatives, or USACE Section 7 requirements under the Endangered Species Act. Tacoma's share of the Joint Funding commitment has not been determined, but is expected to range between 20 and 50 percent. The Tacoma Only funding estimate refers to those measures that will be funded solely by Tacoma and are in addition to Tacoma's share of the Joint Funding commitment.

2 Costs associated with this measure are opportunity costs that will only occur in extreme drought years. Prior guarantee of funding is not necessary to ensure compliance with the conditions of the HCP.

3 Estimated capital expenditure, no operational costs included.

4 Tacoma expenditure, USACE costs not included.

5 The value of lost revenue is included in funding estimates. The cost associated with HCM 2-04 is the foregone value associated with leaving merchantable timber standing in the new inundation zone (elevation 1,141 ft to 1,167 ft) of Howard Hanson Reservoir. The cost of HCM 2-08 includes the foregone value resulting from using the wood debris collected in the reservoir for habitat restoration purposes rather than selling it. The costs of HCM 3-01 include opportunity costs associated with leaving merchantable timber standing in reserves; opportunity costs of extending rotations outside reserves; and management costs associated with delineating, working around, and monitoring special management areas. The estimated costs for HCM 3-02 are primarily the foregone value resulting from leaving merchantable timber in riparian buffers and include the value associated with foregoing timber harvest to comply with both the Washington Forest Practice Rules and HCM 3-02. The HCP requirements are considerably greater than current state Forest Practices Rules, and they will result in the retention of a least double the timber volume.

1

Additional Water Storage (AWS) project at Howard Hanson Dam (HHD). Much of these costs represent cost-share arrangements between Tacoma and the USACE or other entities.

The costs of this HCP represent Tacoma's commitment to manage its water supply in a manner that addresses the needs of the people of South Puget Sound along with the needs of the fish and wildlife in the Green River basin. In some cases, such as restrictions on the use of the FDWRC (HCM 1-01) and additional constraints on the exercise of the SDWR (HCM 1-02), the value to Tacoma of the lost opportunity for additional water supply was not included as a cost under the HCP (see Table 8-1). These costs would only be realized as reduced revenues in extreme drought years, and not as capital expenditures that would require a guarantee in order to ensure successful implementation of the HCP.

As co-sponsors of the AWS project at HHD, Tacoma and the USACE have agreed to cost-share many funding requirements outlined in this HCP. The final cost-share agreement will be subject to negotiations. The USACE must first define its obligations in consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the ESA. Tacoma will define its financial obligations in this HCP as provided for under Section 10 of the ESA. A final resolution of the exact cost-share arrangement will depend on the outcome of the USACE negotiations.

8.2 Estimated Costs of the Monitoring and Research Program

As described in Chapter 6, Tacoma will implement a monitoring and research program consisting of three main types of measures: compliance monitoring to ensure conservation measures are implemented according to specified standards; effectiveness monitoring to provide feedback to improve the performance and functionality of measures where Tacoma is responsible for ensuring results; and funding of a research program designed to provide resource agencies and the MIT with information needed to adaptively manage the natural resources of the Green River on a real-time basis.

8.2.1 Compliance Monitoring

Funds required to implement compliance monitoring will be provided by Tacoma, alone or in conjunction with other agencies. In most cases, compliance monitoring consists of verification that the conservation measures have been funded or implemented. Project completion reports or annual summaries of activities conducted specific to each measure will be prepared and submitted as described in Chapter 5. Tacoma has estimated that costs to conduct compliance monitoring over the 50-year term of the ITP will not exceed $600,000. This amount represents potential cost-share arrangements between Tacoma and the USACE or other agencies. The cost-share percentages are subject to change. Cost reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

8.2.2 Effectiveness Monitoring

Funds required to implement effectiveness monitoring will be provided by Tacoma. Changes to habitat conservation measures HCM 3-01G (Snags, Green Recruitment Trees and Logs) and HCM 3-04 (Species-specific Management Measures) as a result of monitoring efforts may reduce Tacoma's income from timber harvest in the upper watershed. It is difficult to predict the extent of such adaptations to the conservation measures; however, any change will be primarily reflected in changes in Tacoma's revenue from timber harvest in the upper watershed. Revenue from timber sales on Tacoma lands in the Green River watershed is used for additional land acquisition and forest management and water quality enhancement projects in the upper watershed. Reductions in revenue will reduce the rate of land acquisition, but will not represent additional cash outlays on the part of Tacoma or interfere with effective implementation of the HCP.

8.2.3 Research Monitoring

Funds required for the research monitoring program will be provided by Tacoma, alone or in conjunction with other agencies. Annual funding of the research efforts will begin immediately following construction of the AWS project at HHD. The intent of the research fund is to allow the USACE to coordinate with the Green River Flow Management Committee (GRFMC) to assist in the design of an annual Green River research program, subject to approval of the NMFS and the USFWS. Details of the research program are identified in Chapter 6 of this HCP. The program addresses three primary areas of uncertainty associated with rehabilitation of natural resources of the Green River:

1) downstream fish passage at HHD (including reservoir and dam passage);
2) flow management in the middle and lower Green River; and
3) sediment and woody debris transport.

Additional Water Storage Project (Years 1-10)

Contributions to the research fund during the first 10 years of the AWS project represent cost-share arrangements between Tacoma and the USACE or other agencies. The cost-share percentages are subject to changes in the Water Resource Development Act, other Congressional funding initiatives, or USACE requirements under Section 7 of the ESA. During the first 10 years of the research program, Tacoma will share the funding commitment associated with downstream fish passage, flow management and sediment and woody debris transport measures. Total expenditures under the research program cannot exceed the sum of all individual measures.

A total of $3,432,000 has been allocated to the research fund during the first 10 years of the research program (Table 8-2). This sum does not include $100,000 paid directly to the MIT and the Washington State Department of Fish and Wildlife (WDFW) to conduct annual steelhead spawning surveys as per the 1995 MIT/TPU Agreement. The $3,432,000 joint USACE/Tacoma cost-share, and the $100,000 to be paid directly by Tacoma to the MIT and WDFW combine to total the $3,532,000 allocated to fund research and adaptive management within the first ten years of the program (Table 8-2).

Tacoma recognizes that changes in the allocation of funds among different elements of the research fund may be desirable during implementation. To retain the integrity of the HCP but also allow flexibility, funds can be transferred between measures subject to approval of the USACE, the NMFS, and the USFWS. Such changes will be made subject to the cost cap of $3,432,000 during the first 10 years of the research program.

Additional Water Storage Project (Years 11-50)

During years 11 through 50 of the research program, Tacoma will provide complete funding for flow management measures identified in Table 8-2. During this period, funds can be transferred between flow management measures within specific years, or funds for a current year can be retained and carried forward to supplement future expenditures. The funding stream represents a firm commitment that will not be reduced due to increased efficiencies, coordination of research efforts or contributions by other agencies. Funds allocated for future flow management research efforts cannot be advanced to supplement ongoing research efforts. Such changes will be made subject to the flow management research program cost cap of $1,736,000. This amount does not include funds paid directly to the MIT and the WDFW to conduct annual steelhead spawning

Table 8-2. Estimated costs for research and adaptive management associated with Tacoma's Green River Habitat Conservation Plan. Plan 1 begins when water available to Tacoma under its Second Diversion Water Right is initially stored within Howard Hanson Reservoir.

Research Measure	Research Issue	Description of Research Activity	Cost (in thousands of dollars) 1	2	3	4	5	6-10[1]	Subtotal Yrs 1-10	11-15[1]	16-20[1]	21-25[1]	26-30[1]	31-35[1]	36-40[1]	41-45[1]	46-50[1]	Total Cost Yrs 1-50
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Fyke nets	35	35	35	35	35	70	245									**245**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Hydroacoustics (mobile)		50	50		50	50	200									**200**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Paired PIT-tag releases	120	120			120	120	480	Funding for the monitoring of								**480**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Screw trap at HHD outlet			94	94	94	94	376	downstream fish passage in								**376**
Downstream Fish Passage	Fish Collector Passage	Sampling station	30	30	30	30	30	150	300	years 11 through 50 will not be part								**300**
Downstream Fish Passage	Fish Passage Facility	Marked fry	20	20	20				60	of Tacoma's obligations under								**60**
Downstream Fish Passage	Fish Passage Facility	Hydroacoustics (forebay/wet well)	70	70	70	70	70	70	420	Section 10 of the ESA.								**420**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Zooplankton abundance/water quality	30				30	30	90									**90**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Predator abundance			45		45	25	115									**115**
SUBTOTAL			**305**	**325**	**344**	**229**	**474**	**609**	**2,286**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,286**
Flow Management	Side-channel Connectivity	Side-channel (physical)	35			35		35	105	35	35	35	35	35	35	35	35	**385**
Flow Management	Side-channel Connectivity	Side-channel (biological)		38			38	38	114	38	38	38	38	38	38	38	38	**418**
Flow Management	Steelhead Spawning[2]	Redd surveys	10	10	10	10	10	50	100	50	50	50	50	50	50	50	50	**500**
Flow Management	Juvenile Instream Migration	Screw trap (RM 34)[3]	94	94	94	94	94	94	564		188		188		188		188	**1,316**
Flow Management	Spawning Surveys Above and Below HHD	Salmon spawning surveys	15	15	15	15	15	50	125	50	50	50	50	50	50	50	50	**525**
Flow Management	Incubation	Redd monitor/emergence traps	30	30	30				90									**90**
SUBTOTAL[2]			**184**	**187**	**149**	**154**	**157**	**267**	**1,098**	**173**	**361**	**173**	**361**	**173**	**361**	**173**	**361**	**3,234**
Sediment/Wood Transport	Mainstem Woody Debris Survey	Survey mainstem river (RM 61.5-RM33)	8	8	8	8	8	8	48	Funding for the monitoring of sediment/wood transport in years 11 through 50 will not be part of Tacoma's obligation under Section 10 of the ESA.								**48**
Sediment/Wood Transport	Gravel Nourishment	Monitor gravel placement	25	25			25	25	100									**100**
SUBTOTAL			**33**	**33**	**8**	**8**	**33**	**33**	**148**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**148**
TOTAL HCP / AWSP[2]			**522**	**545**	**501**	**391**	**664**	**909**	**3,532**	**173**	**361**	**173**	**361**	**173**	**361**	**173**	**361**	**5,668**

1 Cost represents cumulative total for monitoring conducted over the five-year period.
For example, steelhead redd surveys, at $10,000 per year will be conducted annually for a cumulative total of $50,000 every five years.

2 Cost to support steelhead spawning surveys will be paid directly to the MIT and the Washington State Department of Fish and Wildlife and will not be co-mingled with the Research Fund.

3 Screw traps will be deployed an average of two consecutive years every ten years during years 6-50.

surveys as per the 1995 MIT/TPU Agreement. Tacoma will not provide funding support for downstream fish passage and sediment and woody debris transport measures during years 11 through 50 of the research program. Funding support for these measures during years 11 through 50 of the research program must be provided by other entities.

8.3 Total Estimated Costs Of The Habitat Conservation Plan

Total costs for the Green River HCP are approximately $63,512,000 (Table 8-3). Approximately $17,697,000 of those costs, or about 28 percent, represents a funding commitment of Tacoma. The other 72 percent of those costs represent cost-share arrangements between Tacoma and other entities. Tacoma will fund its commitments made in the HCP, subject to the overall research cost cap established for the HCP. Funding will be from sources at Tacoma's discretion, including, but not limited to revenues from the sale of water, timber and land, and from outside sources such as grants or contributions. All cost estimates and commitments in the HCP are given in 1997 dollars.

8.4 Implementation Schedule

The schedule for implementing conservation, monitoring, and research measures is described in the measure descriptions in HCP Chapters 5 and 6. A summary implementation schedule is provided in Table 8-4 to allow easy reference of the primary measures. Measures associated with Tacoma's water withdrawals from the mainstem Green River will be implemented upon Tacoma's initial exercise of its SDWR, or completion of Type 1 Conservation Measures (i.e., measures designed to offset impacts of a Tacoma water withdrawal activity). Measures associated with management of Tacoma's forestlands and roads in the Upper Watershed begin upon issuance of ITP (Table 8-4).

Table 8-3. Summary of Tacoma's Funding of the Green River HCP (cost in 1997 dollars x 1,000 for 50-year term of the Incidental Take Permit).

Activity	Joint USACE/ Tacoma Funding	Tacoma Funding	Total
HCM Cost Estimate	$41,783	$15,461	$57,244
Compliance Monitoring Cost Estimate (1)	$600	$0	$600
Effectiveness Monitoring Cost Estimate	$0	(2)	(2)
Research Funding Commitment (3)			
Downstream Fish Passage	$2,286	$0	$2,286
Flow Management	$998	$1,736	$2,734
Sediment / Wood Transport	$148	$0	$148
MIT/WDFW Research Funding	$0	$500	$500
Total	$45,815	$17,697	$63,512

1 Tacoma's contribution to compliance monitoring includes potential cost-share arrangements between Tacoma and the U.S. Army Corps of Engineers or other agencies. The cost-share percentages are subject to change. Cost reductions identified through increased efficiencies, competitive bids or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

2 Costs associated with these measures are opportunity costs that will occur only if it is necessary for Tacoma water to increase green-tree retention and reduce overall timber harvest revenues in the upper Green River watersheds. Such reductions in timber revenues will not interfere with the implementation of the HCP.

3 Tacoma's contribution to research funding during years 1-10 of the Additional Water Storage project represents a cost-share arrangement between Tacoma and the USACE or other agencies. The cost-share percentages are subject to changes in the Water Resource Development Act, other Congressional initiatives, or USACE requirements under Section 7 of the Endangered Species Act. The funding stream represents a firm commitment that will not be reduced due to increased efficiencies, coordination of research efforts or contributions by other agencies.

HCM Habitat Conservation Measure
MIT Muckleshoot Indian Tribe
WDFW Washington State Department of Fish and Wildlife
USACE U.S. Army Corps of Engineers

Table 8-4. Schedule for implementing conservation, monitoring, and research measures contained in Tacoma's Green River Habitat Conservation Plan.

HCM/CMM Action	Implementation Schedule
Type 1 Conservation Measures [(a)]	
HCM 1-01; CMM-01 – Minimum Instream Flows Under FDWRC	
Constrain withdrawals under FDWRC	At initial exercise of SDWR
Restrict North Fork well field withdrawals to periods of high turbidity	Begin upon ITP issuance
North Fork well field ramping study	Complete within 2 years after ITP issuance
Make water supply information available via web site	Begin within 1 year after ITP issuance
HCM 1-02; CMM-01 – Seasonal Restrictions on the Second Diversion Water Right	
Exercise SDWR in compliance with seasonal restrictions	Upon completion of SSP pipeline
Make water supply information available via web site	Begin within 1 year after ITP issuance
HCM 1-03; CMM-04 – Tacoma Headworks Upstream Fish Passage Facility	
Construct upstream passage facilities	Before initial exercise of SDWR
Upstream fish passage performance and compliance	Conduct for 2 years following construction
Implement trap and haul program	Upon approval by Services and co-managers
Implement water quality monitoring program	After live adult coho or chinook salmon are transported above HHD
HCM 1-04; CMM-05 – Tacoma Headworks Downstream Fish Bypass Facility	
Construct Headworks downstream passage facilities	Before initial exercise of SDWR
Screen debris moved downstream	Before initial exercise of SDWR
Downstream fish passage performance and compliance	Complete within 1 year following construction
Test modified spillway	Complete within 2 years following construction
HCM 1-05; CMM-03 – Tacoma Headworks Large Woody Debris/Rootwad Placement	
Complete Headworks mitigation projects	Before initial exercise of SDWR
Monitor stability of structures	Multiple years after construction

Table 8-4. Schedule for implementing conservation, monitoring, and research measures contained in Tacoma's Green River Habitat Conservation Plan.

HCM/CMM Action	Implementation Schedule
Type 2 Conservation Measures [(a)]	
HCM 2-01; RFM-01 – HHD Downstream Fish Passage Facility	
Fund HHD downstream passage facility	Completion of PED Phase of AWSP
USACE/Tacoma provide research funds according to schedule in RFM-01 and Table 8-2	January of year starting SDWR storage
HCM 2-02; CMM-02; RFM-02 – HHD Non-Dedicated Storage and Flow Management Strategy	
Post data on water storage and flow management	15 Feb of year when initial SDWR storage starts
USACE/Tacoma provides research funds according to schedule in RFM-02 and Table 8-2	January of year of initial SDWR storage
HCM 2-03 – Upper Watershed Stream and Reservoir Rehabilitation Measures	
Provide funds for upper watershed rehabilitation measures	Start of AWSP construction
HCM 2-04 – Standing Timber Retention	
Retain standing timber	Start of AWSP construction
HCM 2-05; CMM-06 – Juvenile Salmonid Transport and Release	
Transport and release juvenile salmonids above HHD	Upon ITP issuance and approval of fisheries managers
Monitor transport of fish to be released above HHD	Upon ITP issuance and approval of fisheries managers
HCM 2-07; CMM-07 - Side Channel Reconnection – Signani Slough	
Fund Signani Slough restoration	Upon completion of PED phase of AWSP
Monitor stability of restored habitat	Complete within 1 year after Signani Slough constructed
HCM 2-08: CMM-08; RFM-03 – Downstream Woody Debris Management Program	
Fund downstream woody debris management program	Completion of PED phase of AWSP
Fund LWD placement contingency bank	Completion of PED phase of AWSP
Construct database for tracking stored and placed LWD	Complete within 1 year after ITP issuance
Monitor stability of placed LWD	1 year after placement
Fund LWD survey in mainstem Green River (see RFM-03)	1 year after placement

Table 8-4. Schedule for implementing conservation, monitoring, and research measures contained in Tacoma's Green River Habitat Conservation Plan.

HCM/CMM Action	Implementation Schedule
HCM 2-09; CMM-09; RFM-03 – Mainstem Gravel Nourishment	
Fund mainstem gravel nourishment	Completion of PED Phase of AWSP
Maintain records of gravel placement	1 year after placement
Fund gravel transport monitoring (see RFM-03)	1 year after placement
HCM 2-10; CMM-10 – Headwater Stream Rehabilitation	
Fund headwater stream rehabilitation	Completion of PED Phase of AWSP
Fund inundation pool vegetation monitoring	1 year after placement
Fund habitat rehabilitation monitoring	1 year after placement
HCM 2-11 – Snowpack and Precipitation Monitoring	
Fund for snowpack and precipitation monitoring	Before HHD storage of SDWR
Make snowpack and precipitation data available via web site	15 Feb of initial SDWR storage year
Summarize data annually for GRFMC	1 year after HHD SDWR storage
Type 3 Conservation Measures [(a)]	
Upland Forest Management Measures	
HCM 3-01A – Forest Management Zones	
Designate newly acquired lands	As needed, following ITP issuance
HCM 3-01B-J, L, M; CMM-12; EMM-03 - Upland Forest Management Measures	
Implement restrictions specified in HCMs	Upon ITP issuance
Develop database to track harvest units (location, zone, acreage, site index, number/size of snags, etc.)	1 year after ITP issuance
Revisit uneven-age harvest stands in Conservation zone	ITP issuance (revisit 5 years after harvest)
HCM 3-01K – Contractor, Logger and Employee Awareness	
Provide copies of pertinent HCP requirements to contractors	6 months after ITP issuance
Employee training in covered species identification	1 year after ITP issuance

Table 8-4. Schedule for implementing conservation, monitoring, and research measures contained in Tacoma's Green River Habitat Conservation Plan.

HCM/CMM Action	Implementation Schedule
HCM 3-01N – Harvest on Unstable Slope	
Complete slope stability assessment	2 years after ITP issuance
Employee training in slope stability	1 year after ITP issuance
Riparian Management Measures	
HCM 3-02A-B; CMM –13 – Riparian Buffers	
Identify and mark riparian buffers; inspect following harvest	Begin upon ITP issuance
Document RMZ buffer widths	Begin upon ITP issuance
Road Construction and Maintenance Measures	
HCM 3-03A; CMM-14 – Watershed Analysis	
Participate in Watershed Analysis	ITP issuance
HCM 3-03B; CMM-14 - Road Maintenance	
Complete RSRP for all roads on Tacoma land	2 years after ITP issuance
HCM 3-03C, D, E, F; CMM-14 – Road Construction	
Implement road construction/maintenance requirements	Begin upon ITP issuance
Maintain database of road characteristics and treatments	Upon ITP issuance
HCM 3-03G; CMM-14 - Road Closures	
Implement road construction/maintenance requirements	Begin upon ITP issuance
HCM 3-03H; CMM-14 – Roadside Vegetation	
Implement road construction/maintenance requirements	Begin upon ITP issuance
HCM 3-03-I; CMM-14 - Road Abandonment	
Prepare report prioritizing road abandonment	Complete within 2 years after ITP issuance
Complete abandonment of all designated existing roads	5 years after RSRP
Abandon any new roads in commercial and conservation zones after period of use ends	Upon ITP issuance (roads abandoned 2 years after use ends)

Table 8-4. Schedule for implementing conservation, monitoring, and research measures contained in Tacoma's Green River Habitat Conservation Plan.

HCM/CMM Action	Implementation Schedule
HCM 3-03J; CMM-14 - Culvert Improvements	
Inventory road-related fish barriers	Concurrent with RSRP (see HCM 3-03B)
Submit plan for correcting barriers	2 year after RSRP
Complete corrections	5 year after RSRP
Species-Specific Management Measures	
HCM 3-04A-X; CMM-15; EMM-01, 02 – Species-Specific Management Measures	
Implement measures as specified in HCP	Begin upon ITP issuance
Develop protocol for recording and reporting sightings	Complete within 1 year after ITP issuance
Conduct annual query of Priority Habitats and Species database	Annually after ITP issuance
Revisit newly harvested areas to assess snags	ITP issuance (revisit 10 years after harvest)

<u>Footnote (a) Definition of Type of Conservation Measure</u>□Type 1: Protection measure designed to offset impacts of a Tacoma water withdrawal activity.□Type 2: Protection measure designed to offset impacts of a non-Tacoma activity.□Type 3: Protection measures designed to offset impacts of a Tacoma non-water withdrawal activity.

Abbreviations

AWSP = Additional Water Storage Project	PED = Pre-construction, Engineering and Design
CMM = Compliance Monitoring Measure	RFM = Research Funding Measure
EMM = Effectiveness Monitoring Measure	RMZ = Riparian Management Zone
FDWRC = First Diversion Water Right Claim	RSRP = Road Sediment Reduction Plan
HCM = Habitat Conservation Measure	SDWR = Second Diversion Water Right
HCP = Habitat Conservation Plan	SSP = Second Supply Project
HHD = Howard Hanson Dam	

ITP = Incidental Take Permit□LWD = Large Woody Debris

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9. Alternatives to the Proposed Incidental Take

9.1 Introduction

As required under Section 10 of the Endangered Species Act (ESA), Tacoma Water (Tacoma) has considered several alternatives to the incidental take contemplated in this Habitat Conservation Plan (HCP). These alternatives, and the reasons they are not being utilized by Tacoma, are discussed in this chapter.

The Tacoma HCP and Incidental Take Plan (ITP) cover two distinct sets of activities: the withdrawal of water at the Tacoma Water Supply Intake at River Mile (RM) 61.0 (Headworks) facility (and associated water withdrawal activities) and the management of Tacoma's forestlands in the upper Green River watershed above the Headworks. During the preparation of this HCP, Tacoma considered and evaluated a number of alternatives to each set of activities. For purposes of clarity, the alternatives for water withdrawal are considered separate from the alternatives for forestland management. These sets of activities (and their alternatives) are geographically separated, and not interrelated or interdependent in a manner that would warrant simultaneous analysis.

Tacoma has identified and reviewed four alternatives to the proposed water withdrawal. Each alternative integrates other water supply development projects and conservation measures contemplated in Tacoma's Integrated Resource Management Plan. The projects described in the Integrated Resource Management Plan, in combination with the projects proposed as part of this HCP, are necessary to achieve Tacoma's long-term water supply needs and to contribute to Tacoma's regional water supply planning effort with South King County, Seattle, and other communities in the Puget Sound region.

Tacoma has also identified two alternatives to the proposed management of the upper watershed. These alternatives, like the proposed management, are in keeping with Tacoma's overall objective of managing the watershed primarily for water quality and habitat. These alternatives, and the reasons they are not being utilized by Tacoma, are discussed below.

9.2 Alternatives to the Proposed Water Withdrawal

9.2.1 No Action Alternative

Under the no action alternative, Tacoma would not implement the HCP and would not develop the projects described in Chapter 2. Tacoma would thus attempt to avoid/reduce its incidental take of species protected under the ESA, causing other regional municipal water supply utilities, as well as Tacoma, itself, to seek additional sources of water.

Tacoma's continued withdrawal of water from the Green River would have an effect on instream resources, which to date have not been linked to quantifiable levels of take. Since a final ESA Section 4(d) rule for listed fish species has not been issued to identify measures that would be necessary to avoid/reduce take, continued withdrawal by Tacoma could result in undetermined restrictions on water supply operations. If current operations result in take, and if an ITP is not issued as an alternative to current operations, take avoidance/reduction measures could include construction of facilities to allow fish access to the Green River above Tacoma's Headworks, and adjustments to current water withdrawal operations to provide adequate habitat for listed fish species (including seasonal flow management). However, neither option would provide certainty that: 1) take is avoided or reduced; or 2) current and future water supply demands could be met.

For this analysis, no action is defined to mean that Tacoma would neither receive incidental take coverage for nor develop the Second Supply Project (SSP) or its Second Diversion Water Right (SDWR) of up to 100 cubic feet per second (cfs). In addition, Tacoma would not partner with the U.S. Army Corps of Engineers (USACE) to fund development of the Howard Hanson Dam (HHD) Additional Water Storage (AWS) project. Without Tacoma as its partner, the USACE would likely have to abandon development of the AWS project, which would result in the indefinite postponement of most of the AWS project flow management benefits and restoration activities.

In practical terms, the no action alternative would limit Tacoma's long-term municipal and industrial water supply to its First Diversion Water Right Claim (FDWRC) of 113 cfs.

Without its SDWR of 100 cfs, Tacoma would not have the water necessary to supply future residents of the City of Tacoma or residents of other areas currently serviced by Tacoma beyond the year 2001. Tacoma will also need the 20,000 acre-feet (ac-ft) of additional summer and fall water afforded by Phase I of the AWS project for water supply purposes in the near future. Tacoma's current summer and fall supplies will fall short of meeting average water condition year demand of the City's residents and other current service area residents in approximately 15 years, based on Tacoma's population and water forecasts. Drought years already present serious summer and fall supply problems for Tacoma, as evidenced by drought years 1987 and 1992. During those drought years, Tacoma was forced to implement severe summer and fall supply restrictions, which included a total ban on outdoor water use and resulted in economic hardship to some businesses and individuals. Subsequent conservation measures have freed up some water supply that previously added to system demand, but not enough to ensure a stable supply during drought years.

In foregoing development of the SSP and the SDWR under this no action alternative, Tacoma would lack the water resources and the supply mechanism to provide critical water supply to South King County communities, Seattle, or other Puget Sound communities through the Tacoma-Seattle intertie with the SSP. The SSP has been designed to serve as an immediate link between Tacoma and South King County communities, and later as an important link between Puget Sound communities north of Seattle and south of Tacoma through larger regional water supply planning efforts. The Tacoma-Seattle intertie would be the first such link, moving water from the Green River to the City of Seattle. Thus, the SSP is crucial to the development and success of regional water supply planning and intertie efforts, and to a regional water supply plan that will accommodate the region's water supply needs well into the 21st century, allowing Puget Sound communities to share and shift water resources as population demands and fish needs dictate. The SSP intertie would provide greater efficiencies to the participating communities by: 1) increasing water yield through long-term water transfers; 2) supplying water on a short-term emergency basis; 3) supplying water on a short-term basis during turbidity events; and 4) providing additional winter water for artificial aquifer recharge storage. Without the SSP, the Tacoma-Seattle intertie, or the additional water provided by the SDWR, Tacoma's South King County and City of Seattle partners would need to consider, and ultimately develop, other water supply alternatives that could potentially present other short- and long-term impacts to endangered and threatened species in the Puget Sound region.

Under the no action alternative, Tacoma would not be able to fund the improvements that are a part of the SSP, AWS project, and Muckelshoot Indian Tribe/Tacoma Public Utility Agreement (MIT/TPU Agreement), including Headworks fish screen and bypass modifications, habitat rehabilitation, and upstream and downstream fish passage facilities proposed under those projects. Without Tacoma's involvement in the AWS project, the opportunity to provide anadromous fish access to and egress from 220 square miles of upper watershed area, and to implement the other proposed fish and wildlife habitat improvements developed over approximately a 10-year period in cooperation with the USACE, MIT, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Washington State Department of Fish and Wildlife (WDFW), and Washington Department of Ecology (Ecology) likely would be lost.

In addition, over the past 6 to 10 years, Tacoma has been able to work cooperatively with the USACE to reduce Tacoma's water withdrawals during low flow periods critical to fish survival and reproduction. In the face of increasing population demands and without the flexibility offered by the AWS project, Tacoma would not be able to provide assurances to the USACE that it could reduce water withdrawals during critical flow periods, and Tacoma would not sponsor the storage of an additional 5,000 ac-ft of water for flow augmentation on a yearly basis as discussed in Chapter 2.

Tacoma has chosen not to utilize this no action alternative because of the resulting adverse water supply consequences to Tacoma's customers; the inability to contribute to a regional water supply plan; the need for Tacoma, Seattle, and South King County communities to develop alternative water sources; and the loss of the fish and wildlife benefits associated with the SSP, the AWS project, and MIT/TPU Agreement.

9.2.2 Downstream Diversion Alternative – Construct New Diversion at RM 29.2

As an alternative to the HCP and ITP, Tacoma could construct a new diversion facility downstream of the Headworks. Under such an alternative, an HCP could be approved and an ITP issued, and the SSP and the AWS project could be implemented along with their associated mitigation measures.

A preliminary location for this alternative diversion facility has been identified at RM 29.2 (31.8 miles downstream of the existing Headworks) near the Auburn Golf Course. Diverting water at this location would reduce the length of river that would experience decreased flows. Although specific operation patterns have not yet been developed, it is assumed that all of the SDWR and most of the FDWRC could be diverted at this downstream location. The existing diversion would be retained for withdrawal of water for the surrounding communities and to operate a proposed fish trap.

Although an unquantified benefit to fish may occur under this downstream diversion alternative, Tacoma is not pursuing this alternative because of its very high cost relative to an uncertain fisheries benefit. The new diversion would allow Tacoma to provide increased flows in the 31.8 miles of the middle Green River, which would benefit fisheries resources. However, the impacts of a new diversion dam, including the inundation of nearly a mile of the middle Green River, would at least partially offset the benefits of increased instream flows. This alternative would also involve additional costs of approximately $200 million to Tacoma and its project partners for the following reasons.

- Construction of the diversion structure would cost approximately $5 million.
- New and upgraded pipelines would cost approximately $46 million. A portion of the proposed Second Supply Pipeline (from the existing Tacoma Headworks diversion to the vicinity of the new diversion) would not be necessary under this alternative. In its place, a duplicate or enlarged pipeline would be necessary from the new diversion to Tacoma to carry water that is now withdrawn at the existing diversion. In addition, another smaller pipeline would also be necessary from the new diversion to the Tacoma-Seattle intertie location. Eliminating a portion of the Second Supply Pipeline would result in savings of approximately $44 million, but the replacement pipelines would cost an estimated $90 million, for a net cost increase of $46 million.
- A new water treatment plant would cost approximately $125 million. Additional treatment would be required to make the water supply from the new diversion acceptable for delivery as potable water. The new point of diversion would be more susceptible to contamination than the current diversion within a protected watershed. At a minimum, a filtration plant would have to be constructed and operated.
- A new pump station would cost approximately $14 million. Water currently withdrawn from the Green River flows by gravity to the City of Tacoma. Water withdrawn at the new diversion would have to be pumped uphill to Tacoma. This would require a pump station of approximately 22,000 horsepower, which would cost roughly $14 million, not including the costs of land acquisition (approximately 35 acres) or construction of the intake structure. A pump station of this capacity would also require its own electrical substation, which would have additional costs.
- Annual operation would cost approximately $6 million, including $4 million in power costs to pump diverted water to system operating pressures (based on a power cost of $.04 per kilowatt-hour and a uniform power use rate). Additional costs could be incurred to guarantee standby power.
- Additional costs would be incurred annually to handle waste from the treatment facility. The approach to addressing waste handling is undefined at this time and

could not be further refined without the development of a pilot treatment study at the Auburn location.

9.2.3 Reduced Withdrawal Alternative - Supply Tacoma's Service Area Only

Another alternative to the HCP and ITP is a reduced withdrawal alternative that would, in turn, reduce the level of take from that anticipated to occur under the HCP.

Specifically, Tacoma would reduce its proposed water withdrawal from the Green River by designing a SDWR development plan to supply only its current service area. The City of Seattle and Tacoma's South King County partners in the SSP would not receive any Green River water supplies, and they would not partner with Tacoma to develop the SSP. As discussed in the no action alternative, Tacoma's SSP partners would need to shift to other water supply sources, the development of which would likely have other impacts on fish and wildlife.

The development of the SDWR for the purposes of meeting Tacoma's water use forecasts for its service area would be less than the full use and development of the SDWR that would occur under the proposed service for Tacoma, Seattle, and the South King County communities.

Nevertheless, Tacoma would need to develop the SSP or another water supply transport system to move the SDWR water from the Green River to the City of Tacoma, because Pipeline No. 1 (P1) lacks sufficient capacity to transport any SDWR supplies. Tacoma's P1 does not have excess capacity because it was originally completed in 1913 to carry a volume of 113 cfs, which is the amount of water currently used by Tacoma pursuant to its FDWRC. If it did not partner with and supply water to the City of Seattle and South King County communities as SSP project partners, Tacoma likely would be the sole entity funding the construction, operation and maintenance of the SSP. In the absence of a cost-sharing arrangement with these entities, Tacoma likely could not construct the SSP to develop, operate and maintain the project due to the significant cost involved. Tacoma would thus need to research and develop an alternative water supply transport system.

Under this alternative, Tacoma also would not partner with the USACE on the AWS project implementation. Accordingly, the impacts associated with the storage of 20,000 ac-ft of water from the spring hydrograph would be reduced to the level of impacts associated with the reduced withdrawal of water from the Headworks to supply only Tacoma's service area.

Similar to the no action alternative, the fish and wildlife mitigation and restoration benefits of the AWS project would not be implemented and the flow management benefits of the AWS project and additional yearly storage of up to 5,000 ac-ft would disappear under this alternative. Without the summer and fall flow and supply augmentation offered by the AWS project, Tacoma's supplies also would fall short of meeting the water supply demands of Tacoma's current service area during summer and fall peak periods.

Tacoma chose not to utilize this reduced withdrawal alternative because it is not economically viable, it does not provide the long-term fish and wildlife benefits associated with the AWS project, and because the flow management benefits of the AWS project and optional storage of up to 5,000 ac-ft each year would not be available to benefit fish habitat and survival or to meet the summer and fall supply demands of the Tacoma service area. Under this alternative, Tacoma could continue to meet the needs of its direct service area for perhaps 15 years, but the long-term water supply prospects for Tacoma and others who rely on it would be in doubt.

9.2.4 Reduced Withdrawal Alternative - Supply Tacoma's Current Service Area and Lakehaven Utility District

Under this fourth alternative to the HCP, Tacoma would develop a portion of its SDWR to serve both Tacoma's service area and Lakehaven Utility District's customers. The amount of SDWR water utilized would be less than the full development proposed as part of the HCP alternative.

Under this alternative, Tacoma would not partner with the USACE in the development of the AWS project, and, as discussed above, the USACE likely would not be able to proceed with the AWS project without Tacoma as a project partner. In order to transport the SDWR supply from the Green River to Tacoma's current service area and to the Lakehaven Utility District, Tacoma would need to develop an additional water supply transport system or expand the capacity of P1, because, as explained in the no action alternative, the Pipeline does not have the capacity to transport SDWR water. In addition, Tacoma and Lakehaven Utility District would derive a reduced benefit from the SDWR without the AWS project, because the utilities would face summer and fall supply problems without the storage and release flexibility provided by the AWS project.

To remedy summer and fall supply shortfalls, Tacoma and Lakehaven would need to develop an alternative off-site storage project for SDWR supply storage during winter months. Lakehaven Utility District has conducted a feasibility analysis of an off-site water storage project called the "Oasis Project," which may serve this purpose. This project has no fish or wildlife benefits associated with its construction, operation, and maintenance, and its true feasibility is not known at this time. Several years would be needed to fully determine the feasibility of this project, including the amount of water that could actually be stored and the level of treatment required before the water could be used for municipal and industrial purposes.

This alternative likely would reduce the impacts on listed species relative to the HCP alternative, because Tacoma would need to develop only 50 percent of its SDWR to serve the Lakehaven and Tacoma communities over the next 30 years. This alternative could reduce Tacoma's impact on covered species that would otherwise result from the AWS project spring hydrograph water withdrawal. However, without the AWS project, the fish and wildlife benefits planned as part of that project would not proceed, and many of the benefits of flow management and flow augmentation made possible by the AWS project would not be realized. Tacoma's Seattle and South King County partners in the SSP would be required to develop alternative sources of water supply in the future, and any alternative supply development likely would have independent short- and long-term impacts on protected species in the Puget Sound region.

The uncertainties of off-site storage at the Oasis Project site, the absence of long-term fish and wildlife improvements associated with the AWS project, the possible impacts associated with replacement supplies for Seattle and South King County communities, and the eventual summer and fall water shortages impacting Tacoma and Lakehaven's municipal and industrial customers have caused Tacoma to decide against utilizing this alternative.

9.2.5 Supply Tacoma, Seattle and South King County Communities Without the Howard Hanson Dam Additional Water Storage Project

Tacoma could attempt to meet the current and future water demands of its own service area as well as the demands of its regional water utility partners without AWS project construction. To pursue this option, Tacoma would fully develop its SDWR and the SSP as described in the HCP alternative. Tacoma would continue its partnership with South King County communities and the City of Seattle to develop the SSP, and would supply water from its SDWR through the SSP to these communities. Tacoma would not, however, partner with the USACE to fund design and construction of the AWS project. Therefore, the impacts and benefits of the AWS project discussed in the previous alternatives would not be realized under this alternative.

This alternative potentially maintains the level of impacts associated with use of the SDWR during the spring hydrograph. The absence of the AWS project from this alternative presents the same concerns identified in the previous alternatives, including loss of flow management made possible by the spring storage of water and storage of up to additional 5,000 ac-ft each year, and the loss of fish and wildlife restoration measures proposed in the AWS project.

Tacoma likely would be required to develop off-site storage for the SDWR supply under this alternative, and, as discussed in Section 9.4, Tacoma has not formulated an off-site storage project that could immediately replace the additional storage provided by the AWS project. To the contrary, it would be several years before Tacoma could determine the feasibility of any potential off-site storage project. In the absence of a proven off-site storage option, supplying the full amount of Tacoma's SDWR to Seattle, King County and Tacoma residents would result in summer and fall supply shortages during drought and low water years.

Although this alternative may result in the reduction of some take related to the AWS project storage of 20,000 ac-ft from the spring hydrograph, Tacoma believes the long-term fish and wildlife improvements associated with the AWS project, the lack of proven off-site water storage capacity, and the municipal and industrial water supply assurances that result from the increased AWS project storage all combine to make this a much less desirable alternative than the HCP.

9.2.6 Diversion Dam Removal Alternative – Remove Headworks

Under this alternative, Tacoma would cease its diversions from the Headworks, and would remove the Headworks diversion dam. If this alternative was implemented, it would not be necessary for Tacoma to seek an ITP because any potential for take as a result of Tacoma’s diversion activities would be eliminated. However, this alternative was not considered for adoption because of severe water supply impacts, uncertainty about replacement water supplies, and unknown costs and environmental impacts associated with developing a replacement water supply. In addition, the mitigation benefits associated with the HCP would not be implemented.

9.3 Alternatives to the Proposed Management of the Upper Watershed

9.3.1 No Action Alternative

Under the no action alternative, Tacoma would continue to manage its forestlands in the upper Green River watershed (approximately 15,000 acres) according to its existing Forest Land Management Plan, and in compliance with current Washington Forest Practices Rules and Regulations. Tacoma would also implement existing agreements for habitat enhancement with the MIT and any appropriate mitigation plans for the AWS project and SSP if required under one of the alternatives to the proposed water withdrawal. Tacoma would manage its forestlands according to three forest management zones (Natural, Conservation, and Commercial) and apply timber harvest and forest management restrictions within the zones.

Tacoma is not proposing to adopt the no action alternative because it may not allow for the long-term use of its lands in the upper Green River watershed in a manner consistent with its Forest Land Management Plan. Specifically, limitations on timber harvesting activities due to ESA concerns may interfere with Tacoma's objective to use timber harvest revenues to acquire additional lands in the upper watershed. In order to continue its forestland management activities in a manner that assures revenue generation over the long term, Tacoma has prepared this HCP to allow for timber harvesting in a manner that avoids/reduces any potential incidental taking to the maximum extent practicable.

9.3.2 Manage Tacoma Lands in the Upper Green River Watershed with no Timber Harvesting

Tacoma could manage all of its forestlands in the upper Green River watershed without timber harvest. This would allow for the maintenance of existing late-seral coniferous forest, and the development of additional late-seral forest over time in areas that currently support second-growth forest. This is essentially the management proposed for the Natural Zone under the HCP. It would be extended to the other two forest zones under this alternative. By eliminating all harvest activities, Tacoma would eliminate the potential for incidental take of aquatic or upland species that could result from active forest management.

Tacoma did not utilize this alternative for several reasons. First, it would preclude a source of funding (commercial timber sale revenues) that is currently used for acquiring new lands in the watershed. Second, it would prevent Tacoma from conducting timber harvesting to accelerate forest succession in second-growth stands in the Conservation

Zone, thereby extending the time required to recreate late-seral forest conditions. Third, there would be no opportunity under this alternative to conduct selective harvesting in riparian zones to accelerate forest development along streams. Consequently, early successional forest conditions, which currently exist in some riparian zones, would persist longer under this alternative. The result would be less benefit to stream-dwelling fish than the HCP. Lastly, this alternative would conflict with some of the proposed fish and wildlife mitigation measures developed by Tacoma and the USACE, such as the development of big-game forage plots.

9.3.3 Manage Tacoma Lands in the Upper Green River Watershed with Timber Harvesting to Create or Enhance Fish and/or Wildlife Habitat Only

Tacoma could eliminate commercial timber harvesting on its lands in the upper Green River watershed, but continue to remove trees singly or in stands to meet the various habitat mitigation and enhancement objectives in the HCP. This would be a combination of the HCP and the "No Commercial Harvest" alternative (see 9.3.2 above). Timber harvesting would be used only as a habitat management tool; there would be no harvest to generate revenue. This alternative would have the combined benefits of these other two forest management alternatives, except there would be no commercial timber harvest revenues to offset mitigation costs and/or fund the purchase of additional lands.

Tacoma did not utilize this alternative because it believes the minor environmental benefits would not outweigh funding costs. The HCP alternative is designed to have minimal impact on the upper watershed, so the additional environmental benefits of avoiding commercial timber harvest altogether would be minimal.

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