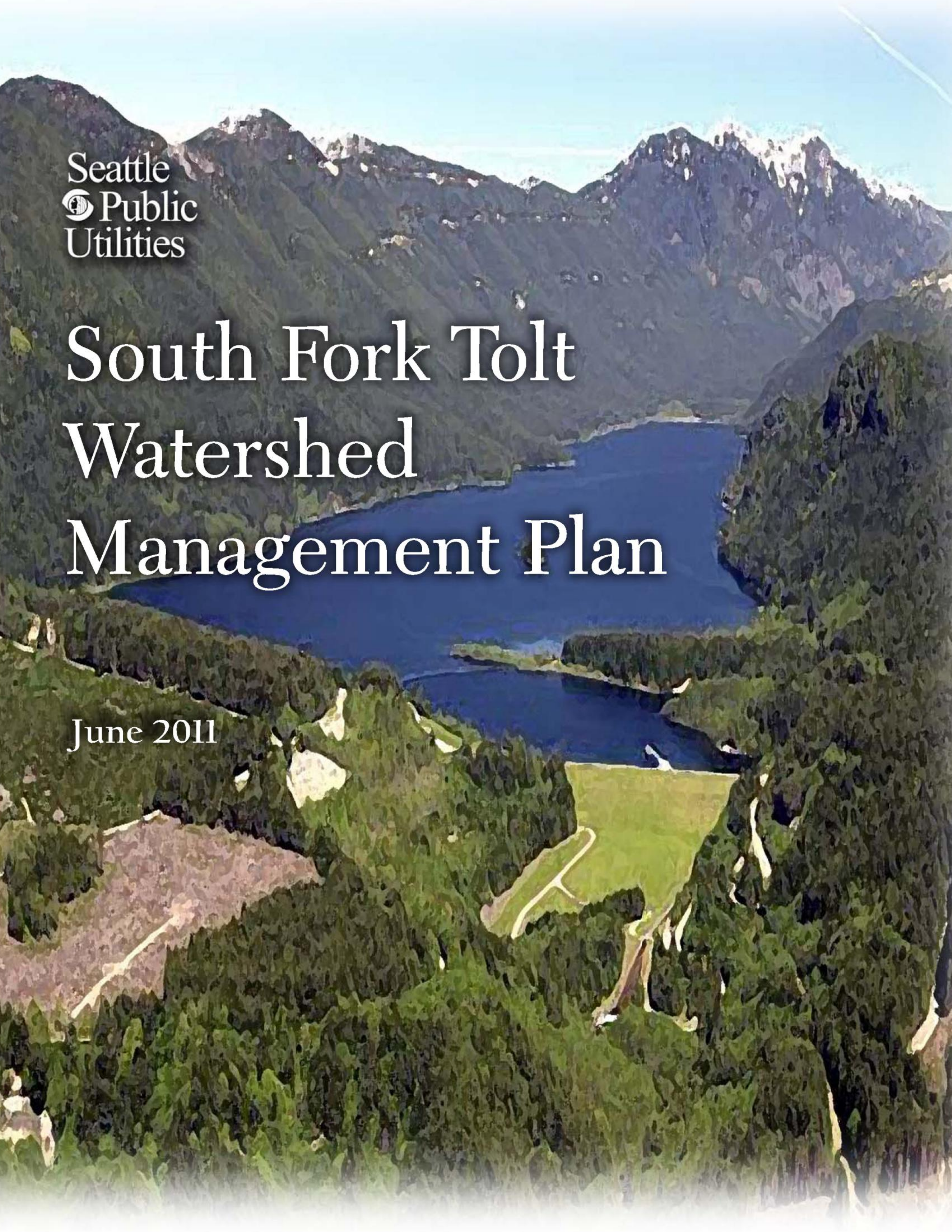
Seattle Public Utilities

South Fork Tolt Watershed Management Plan

June 2011



SOUTH FORK TOLT WATERSHED MANAGEMENT PLAN

JUNE 2011

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Seattle Public Utilities

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ACKNOWLEDGMENTS

Seattle Public Utilities gratefully acknowledges the dedication and hard work of the staff members and consultants responsible for the South Fork Tolt Watershed Management Plan. These individuals have put forth outstanding efforts and many dedicated hours to provide Seattle Public Utilities with a comprehensive plan for the protection of Seattle's water supply and stewardship of the South Fork Tolt Municipal Watershed.

Seattle Public Utilities

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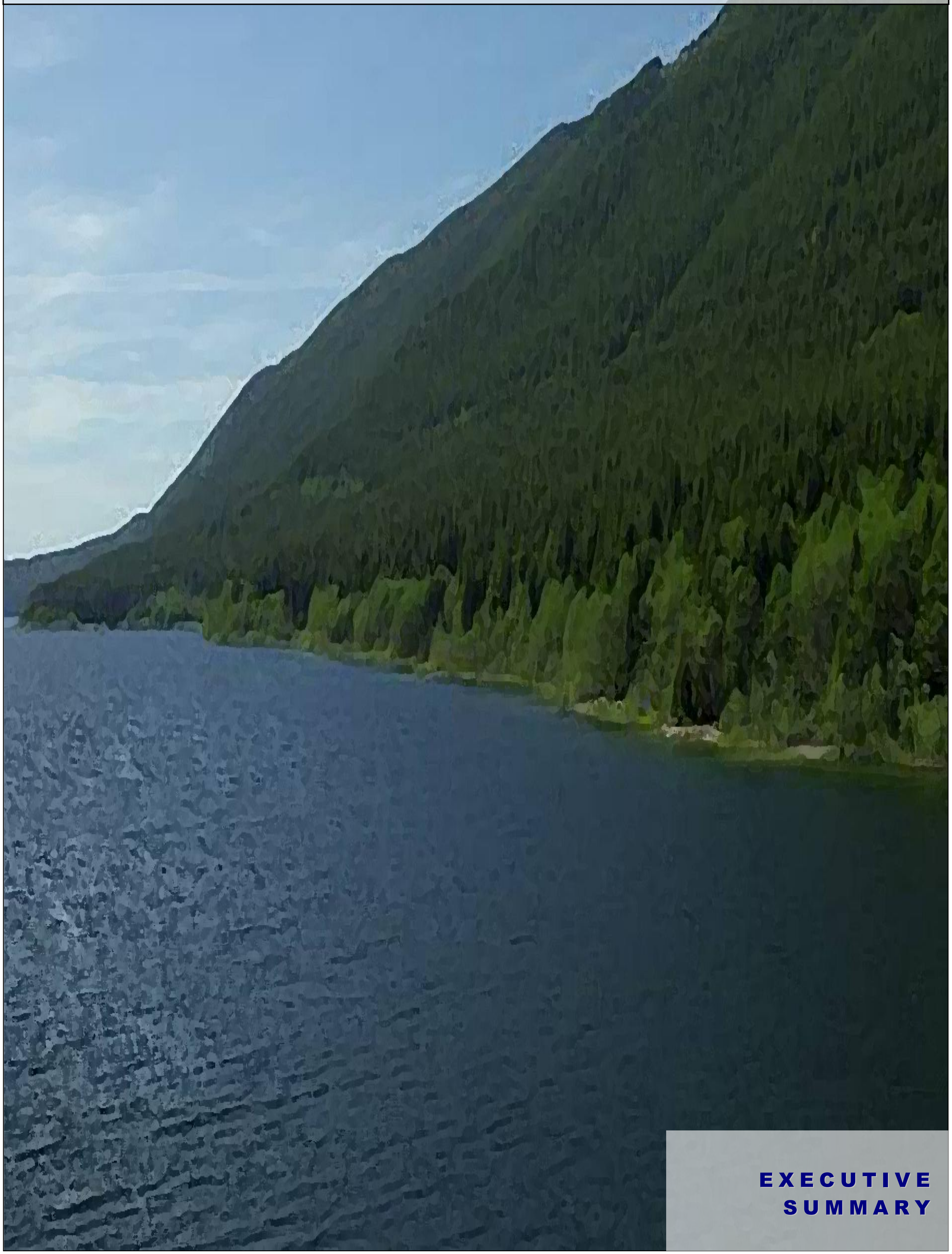
READER'S GUIDE

The *South Fork Tolt Municipal Watershed Management Plan* is organized into the following components to facilitate use by a varied audience:

- **Executive Summary**—Overview of the Plan, focusing on issues and recommended actions
- **Part 1, Introduction and Historical and Current Conditions**—Description of the planning process and generalized description of the historical and physical characteristics of the SFTMW
- **Part 2, Technical modules**—Chapters for each technical area, providing background information, summary of technical analyses, issues, options analysis, and recommended actions:
  - Watershed Protection
  - Forest Resources
  - Aquatic Resources
  - Fish and Wildlife
  - Invasive Species
  - Cultural Resources
  - Transportation
- **Part 3, Implementation**—Sets forth the implementation priorities and schedule for each action recommended in the Plan.
- **Appendices**



EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The South Fork Tolt Municipal Watershed (SFTMW) is the area draining to the South Fork Tolt Reservoir, from the South Fork Tolt Dam upstream to the headwaters of the South Fork Tolt River (Figure ES-1). The SFTMW supplies one-third of the drinking water that Seattle Public Utilities (SPU) distributes to over 1.4 million customers in the Seattle metropolitan area. The *South Fork Tolt Watershed Management Plan* provides a framework for managing City-owned lands in the municipal watershed to provide high-quality drinking water and restore forest ecosystem function, using the most efficient operation and maintenance standards for water supply facilities.

The vision for management of the watershed is as follows: *It is envisioned that the South Fork Tolt Municipal Watershed will remain a crucial part of the Seattle water supply system and be managed through progressive stewardship that promotes excellent water quality and preserves opportunities.*

Four goals were developed to guide management decisions for the SFTMW:

- **Goal 1**—Maintain and protect source water quality and quantity for municipal water supply and downstream ecosystems.
- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the municipal watershed.
- **Goal 3**—Protect the cultural resources of the municipal watershed.
- **Goal 4**—Manage the municipal watershed based on social, environmental and economic considerations.

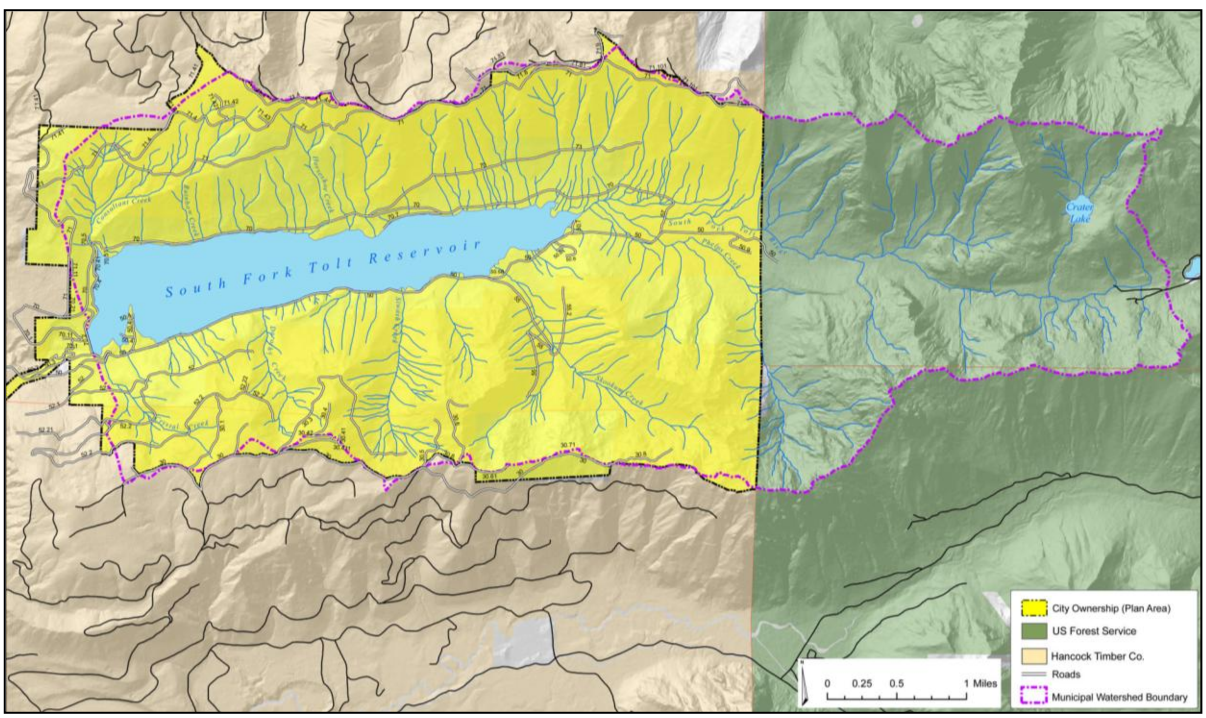


Figure ES-1. South Fork Tolt Municipal Watershed

The Plan describes current conditions, current issues and recommended actions for the SFTMW in the following technical areas:

- **Watershed Protection**—Fire prevention, access control, watershed posting, patrols and incident response, water quality monitoring, issues associated with federal land within the SFTMW, shared road-use agreements with the neighboring private landowner, and mining claims within and near the municipal watershed;
- **Forest Resources—**Forest protection and restoration to improve habitat for wildlife and fish and maintain water quality;
- **Aquatic Resources**—Fish distribution and habitat, channel and wetland processes, landslides and sediment delivery, riparian conditions and restoration treatments, sensitive resources, road erosion, hydrology, and water quality;
- **Fish and Wildlife**—Current and anticipated future habitat to support fish and wildlife needs into the future, the need for monitoring and research, impacts on habitat from past and present management activities;
- **Invasive Species**—Early detection/rapid response protocol to guard against invasive species infestations; efforts to control invasive species;
- **Cultural Resources**—Inventory work to document and map known cultural resources, and guidelines and policies for working in and around cultural sites in the municipal watershed; and
- **Transportation**—Access needs and recommendations to maintain a limited road network to support these needs (including neighboring property access needs governed by the shared Road Use Agreement discussed below), with a schedule to decommission the remaining unnecessary road segments.

History and General Description

The SFTMW is 35 miles east of Seattle on the western slope of the mid-Cascade Range, near the towns of Carnation and Duvall. The SFTMW encompasses the 12,107-acre drainage area upstream of the South Fork Tolt Dam. The western 8,339-acres of the municipal watershed are City-owned and managed, and the eastern 3,708 acres are National Forest System lands administered by the Mt. Baker-Snoqualmie National Forest. The City-owned lands within the SFTMW are closed to public access.

The City of Seattle purchased its water rights to the Tolt River drainage basin from the Mountain Water Company in 1936. Logging by the Weyerhaeuser Company in the reservoir area began around 1946 and continued until 1957. An extensive forest road system was constructed to support logging activities and construction of the water supply infrastructure. Intense logging within the reservoir area occurred between 1953 and 1957. Timber harvest occurred over much of the municipal watershed until the mid-1990s. Some timber harvest has also occurred on National Forest System lands administered by the Mt. Baker-Snoqualmie National Forest within the municipal watershed.

In 1959, an agreement known as the "Watershed Operations Agreement" was executed between Weyerhaeuser and the City for the exchange of 1,400 acres of land to be used for the South Fork Tolt Reservoir and pipeline construction. An agreement for shared road use and maintenance was also executed in 1959. Following dam construction in 1963, the resultant reservoir inundated several miles along the former main stem of the South Fork Tolt River as well as the lower portions of numerous tributary streams. The City began diverting municipal-supply water from the South Fork Tolt River in 1964. The South Fork Tolt Reservoir is the primary storage reservoir in the Tolt water system, holding 18.3 billion gallons (56,160 acre-feet) of water. The City of Seattle completed negotiation for acquisition of all Weyerhaeuser-owned lands in the SFTMW in 1997. In 2000, the Tolt Filtration Plant came on-line, providing ozonation and ultraviolet light disinfection, and carbon filtration, to the water supply originating from the South Fork Tolt Reservoir.

The City currently maintains relations with just two major neighboring landowners (Figure ES-1):

- The National Forest System lands within the SFTMW are managed to be consistent with the 1990 Mt. Baker-Snoqualmie Forest Plan, as amended.
- Hancock Forest Management, Inc.—This private owner purchased the Snoqualmie Tree Farm from Weyerhaeuser in 2003. Most of the land contiguous with the west half of the SFTMW, and most of the land in the adjacent drainages to the north and south, is owned and managed for commercial forest products by Hancock Forest Management Inc. King County owns the development rights to the land sold to Hancock at that time. Shared road use and conduct of parties while passing through neighboring lands are formally addressed through the Watershed Operation Agreement and the Road Use Agreement.

WATERSHED PROTECTION

A comprehensive management plan for watershed protection includes active on-site patrols and surveillance, strict access and control measures, closed gates, a workable lock and key system, posting of boundaries, fire prevention and suppression, emergency response capabilities, continued data collection, and sanitation facilities. Watershed protection also requires coordination with neighboring property owners on access and land use issues that can affect conditions within the municipal watershed.

Key Issues

The following are the key issues related to watershed protection in the SFTMW:

- Current facilities and level of service for fire prevention and suppression in the SFTMW are inadequate in the following areas:
  - Industrial Fire Precaution Level (IFPL) signage does not exist at all SFTMW entry points to inform contractors of daily fire danger level.

  - Staffing and fire-fighting equipment are insufficient to perform fire patrols on days of extreme fire danger, to promptly update IFPL signs, and to respond to fire starts.
  - Local fire departments cannot provide initial response to the SFTMW in a timely manner due to some deteriorated road conditions, gated access, and the remoteness of its location.
- Access and control infrastructure and procedures do not fully support SPU security requirements for watershed protection in the following areas:
  - Gates that control access to the SFTMW from the west are not up to SPU standards.
  - There are no gates at the east end of the SFTMW on National Forest System lands.
  - Boundary posting is absent or deteriorated to a point of being illegible in most locations along City-owned boundaries of the SFTMW.
  - Keys to SFTMW gates are controlled and issued from the Operations Control Center in Seattle, but permits are issued by staff within the Watershed Services Division at Cedar Falls. Key-issuance protocols and padlock installations are not handled in a consistent manner, which results in reduced level of access control.
- There are no portable or semi-permanent toilets located upstream from the dam.
- SPU Watershed Protection staff does not conduct daily physical monitoring of critical infrastructure assets (infrastructure necessary for the delivery of water).
- No emergency supplies (fire response trailer, spill response drums) are located in the SFTMW.
- Adequate staffing levels are often not available to staff two-person water quality and quantity sampling teams.
- There is potential for activities on the National Forest System lands within the municipal watershed that may be incompatible with the protection of the municipal water supply.
- The Watershed Operations Agreement and Road Use Agreement have provided a general administrative framework for coordinating with Hancock Forest Management, but they have never been tested in a technical or legal sense.
- The City has no certainty and only limited effective control over the future disposition and activity on existing mining claims in the municipal watershed.
- There is a lack of clarity about policies, procedures, roles, and responsibilities associated with watershed protection services for the SFTMW.

Recommended Actions

The following recommended actions represent a conservative approach to bringing watershed protection service levels in line with SPU standards while acknowledging the remote location of the SFTMW and relatively low level of management activities that will take place within the SFTMW.

- There is a need for a comprehensive Tolt Water Supply Security and Protection Plan, including areas downstream of the dam.
- IFPL signs should be installed at access gates on the 50 and 70 Road entrances to the municipal watershed.
- A fire trailer should be stationed at the Vista House above the dam during fire season, equipped with a 300-gallon water tank, 13-horsepower pump, and a minimum of 300 feet of hose. The trailer should be stored in a simple shelter or garage to reduce its exposure to weather and ensure proper operation of pumps and equipment for immediate fire response.
- Centralized key and padlock administration should be implemented that is consistent with SPU key-management policies, combined with the requirement that all non-SPU users of the municipal watershed obtain and display a valid permit. Cyber-locks should be installed on all gates from the Kelly Road to the municipal watershed boundary and at all gates entering the Municipal Watershed.
- Nine existing gates should be replaced to meet current SPU security standards, and several new gates to control access should be installed. Proper signage that conforms to current SPU standards will need to be installed on all gates.
- “No Trespass” signs should be posted every 100 feet around the perimeter of City-owned lands in the SFTMW. The posting line will require yearly maintenance to keep up its appearance and replace worn and weather-damaged signs.
- Semi-permanent portable toilets should be installed and maintained at remote locations of the municipal watershed upstream from the dam, and portable toilets should be ready and available to be moved to locations where they will be most needed depending on activities in the watershed.
- All non-SPU individuals entering the SFTMW must be informed of their obligations within the watershed, including compliance with SPU watershed access and control regulations, which require sanitary facilities at all work sites and prohibit any activities that could contaminate the water supply.
- Proactive infrastructure checks should be conducted to identify problems as they arise.
- Incident response, investigation, resolution, reporting, and follow-up capabilities will need to increase to meet SPU security and emergency management policy.
- A properly outfitted 12-foot rescue cache trailer should be staged at the Vista House. It should contain an inventory of medical supplies, rescue equipment, emergency survival supplies, lighting, communication, food, water, and spill response supplies. Fifty-five gallon spill response drums should be purchased and deployed at the six bridge crossings on reservoir perimeter roads.
- SPU should evaluate the City’s options for managing the risk of incompatible land uses in the municipal watershed and assess the costs, benefits, risks, and feasibility of acquiring federal lands in the SFTMW as a means to reduce the risk of future incompatible land uses.

- The Watershed Operating Agreement and Road Use Agreement with Hancock Forest Management, Inc. should be updated to address all current conditions and issues.
- SPU must determine whether any mining claims in the SFTMW were improperly classified as active because they were filed after the effective date of the mineral withdrawal mandated by Public Law 97-350. SPU should also evaluate the City's options for managing future risk associated with active claims.

FOREST RESOURCES

By the time that harvesting of old-growth forests in the SFTMW ended in the 1990s, three-quarters of the forest in the basin had been harvested. Regeneration of secondary forests was slow except on productive sites in the valley bottom. Large areas on the south side of the basin remain in early-successional stages due to shallow soils and poor growing conditions. The remaining old-growth forests in the City-owned portion of the SFTMW are located on steep rocky slopes, mostly in the Phelps, Skookum, and Siwash subbasins.

Forest management goals of the City-owned portion of the SFTMW contrast sharply with the management of forest on neighboring lands. Lands owned by Hancock Forest Management to the north, south, and west are managed to maximize timber production using even-age stand management. The forest lands to the east are managed by the USFS and are predominantly old-growth forest and sub-alpine shrub vegetation, with no current forest management activities, and no expectation for activities in the future.

Key Issues

Past forest management has drastically disturbed forest and altered natural ecosystem functions in the watershed, such as forest habitat, productivity, and sediment delivery and transport in streams. The following are the key issues related to forest resource management in the SFTMW:

- Young forests with limited tree species composition and homogeneous forest structural conditions have lower habitat value, biodiversity, and summer base flows in tributary streams.
- The reduced tree species diversity and low number of large residual standing and down dead trees may reduce the resilience of the ecosystem to withstand or recover from further disturbance or adapt to gradually changing environmental conditions that occur from climate change.
- The removal of mid-slope roads and roads on steep slopes in the southeast portion of City-owned lands in the basin creates operability constraints for possible forest management. These areas should be excluded from active management or be considered for hands-only restoration treatments.
- The SFTMW's position between industrial forest lands (mostly early seral forest) and National Forest (mostly late seral forest) creates a strong contrast in forest age distribution and structure on the landscape. This places a greater importance on the management of

SFTMW forest lands to create a landscape more effective in fostering biodiversity and providing resilience in the face of environmental changes and disturbance.

Recommended Actions

An active program of restoration treatments in second-growth forests is recommended to facilitate the recovery of ecosystem functions and increase the resilience to disturbance. Objectives of this program are as follows:

- Protect and promote erosion prevention and sediment retention functions of natural forested landscape.
- Promote the development of late-successional forest structures.
- Provide wildlife habitat elements.
- Sell surplus trees to offset costs of restoration activities.
- Maintain reserve areas including non-managed remnants of old-growth, inaccessible areas of the watershed, and unstable slopes.

Habitat restoration will be accomplished through a range of treatments:

- **Restoration thinning**—Thinning to 150 to 250 trees per acre, and creating canopy gaps (for young dense forest 15 to 40 years old)
- **Ecological thinning**—Variable density thinning to 100 to 240 trees per acre, including canopy gaps and unthinned skips (for older dense forests with closed canopy)
- **Planting**—Planting site appropriate minor tree species to increase species diversity
- **Understory thinning**—Thinning to 100-250 trees per acre (for young dense trees in understory)
- **Habitat enhancement**—Top or girdle clusters of large trees per acre (for older dense forests with few snags)

The proposed management plan establishes acreages for each type of treatment to be carried out each decade through 2086. Treatments for specific areas within the SFTMW will be selected based on the following criteria:

- Defined management zones with associated restoration goals,
- Potential productivity of the site,
- Potential for coordinating with other restoration activities, and
- Forest stand conditions.

Under the recommended management approach, more than half of the forested lands of the SFTMW should consist of multi-story forest habitat by about 2027.

AQUATIC RESOURCES

Protection of drinking water quality and protection of aquatic habitats both require protection of vegetation near water bodies and minimization of sediment delivery to streams from upland activities. Streams, lakes, ponds, and wetlands function as an interrelated system that provides water and aquatic habitat for a variety of animals.

Nineteen tributary subbasins have been delineated within the SFTMW. Major tributaries to the South Fork Tolt Reservoir include the main stem South Fork Tolt River (including Phelps Creek), and Skookum and

Siwash creeks. Consultant, Rainbow, and Horseshoe creeks and numerous unnamed drainages enter the reservoir from its north side, while Crystal, Dorothy, Siwash, Chuck Judd, Skookum, and several unnamed creeks enter the reservoir from the south. Almost 80 percent of the total length of streams consists of small, steep tributaries.

Lake habitat in the SFTMW includes the South Fork Tolt Reservoir and Crater Lake. Reconnaissance surveys of the SFTMW indicate very few wetlands in the steep terrain of the basin. Wetland habitat is limited to areas associated with the delta area of the South Fork Tolt River at the eastern edge of the South Fork Tolt Reservoir, several small depressional wetlands on topographic benches along the south ridge of the SFTMW, and meadow systems in the headwater areas of the main stem South Fork Tolt River.

Streams and wetlands in the SFTMW have been impacted to various degrees by past timber harvest and activities such as road building. These activities affected such watershed processes and conditions as sediment delivery, riparian, vegetation and recruitment of large woody debris (LWD), all of which directly affect aquatic habitat and resources. The result of these practices has been that many landslides delivered into the South Fork Tolt Reservoir, the creation of barriers to the movement of fish and wildlife, and chronic delivery of road-generated fine sediment to streams and the reservoir. The SFTMW has experienced only one known landslide since 1997—given that the majority of previous landslides were associated with roads, the program of road decommissioning appears to have been effective in reducing and potentially eliminating most landslides. These results suggest that current landslide rates may be approaching natural or background rates in the SFTMW, however sediment from former landslides continue to move through the system into the reservoir.

Identification of critical aquatic resources required a determination of the following:

- **Impacted Areas**—Areas where key processes are most likely to have been impacted by forest management;
- **Sensitive Resources**—Areas that are most sensitive to the impacts of forest management; and,
- **Linkages**—The overlap between impacted areas and sensitive resources, indicating resources that likely have been severely degraded as a result of past management activities.

Key Issues

The following are the key issues associated with aquatic resources in the SFTMW:

- There is poor near-term LWD recruitment potential in large, low-gradient, fish-bearing streams.
- Fine sediment is being delivered to streams from some portions of the SFTMW road system.
- Roads within or adjacent to wetlands can act as barriers to movement of amphibians using these wetlands as habitat.
- Improperly installed or poorly maintained culverts represent fish-passage barriers on streams.
- Timber harvest and road construction have also resulted in bank instability,

channel widening, and turbidity within the reservoir.

- Timber harvest and road building in the SFTMW can result in an increase in the frequency of landslides, which deliver sediment to fish-bearing streams and the reservoir.

Recommended Actions

Sediment impacts on the City's source water were a primary consideration in formulating recommended actions related to aquatic resources. Sediment contribution to the reservoir negatively impacts the City's water supply through reservoir infilling as well as higher filtration costs. Restoring aquatic resources will hasten recovery of the disturbed system to a more natural level of sediment contribution. The recommended actions fall into four general project types:

- **LWD placement projects**—Construction of engineered log jams to deflect flow away from floodplain channels tributary to the South Fork Tolt River immediately upstream of the reservoir would reduce the likelihood of main stem channel avulsion and partial or complete scour of the floodplain channels. Addition of LWD to one of these floodplain channels would also improve fish habitat.
- **Headwater Riparian Thinning**—Riparian thinning involving directional tree-felling toward steep gradient, high sediment producing streams to create needed sediment storage sites, thereby reducing the chronic disturbance to downstream habitat, as well as moderating the release of sediment into the reservoir.
- **Riparian treatments along fish-bearing streams**—Increasing the growth rate of existing conifer trees by thinning and by under-planting conifer trees in deciduous-dominated riparian stands will increase future LWD recruitment potential. To address this issue, riparian zones associated with the larger fish-bearing streams will be further evaluated to assess the efficacy of active restoration involving riparian thinning and under-planting.

FISH AND WILDLIFE

Habitat available for fish and wildlife in the City-owned portion of the SFTMW includes young forest, the reservoir, and various special habitats such as rock outcrops, cliffs, talus slopes, meadows, wetlands, and shrub-dominated sites. Available forest habitat was profoundly altered from natural old-growth forest conditions, leading to a lack of old-growth-dependent species in the SFTMW. Although current information on fish and wildlife species in the watershed is very limited, the following information is available:

- Old-growth-dependent species such as northern spotted owl, marbled murrelet and northern goshawk are not known to occur on the City-owned land within the SFTMW. Northern spotted owls and marbled murrelets have been documented on USFS-owned land within the SFTMW.

- Black-tailed deer are known to inhabit the SFTMW, but the Washington Department of Fish and Wildlife (WDFW) has no records of elk being present in the entire South Fork Tolt basin, either historically or at present.
- Wolverines are not likely to be found in second-growth forest of City-owned lands within the watershed.
- The South Fork Tolt Reservoir provides one of the few undisturbed lake environments in western Washington where common loons can reproduce without high levels of human activity and associated disturbance. Common loons regularly nest on the reservoir, and SPU staff annually deploy and monitor an artificial nesting platform to aid the loons in overcoming the difficulties of water level fluctuations.
- A variety of amphibian species depends upon the small ponded depressional wetlands in the SFTMW for breeding and rearing habitat.
- The fish community using habitat within the SFTMW upstream of the reservoir is relatively simple, consisting of cutthroat trout, cutthroat/rainbow hybrids, and torrent sculpin. Existing survey data indicate that fish use is limited primarily to the reservoir and lower reaches of tributary streams, although the upper limit of salmonid distribution has not yet been definitively determined. Anadromous salmonids have not historically had access to this portion of the Tolt River Watershed due to a natural fish passage barrier approximately one-third mile below the South Fork Tolt Dam (Williams, 1975).

Key Issues

The following issues relate to the need for greater information about the habitats and populations for fish and wildlife in the watershed:

- Some information about the amount and distribution of important habitats and special habitat features such as meadows, rock outcrops, talus, cliffs, snags, and downed wood was collected during data collection for this plan; however, detailed documentation of special habitat conditions has not yet been generated.
- There is little known about the presence and distribution of most fish and wildlife species, such as northern spotted owl, marbled murrelet, northern goshawk, and amphibians.

The following issues relate to protecting habitat in the SFTMW:

- Special habitats (meadows, wetlands, old-growth forests) and special habitat elements (snags, downed wood, large branches, and large woody debris in streams of concern) are rare and require protection.
- Habitat associated with known locations of species are in need of protection from disturbance.
- SFTMW management should not exacerbate natural disturbances, such as floods, forest fire, wind-throw, and landslides.
- The effects of climate change on the SFTMW ecosystem are uncertain.

- There is uncertainty whether landscape conditions outside the SFTMW will remain constant. Habitat conditions on neighboring lands affect landscape-scale habitat connectivity for some species.

The following issues relate to restoring essential ecological processes in the SFTMW:

- A history of clear-cut timber harvest has reduced and/or degraded habitat for species of concern in the SFTMW.
- Forest habitat within the watershed should be managed primarily for late-successional forest structure and processes.
- Aquatic and forest restoration should focus on areas such as migration pathways between existing old-growth or late-successional forest habitat, corridors between ponds and upland forests, and connectivity between wetland habitats.
- Special habitat elements such as snags, downed wood, and large branches in forests and large woody debris in streams may be insufficient to support some species.
- Invasive plant species may threaten habitat quality for many wildlife species.
- Minimizing or reducing existing road impacts by road decommissioning and improvements would benefit a variety of species.

Recommended Actions

Fish and Wildlife recommendations were developed following an evaluation of legal requirements, consistency with SPU goals for the SFTMW, and consistency with other Plan components. The following recommendations represent a minimal level of service related to fish and wildlife resources of the SFTMW:

- Mapping and ground verification of Special Habitats should be undertaken.
- The presence and quantity of habitat elements, such as snags and downed wood should be assessed during project planning in all proposed treatment areas in order to protect these features and to potentially increase their abundance.
- Surveys to document the presence of common loon, marbled murrelet, and amphibians should be continued and expanded.
- Efforts to monitor and provide common loon nesting platforms in the reservoir should continue.
- An assessment of northern goshawk habitat quality should be conducted to identify areas where this species could potentially occur.
- If found, nest sites of spotted owl, marbled murrelet, and other listed or sensitive species (e.g., common loon, peregrine falcons) should be protected by implementation of noise and disturbance restrictions within minimum distances of nest sites or occupied stands, depending on the species.
- Pieces of large woody debris occurring on the reservoir delta should be left in place, and cabled if necessary. Large woody debris taken from the reservoir in order to protect the dam should be stockpiled for use in stream restoration.

- Disturbance to the delta from heavy equipment should be completely avoided or at least minimized.

INVASIVE PLANT SPECIES

Invasive species (including terrestrial and aquatic plants, pathogens, insects and other animals) pose significant risks to native biodiversity, fish and wildlife habitat, and basic ecological functioning. Currently, yellow hawkweed and tansy ragwort are the only invasive species documented in the SFTMW that are addressed by invasive species control regulations. However, comprehensive surveys have not been conducted for either of these two plants or for other invasive species. Some invasive plants that could cause ecological damage, but are not legally required to be controlled, have been observed, but not mapped or controlled. These include evergreen blackberry, Himalayan blackberry, Scots broom, bull thistle, and Canada thistle. Most of these plants have been seen along the roads adjacent to the reservoir.

The invasive species control program described in this management plan is part of a larger SPU Terrestrial Plant Invasive Species Management Program for the Utility's major watersheds. SPU will use Integrated Pest Management (IPM) principles to minimize the risk of invasion and to control any invasive species detected. IPM requires an evaluation of each invasive species patch to determine the most effective and cost-effective control methods. It is expected that these will vary by species and site-specific conditions.

Key Issues

Key issues associated with invasive species in the SFTMW are largely associated with future activities and events, many of which cannot be clearly predicted:

- Large-scale natural disturbances such as wildfires would increase the risk of infestation by invasive plants, especially if there is a nearby seed source, as well as pathogens and insects. Because events like this are effectively unpredictable, it is difficult to plan for them.
- Changing management strategies on neighboring properties could significantly alter the risk of invasion by new non-native species.
- Any ground-disturbing work within the watershed will increase the risk of invasion, especially if it is located near an existing plant infestation that could serve as a seed source.
- Climate change is predicted to create conditions that will favor invasive species over native plants because of increased disturbance and higher carbon-dioxide levels in the atmosphere. However, the extent to which this may happen within the SFTMW is unknown.
- Little research has been conducted on the actual impact of specific invasive species on habitat for fish and wildlife species in the western Cascade Mountains.

Recommended Actions

The following recommendations for invasive plant species management in the SFTMW would have the lowest ecological risk, lowest long-term costs, and highest ecological, social, and economic benefits:

- Implement an early detection/rapid response protocol, which entails surveying a portion of the SFTMW every year, to cover the entire watershed every five years, and treating new infestations immediately.
- Encompass all invasive species survey and control in the SFTMW within the larger Invasive Species Program for SPU's major watersheds.
- Complete plant surveys.
- Complete invasive plant experimental control efforts.
- Utilize Integrated Pest Management (IPM) principles.

CULTURAL RESOURCES

Protecting cultural resources in the City-owned portions of the municipal watershed is one of the primary goals for SPU's management of the SFTMW. A cultural resource management plan (CRMP) for the Cedar River Municipal Watershed established procedures in 2004 to limit and reduce potential conflicts between SPU's primary mission activities and applicable regulations governing cultural resource protection. Although the SFTMW is much smaller and contains fewer known and potential cultural resources, the similarity of cultural resource management issues supports incorporation of the standards and protocols established in the CRMP for the Cedar into the recommended actions in this plan for the SFTMW.

Key Issues

The key issues associated with cultural resources in the SFTMW are as follows:

- Formal guidelines are lacking for compliance with federal, state, and city ordinances to provide protection of cultural resources.
- Protocols regarding unanticipated discovery of cultural resources, treatment of human remains, response to vandalism, and emergency response do not exist for the SFTMW.
- The GIS database is incomplete for known and potential cultural resource information in the SFTMW. This information is needed for cultural resource protection during planned activities, such as bridge replacement or road decommissioning, as well as emergency responses to flooding, fire, and earthquakes.
- Formal guidelines are lacking for information sharing and confidentiality for all parties involved.
- Formal guidelines are lacking for the curation of cultural material.
- City maintenance staff have not been oriented and trained in their responsibility to protect cultural resources and in identification of cultural material that they might encounter.
- No formal system exists to educate contractors and other visitors to the SFTMW about cultural resource protection requirements.

Recommended Actions

The following actions are recommended for cultural resource management in the SFTMW:

- SPU should adopt cultural resource management standards for the SFTMW adapted from the U.S. Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation*. SPU should apply the standards in a reasonable manner, considering the economic and technical feasibility of implementing them within the context of its responsibility for the overall management of the watershed and its other resources.
- The existing GIS database for known and potential cultural resource information needs to be updated as new information becomes available. SPU will soon be conducting a traditional cultural property survey; the results of this survey will be incorporated into the GIS database when complete.
- All SPU staff should be required to consider protection and management of cultural resources in planning for projects or maintenance work in the SFTMW, especially for projects that may involve ground disturbance or vegetation modification. Staff members should review the SFTMW GIS database during the planning stages of any proposed activities to determine if the proposed project area includes identified cultural resources and to determine the area's potential for unrecorded cultural resources.
- SPU should adopt and follow the recommended protocols for the following circumstances:
  - Unanticipated discovery of cultural materials,
  - Treatment of human remains,
  - Response to vandalism, and
  - Emergency response.
- Mitigation through archaeological data recovery, recordation of standing structures, or other measures should be conducted based on the guidance of The Advisory Council on Historic Preservation's *Recommended Approach for Consultation on the Recovery of Significant Information from Archaeological Sites* (64 FR 27085-87, 18 May 1999).

TRANSPORTATION

A functioning forest road system is an integral element of the SFTMW. The basic guiding principle for the future of this road system is to manage the balance between access and impact. The road system provides access for all types of management activities. The road system is also a source of negative impacts on habitat and water quality. The roads must be managed to provide access, while reducing the negative impacts as much as possible. The road system is in place to serve management activities and is not a valuable asset in itself aside from this service.

The historic road network accessed most of the area within the SFTMW, however, many roads in the watershed were decommissioned following the acquisition of lands from Weyerhaeuser. The roads are in a variety of conditions, affecting drivability and stability, and will need ongoing repairs, maintenance and decommissioning. Extensive road network improvements have been performed since 1993, including decommissioning, surfacing, and reduced usage, and these improvements have significantly reduced many of the adverse impacts of the SFTMW road system. Each road in the SFTMW was classified into one of four categories:

- **Core Roads**—These roads are needed for long-term use. Activities on these roads will be governed by Road Use Agreements. There are 40 miles of core roads in the SFTMW.
- **Temporary Roads**—These roads will provide access for a limited time for projects developed under the watershed management plan. Temporary roads may be needed for five years or until 2060, or any time in between. There are eight miles of temporary roads in the SFTMW.
- **Non-Essential Roads**—These roads have been identified as serving no current or future access needs. They will be scheduled for decommissioning to a standard that will eliminate potential adverse environmental impacts from the road. Three miles of roads are currently classified as non-essential.
- **Decommissioned Roads**—These roads have been decommissioned to stabilize them and reduce future risk of impacts on water quality and habitat. There are 32 miles of decommissioned roads in the SFTMW.

Key Issues

Roads within the SFTMW continue to have both direct and indirect adverse effects including the following:

- Contribution of fine sediments through streams and direct discharge into the Tolt Reservoir.
- Changes in stream channel structure and geometry from increased sediment loads
- Interruption of sediment and wood transport at stream crossings
- Road encroachment into floodplains and riparian zones
- Barriers to fish passage and wildlife migration.

Overall, 50 percent of the active roads in the watershed deliver directly to streams, and isolated erosion features related to roads remain on the south side of the SFTMW.

Improvement and maintenance of roads used by adjacent landowners, and the frequency and nature of their use needs to be addressed in the road use agreements with Hancock Forest Management Inc.

Recommended Actions

The short and long-term need for each road was weighed against its possible impacts on water quality and habitat in addition to the financial cost required to improve, decommission, or maintain it. Recommended actions focus on providing access for management projects and ongoing work, while working to reduce impacts on water quality and habitat. Future road work falls into three categories:

- **Road improvements**—Road improvements address issues such as poor or improper drainage; structural concerns associated with the cut-slope, prism, or fill-slope; and road shaping and surfacing. Roads are prioritized for improvements based on the capacity of the existing road to provide needed access, the extent to which current conditions are contributing to resource degradation, and the extent to which economically feasible solutions exist to address the critical concerns. Three road segments have been prioritized for improvement prior to 2014. Eight other roads have been given a moderate priority, reflecting those contributing adversely to water quality, but which in their present condition are able to meet SPU's access needs.

- **Maintenance**—Road maintenance represents annual work needed to prevent drainage problems from escalating into larger problems and maintaining road tread to achieve designed drainage characteristics.
- **Decommissioning**—When a road is no longer needed for access, it is reclassified as non-essential and placed on the list of roads to be decommissioned. Road decommissioning commonly involves the removal and relocation of over-steepened and unstable fill, as well as the restoration of natural drainage patterns and stream crossings. Three roads have been identified for decommissioning prior to 2014 because of their adverse impacts to aquatic habitat and water quality, and expensive annual maintenance requirements. Eleven additional roads, classified as non-essential, have been given a moderate priority, and sufficient funds; these will be decommissioned between 2014 and 2025.
- **Road schedule**—A road schedule was developed to prioritize road improvements and decommissioning (Tables 9-3 and 9-4).

Road management standards for maintenance and improvement in the SFTMW will be the same as those used to manage the Cedar River watershed (*City of Seattle Cedar River Watershed Road Management Standards and Guidelines*, Draft, January 2004). These standards address all aspects of road construction, maintenance, and decommissioning. They include work methods, drainage structures, materials, and environmental protection. They describe methods to ensure that all road work is conducted to provide protection of water quality and habitat, reduce road failures, and provide appropriate safe access.

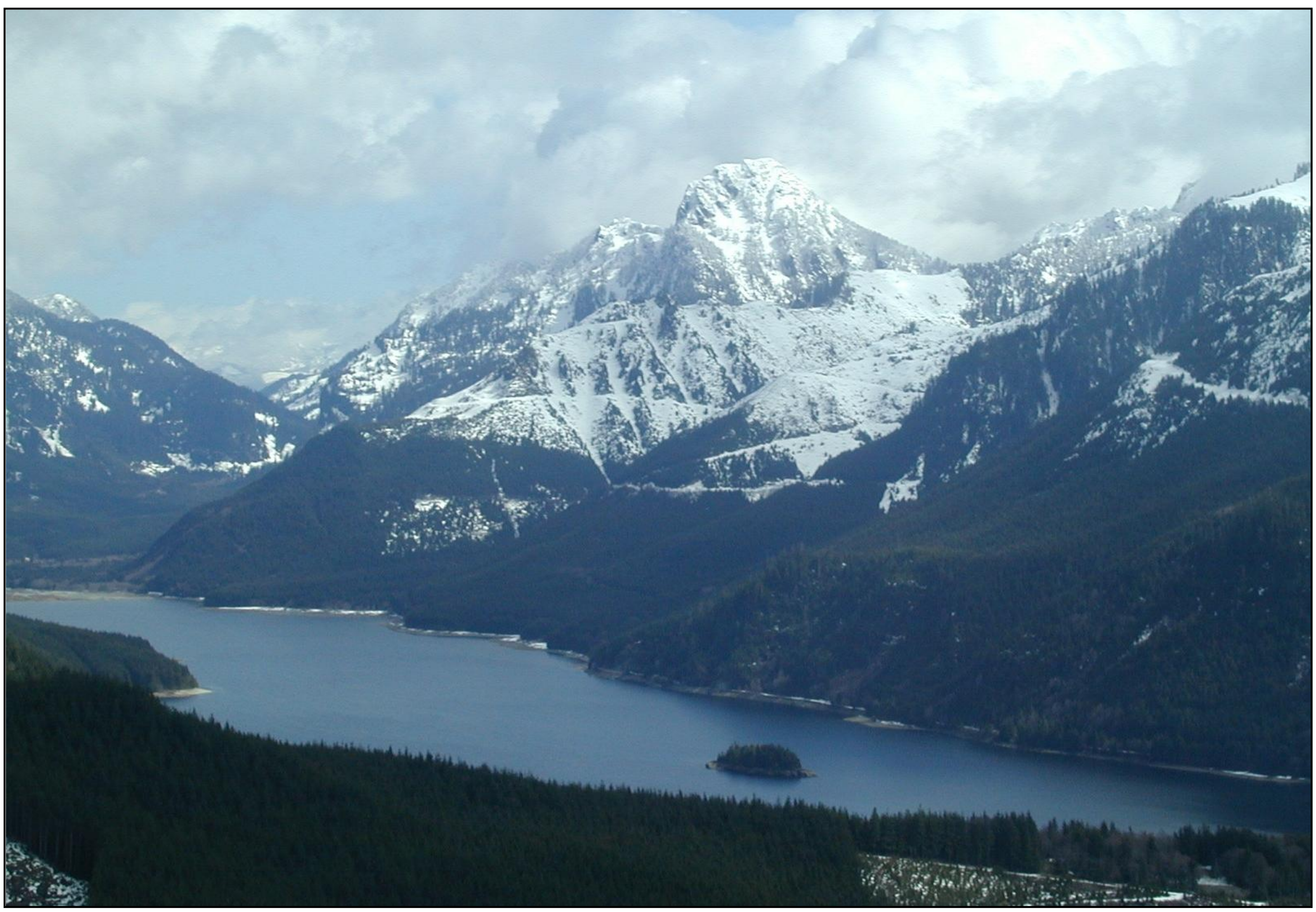
IMPLEMENTATION

The South Fork Tolt Municipal Watershed Management Plan (Plan) will be implemented over a 20-year timeframe and will be reviewed and updated as needed during that time. A complete review and update of the Plan will commence at the end of the 20-year period. The vision and goals of the Plan are fixed; however, the recommended actions are designed to be revised and updated as appropriate, thus providing flexibility with respect to when and how the actions are implemented.

Each recommended action will be included in one or more of the following phases:

- **5-Year Phase**—This phase includes many of the watershed protection actions as well as forest and aquatic resources, restoration actions, and transportation actions pertaining to watershed health and water quality.
- **10-Year Phase**—Many 10-Year Phase actions are subsequent phases or monitoring related to actions initiated in the 5-Year Phase.
- **20-Year Phase**—These actions, although still important, are more integral to achieving other watershed management goals.
- **As-Needed Actions**—As-Needed Actions that are essential to meeting the primary goal are those that are required to occur prior to the design and construction of new structures, initiation of a new activity, or granting of a new permit.

Phasing priorities are related to the ability of the action to help achieve the primary goal of maintaining and protecting source water quality and quantity for the municipal water supply and downstream ecosystems. Actions that are most critical to meeting this goal were assigned to 5-Year Phase or As-Needed Actions.

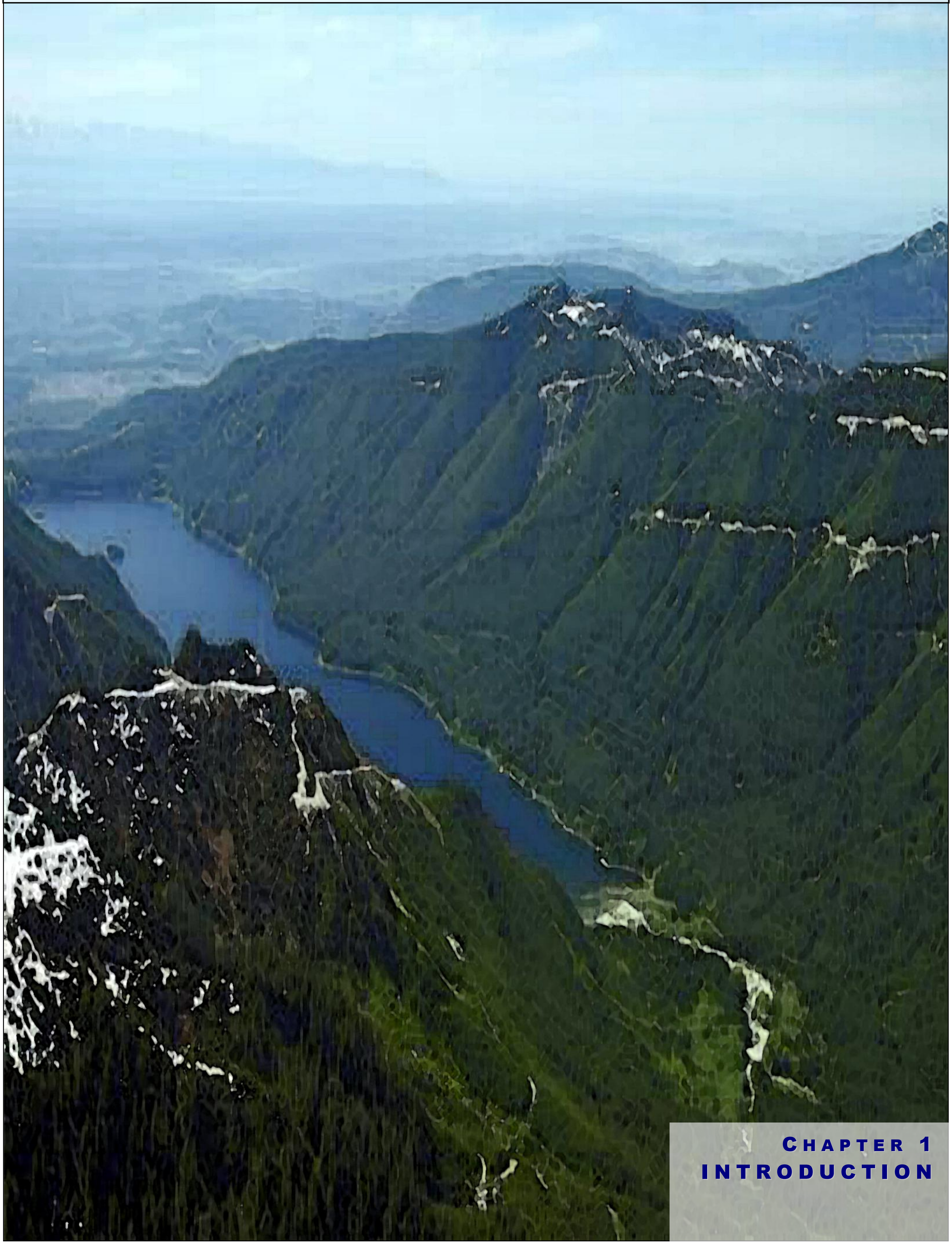


Seattle Public Utilities

South Fork Tolt Watershed Management Plan

PART 1.
INTRODUCTION AND BACKGROUND

June 2011



Chapter 1
INTRODUCTION

CHAPTER 1. INTRODUCTION

Seattle Public Utilities (SPU) provides drinking water to over 1.4 million customers in the Seattle metropolitan area. This water supply originates from two watersheds in the Cascade Mountains: the Cedar River watershed and the South Fork Tolt River watershed. Approximately two-thirds of the water comes from the Cedar River and one-third from the Tolt River each year. SPU owns all of the land in the Cedar River Municipal Watershed (CRMW) and 70 percent of the land in the South Fork Tolt Municipal Watershed (SFTMW) upstream of the South Fork Tolt Dam (see Figure 1-1). The U.S. Forest Service (USFS) owns and manages the eastern 30 percent of the basin. Unsupervised public access is prohibited by SPU in all of the City-owned portions of the two watersheds in order to protect water quality and infrastructure in these supply systems.

The area draining to the South Fork Tolt Reservoir, from the dam upstream to the headwaters of the South Fork Tolt River, constitutes the South Fork Tolt Municipal Watershed (SFTMW; see Figure 1-2). This *South Fork Tolt Watershed Management Plan* provides a framework for managing lands in the City-owned portions of the municipal watershed to provide high-quality drinking water and manage the forest for late-successional and old-growth forest habitat, using the most efficient operation and maintenance standards for water supply facilities.

The management plan's recommendations apply specifically to the City-owned portion of the municipal watershed, though they are intended to benefit the entire SFTMW.

VISION AND GOALS

SPU developed this watershed management plan through technical work groups and a steering committee, whose members collectively developed the following vision to guide the City's management of the SFTMW.

> *It is envisioned that the South Fork Tolt Municipal Watershed will remain a crucial part of the Seattle water supply system and be managed through progressive stewardship that promotes excellent water quality and preserves opportunities.*

Four goals were developed to guide management decisions for the SFTMW:

- **Goal 1**—Maintain and protect source water quality and quantity for municipal water supply and downstream ecosystems.
- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the municipal watershed.
- **Goal 3**—Protect the cultural resources of the municipal watershed.
- **Goal 4**—Manage the municipal watershed based on social, environmental and economic considerations.

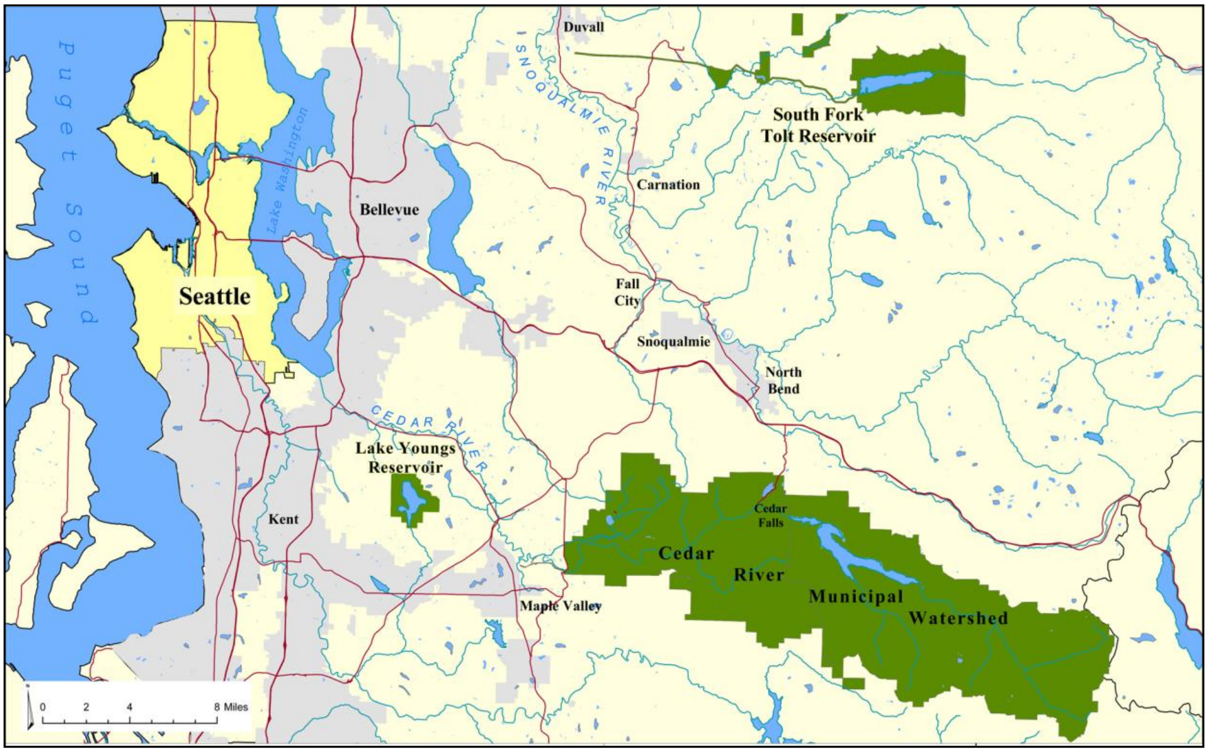


Figure 1-1. SPU Land Ownership within Cedar River and South Fork Tolt River Watersheds.

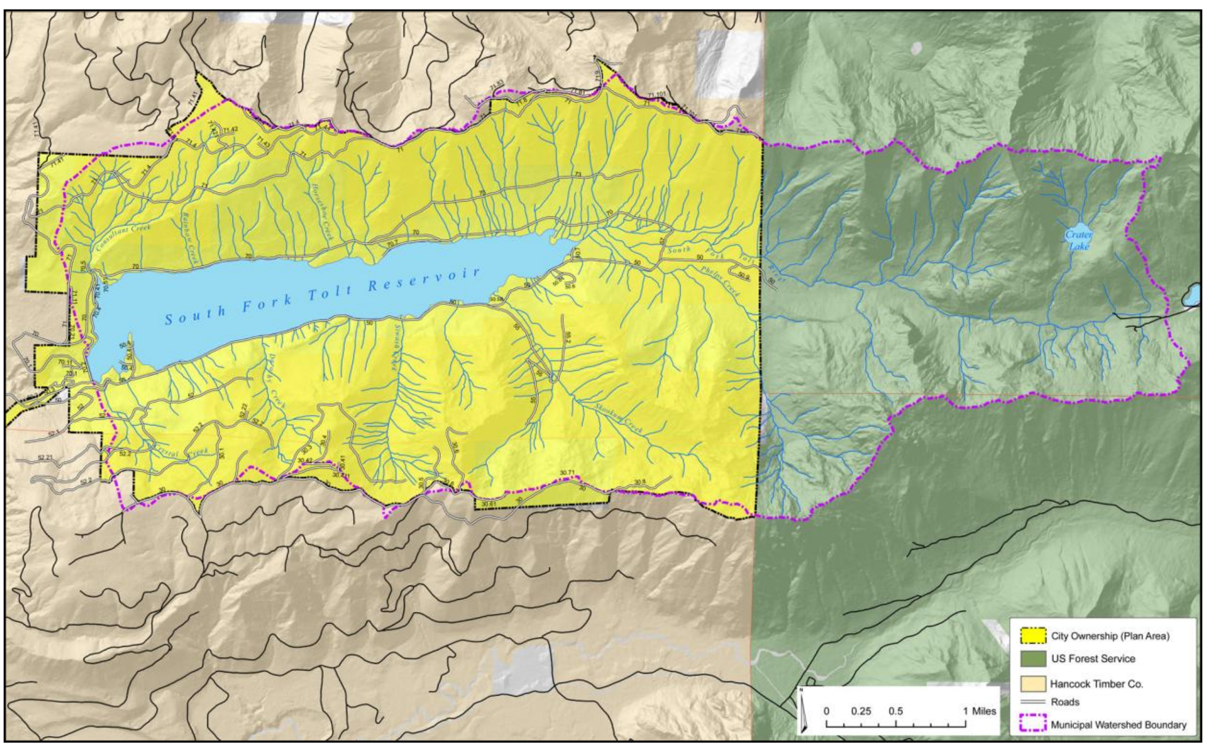


Figure 1-2. South Fork Tolt Municipal Watershed.

PLANNING PROCESS

The *South Fork Tolt Watershed Management Plan* was developed through a data collection and analysis effort followed by identification of a series of restoration and management activities.

Overseen by a Steering Committee, SPU staff was divided into work groups addressing the following technical areas:

- **Watershed Protection**— Watershed protection was addressed by two work groups: one developed a plan to upgrade and update the level of protection in the SFTMW through improved access control, watershed posting, patrols, and incident response; the other evaluated issues associated with federal land within the SFTMW (30 percent of the municipal watershed), shared road-use and operation agreements with the primary neighboring private landowner (Hancock Timber Management, Inc.), and mining claims within and near the municipal watershed.
- **Forest Resources**—The forest resources technical work group modeled forest management options to assess long-term forest habitat development and timber management opportunities. These included a commercial forestry option, two restoration forestry options, and a "status quo – no action" forest management option. This analysis and subsequent policy discussions led to a restoration forestry focus for management of forest lands in the SFTMW.

The interdependent nature of many of the technical areas mandated a high level of interaction among technical work groups throughout the planning process.

- **Aquatic Resources**—The aquatic resources work group conducted assessments of fish distribution and habitat, channel and wetland processes, landslides, riparian conditions, road erosion, hydrology, and water quality. They then used this information to evaluate aquatic needs and to develop management recommendations.
- **Fish and Wildlife**— The fish and wildlife work group used available survey data and information on current and anticipated future habitat in the municipal watershed to develop management recommendations to support fish and wildlife needs into the future.
- **Invasive Plant Species**—SPU's Major Watershed Invasive Species Management Program provided the basis for this work group's activities. The program uses an early detection/rapid response protocol to guard against invasive plant species infestations.
- **Cultural Resources**—SPU's Cultural Resources Management Plan for the Cedar River watershed provided the basis for this work group's activities. New inventory work was undertaken to document and map known cultural resources, and guidelines and policies were identified for working in and around cultural sites in the municipal watershed.
- **Transportation**—The forest road system in the SFTMW provides access for watershed operations and monitoring,

natural resource surveys, management and restoration, and road uses by neighboring landowner Hancock Forest Management, Inc. (through a road use agreement). Many unnecessary road segments in the municipal watershed have previously been decommissioned. The transportation work group compiled access needs and developed recommendations to improve and maintain a limited road network to support these needs, while setting forth a schedule to decommission the remaining unnecessary road segments.

These technical work groups, along with the Steering Committee, worked together during 2007 and 2008 to develop a vision and goals, conduct technical analyses, identify management issues needing redress, and formulate management recommendations. Alternate management scenarios were developed for most categories, and evaluated based on SPU's triple bottom line approach to asset management, which considers detailed analysis of potential activities for ecological, social, and fiscal outcome.

The interdependent nature of many of the technical areas addressed by this plan mandated a high level of interaction among technical work groups throughout the planning process. The flow chart in Figure 1-3 illustrates the relationships among technical areas. Watershed protection, forest resources, and aquatic resources planning were in large part independent planning

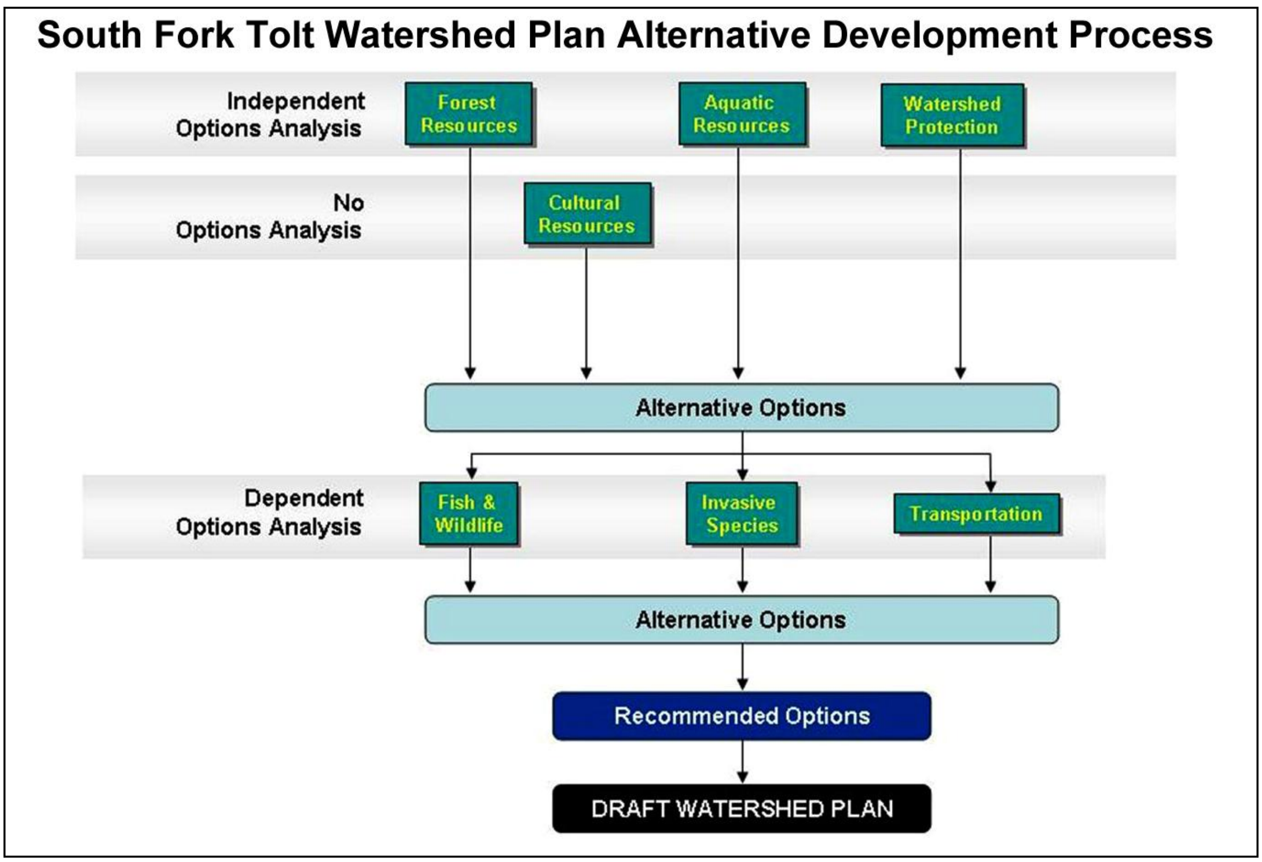


Figure 1-3. Technical Area Dependencies.

areas, which, in turn, informed and influenced the recommendations developed for fish and wildlife, invasive plant species, and transportation. For example, the forest resource management strategy serves as a primary driver for the level of fish and wildlife program activities and for the type and extent of forest roads operations and maintenance. The cultural resources planning area was largely a stand-alone planning area.

Because much of the planning process depended on the strategic direction taken for long-term forest management, the analysis of forest options preceded much of the planning for other technical work groups. Modeling conducted for the forest options analysis indicated that revenues from either a commercial forestry option or a hybrid commercial-restoration option would not outweigh the potential environmental benefits of the restoration option. SPU's executive level management approved the recommendation to adopt the restoration forestry option for the Watershed Management Plan and structured the rest of the planning process to complement and support it. Thus, the implementation strategy and schedule for activities, including road improvements, aquatic restoration, wildlife study, and invasive plant management, were all significantly driven by the choice of a restoration forestry approach in the SFTMW.

Following this important underlying landscape approach, each technical discipline area work group evaluated a spectrum of management options or service levels that compared the status quo to a range of increased program or project activities, as follows:

- Current (status quo) management activities in the SFTMW (base case);
- Legally required management activities (in most cases these are nearly the same as the current level of management);
- Minimal level of management activities consistent with SPU policies, and for dependent discipline areas, consistency with the selected restoration forestry management option; and
- Substantially increased management activities to address areas where analysis of issues indicates a need for considerably more programmatic involvement in the SFTMW.

These options were evaluated by each work group in concert with other work groups and the plan economist, and then a recommended program of projects and activities was presented to the Steering Committee, so that an appropriate level of service could be determined for inclusion in the plan.

In most cases, a service level above current management activities was recommended to correct identified deficiencies, however, a substantially increased level of management activities was only recommended where staff clearly determined it to be in the long-term best interest of SPU and its ratepayers.

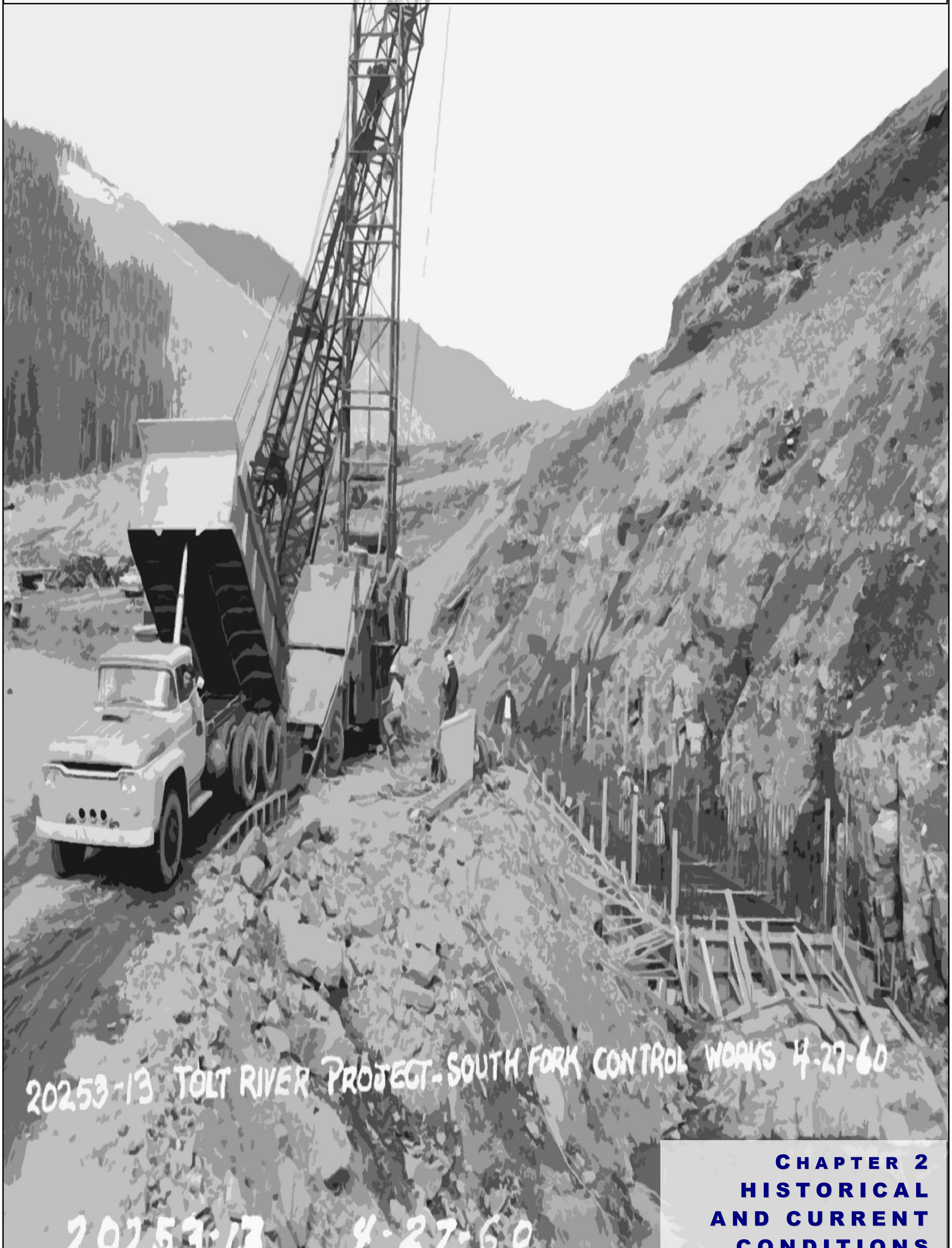
A stakeholder/tribal outreach program was conducted in conjunction with developing the

Modeling of forest options indicated that revenues from a commercial forestry option or a hybrid commercial/ restoration option would not be enough to outweigh environmental benefits of the restoration option.

Plan. This program consisted of the following elements:

- Identification of tribes/stakeholders
- Individual interviews with each interested tribe/stakeholder
- Stakeholder meetings and presentations to stakeholder groups as requested
- Field tours for interested tribes/stakeholders
- Website with downloadable project documents
- Periodic email updates
- Opportunity for review and input on draft South Fork Tolt Municipal Watershed Plan

Approval of the final South Fork Tolt Watershed Management Plan will consist of review and approval by the SPU Asset Management Committee and the Director of SPU. State Environmental Policy Act (SEPA) review will be completed prior to final approval, providing an additional opportunity for tribes, stakeholders, and the general public to provide comment on the Plan.



CHAPTER 2 HISTORICAL AND CURRENT CONDITIONS

CHAPTER 2.
HISTORICAL AND CURRENT CONDITIONS

WATERSHED LOCATION AND GENERAL DESCRIPTION

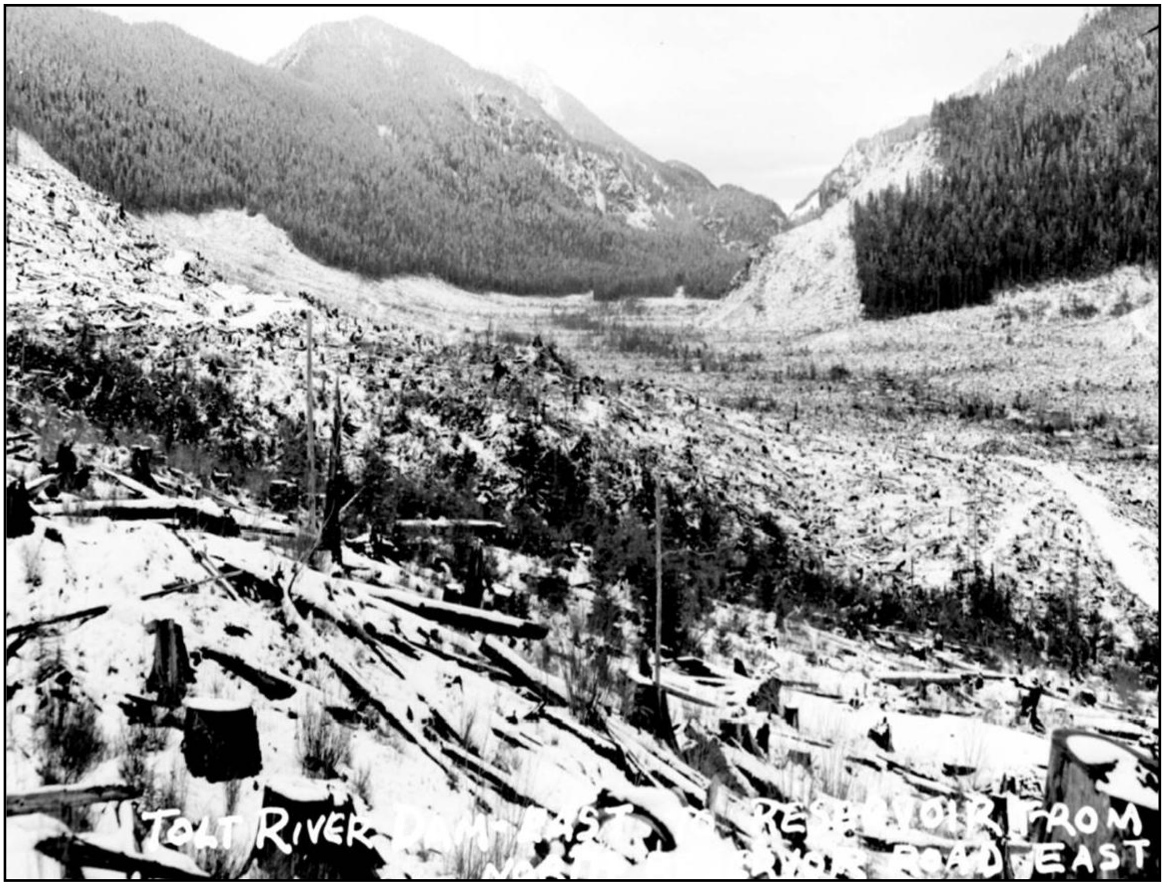
Located on the western slope of the Cascade Range in Washington State, the SFTMW is 35 miles east of Seattle, near the towns of Carnation and Duvall. The SFTMW encompasses the 12,107-acre drainage area upstream of the South Fork Tolt Dam (elevation 1,765 feet). As discussed in greater detail below, the western 8,339-acres (approximately 70 percent) of the municipal watershed are City-owned and managed, and the eastern portion (3,708 acres) of the watershed lies within the Mt. Baker Snoqualmie National Forest (MBSNF) and is managed by the USFS. The watershed varies from 1 to 3 miles wide (north-south) and is 8 miles long (east-west), with a U-shaped valley characteristic of glaciated mountain drainages. The South Fork Tolt headwaters are among 3,000 to 5,500-foot Cascade mountain peaks, with steep valley walls descending to the wide valley floor. The humid mountain climate of the region brings most of the annual precipitation during the winter as snow, with rain/snow mix in the lower elevations. This climate supports a predominantly coniferous forest, which is currently recovering from extensive logging that occurred in the mid-twentieth century on land that was then privately owned but is now City-owned land.

HISTORICAL CONTEXT

Early Human Uses of the SFTMW

The earliest known human uses of the Tolt River watershed were by Native American Indian tribes and early European residents. These early inhabitants left evidence of their use that provides information on how they interacted with the local environment, how that environment changed over time, and how they interacted with others in other areas. In the entire Tolt River watershed (~63,000 acres including the North Fork, all of the South Fork Tolt above and below the South Fork Tolt Dam, and the main stem Tolt River), there are 15 documented archaeological and historic sites and isolates, including two hunter-gatherer sites and one historic structure on SPU property. There are also 30 documented historic use and ethnographically recorded sites, with archaeological components unknown. One is the village site, Stuwe'yuqW, at the confluence of Stossel Creek and the Tolt River, near the archaeological site at the Tolt Filtration Plant solids disposal area. Three recorded trails pass through the greater Tolt River watershed. However, within the SFTMW, there is record of only one historic trail (see Map 18). While physical evidence of this trail has not been found to date, its documented presence indicates a higher probability of artifacts or other archeological/cultural features.

Watershed
A region defined by patterns of stream drainage; a watershed includes all the land that contributes water to a particular stream or river.



Clearcut of the Reservoir Basin in 1959.

A lone artifact, identified as a prehistoric scraper, was recorded by the U.S. Forest Service (USFS) on the exposed lakeshore of Crater Lake, within the USFS-owned portion of the SFTMW. As the trail within the SFTMW heads toward Crater Lake, the isolate would seem to indicate that this trail was in use by native people in the area.

Land Ownership and Uses/Development of Water Supply

Initial pioneering ownership of the SFTMW was split among Washington State, the Mt. Baker-Snoqualmie National Forest, and the Weyerhaeuser Company (Morse, 1960). The property owned by Weyerhaeuser was part of the Snoqualmie Tree Farm, which was under the company's ownership for more than 100 years.

The City of Seattle purchased its water rights to the Tolt River drainage basin from the Mountain Water Company in 1936. At that time, no infrastructure existed for diversion, conveyance, or distribution of the water, and the City did not own land in the Tolt watershed.

Logging by the Weyerhaeuser Company in the reservoir area began around 1946. Starting in 1953, Weyerhaeuser began voluntarily removing timber in the bottom-land forested portion of the basin on both its own land and state-owned land in preparation for the future Tolt reservoir. Intense logging within the reservoir area occurred between 1953 and 1957 (Tyler, 1960). Timber harvest by Weyerhaeuser continued over much of the municipal watershed until the mid-1990s. Some timber harvest has also occurred on USFS-owned lands in the municipal watershed.

An extensive forest road system was constructed to support logging activities and construction of the water supply infrastructure. Although these roads probably met the standards of that time, many are considered inadequate for resource protection by today's standards. To partially address this problem, the City has decommissioned approximately 25 miles of unnecessary roads to date, leaving approximately 30 miles of road remaining in the basin today.

The watershed provides up to 100 million gallons of drinking water each day.

In 1959, an agreement known as the "Watershed Operations Agreement" was executed between Weyerhaeuser and the City for the exchange of 1,400 acres of land to be used for the South Fork Reservoir and pipeline construction. The agreement gave the City the right to control access, enforce trespassing laws, and impose sanitation regulations. The agreement also stated that Weyerhaeuser must conduct logging in an environmentally sensitive manner that would not cause unreasonable turbidity, siltation, or erosion. Shortly thereafter, on February 25, 1959, a contract was awarded to Strong Macdonald to remove remaining tree stumps and debris, which the City believed would taint the taste of the water. Macdonald removed the stumps and burned all material that could float.

Following dam construction in 1963, the resultant reservoir inundated several miles along the former main stem of the South Fork Tolt River, as well as the lower portions of numerous tributary streams. The lower portions of Consultant and Crystal creeks were diverted away from the immediate area of the dam to better facilitate dam operation. The City began diverting municipal-supply water from the South Fork Tolt River in 1964. To ensure source water protection, the City established a no-public-access policy for the City-owned lands within its municipal watersheds, including the SFTMW.

The South Fork Tolt Reservoir is the primary storage reservoir in the Tolt water system, holding 18.3 billion gallons (56,160 acre-feet) of water at maximum operating level. From the intake structure in the reservoir, water flows by gravity for 4.8 miles through piping to a Seattle City Light hydroelectric facility and then through a pipeline to the Regulating Basin (see Figure 2-1). The Regulating Basin provides storage and reduces pressure in transmission pipelines. Approximately 1.5 miles downstream from the Regulating Basin, water passes through the water filtration and treatment facility. The filtered and treated water then enters a large-diameter transmission pipeline system for distribution to SPU's service area. The SFTMW watershed provides up to 100 million gallons of drinking water each day.

The reservoir intake structure also delivers water to the base of the dam to meet stream flow requirements and to protect instream resources in the South Fork Tolt River downstream of the reservoir. At the Seattle City Light hydroelectric facility, water can also be routed to the river at approximately river mile 2.3.

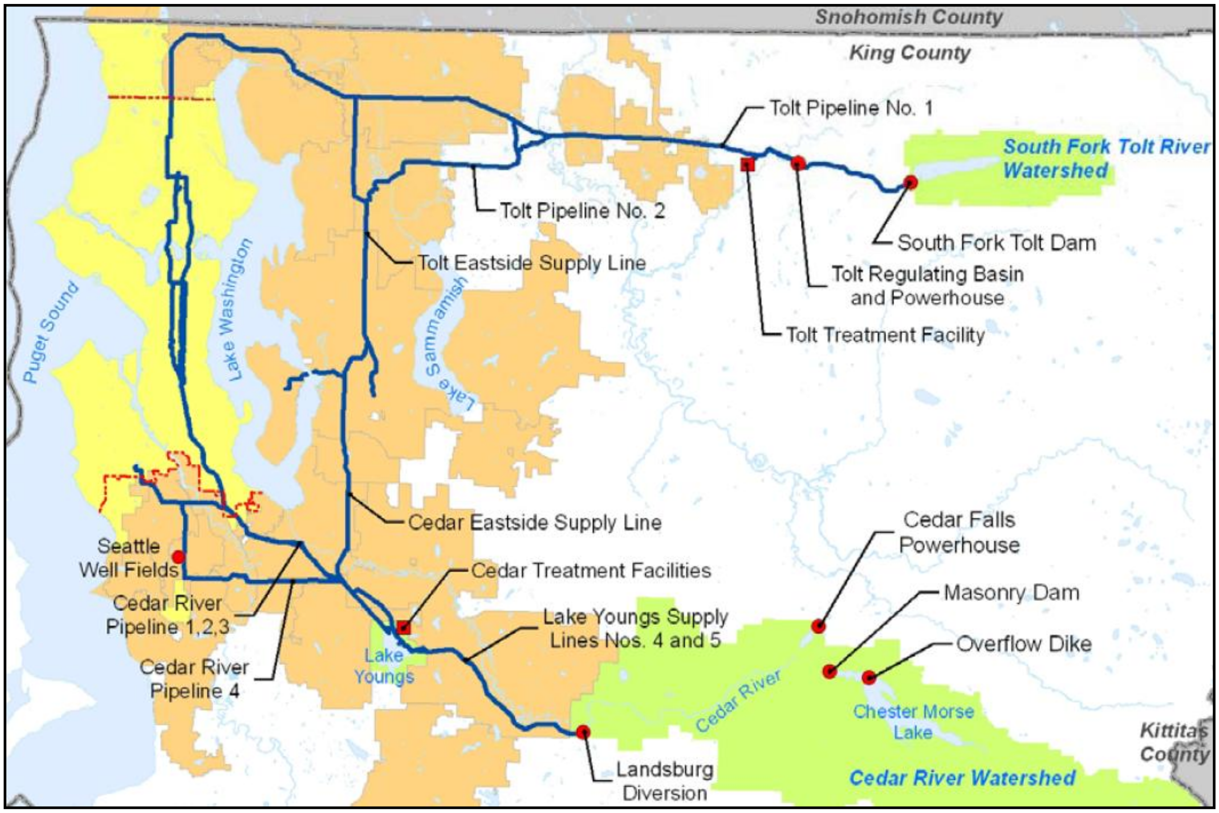


Figure 2-1. Seattle Regional Supply System Overview.

In 1988, Seattle City Light obtained a Federal Energy Regulatory Commission (FERC) license to construct the South Fork Hydroelectric Project to generate electricity using the water flow from the South Fork Tolt Reservoir (FERC Project Number 2959; expiration July 2029). The hydroelectric project started producing electricity in 1995. It generates an average of 8.4 megawatts and is fully automated and remotely controlled.

The City of Seattle completed negotiation for acquisition of all Weyerhaeuser-owned lands in the SFTMW in 1997, through a land exchange with the Weyerhaeuser Company for some of the City's real property holdings in the North Fork Tolt River basin. SPU currently owns 68.9 percent (8,339 acres) of the SFTMW. The USFS manages 30.6 percent (3,708 acres) of the basin area east of the reservoir, within the Mt. Baker-Snoqualmie National Forest (MBSNF). Hancock Forest Management, Inc. owns the remaining 0.5 percent (60 acres; formerly owned by the Weyerhaeuser Company) (see Map 4).

Neighboring Property Ownership and Uses

The City maintains a working relationship with two major neighboring landowners: the USFS and Hancock Forest Management, Inc., which purchased the Snoqualmie Tree Farm from Weyerhaeuser in 2003.

National Forest System Lands

National Forest System lands within the SFTMW are managed to be consistent with the 1990 Mt. Baker-Snoqualmie Forest Plan

(USFS, 1990), as amended. National Forest System land designations in the SFTMW are shown on Map 4. Most of the National Forest System land in the SFTMW is designated Alpine Lake Management Area 27 (MA 27) – Dispersed Recreation (2,517 acres), which generally includes passive forest recreation outside of developed sites with modern facilities where concentrated use occurs. Other allocations include: Riparian Reserves (which overlap about 50 percent of the land area); Administratively Withdrawn MA 27 – Special Area (373 acres); Late-Successional Old-Growth (259 acres); Matrix MA 27 – General Forest (449 acres), and Matrix MA-27 – Scenic Forest (110 acres). Only the 569 acres of Matrix MA 27 – General and Scenic Forest land allocations are available for timber harvest.

In the Mt. Baker-Snoqualmie Forest Plan, Management Area Prescription Number 23 (Other Municipal Watersheds) requires that the USFS manage "small municipal watersheds" to "provide water at a level of quality and quantity, which, with treatment by the purveyor, will result in satisfactory and safe water supply with varying emphasis on timber production, recreation, and other uses." The prescription allows moderate recreation and limited timber harvest. No timber harvest or other construction-related ground-disturbing activities are currently proposed. (D. Schrenk, USFS, Personal Communication, March 5, 2008).

No timber harvest or other construction-related ground-disturbing activities are currently proposed.

USFS land designations in the SFTMW prohibit or greatly restrict road-building and timber harvest. Federal road construction and maintenance activities must meet water quality and other environmental protection objectives, as mandated by the MBSNF Forest Plan. About a half-mile of the USFS Money Creek Road penetrates from the east into the SFTMW, and is used seasonally for public access (Map 3). There is no gate or signage at the SFTMW's boundary indicating the presence of a municipal water supply watershed. No maintained foot trails exist on this federal land. User-made trails to the Damon Mine site and the Morning Star Mine site near Crater Lake are used by the public, but they are not maintained. The public visits entrances to both mines, which are currently not secured.

Aside from those two areas, access across this federal land requires foot travel through steep, difficult terrain. Camping is evidenced both at Crater Lake and at the Damon Mine entrance. SPU anticipates that fire suppression on federal lands would rely on water delivered by helicopter.

There are about seven active mining claims on the USFS land. None are currently being worked, but at least one claimant filed an application with the USFS in 2003 to extract mineral ores. The applicant eventually modified the application to exclude mining activity in the SFTMW.

Hancock Forest Management, Inc.

Most of the land contiguous with the west half of the SFTMW is owned and managed for commercial forest products by Hancock Forest Management Inc. The City and Hancock share numerous roads to access their land holdings in the SFTMW and nearby areas (see Map 5). This shared road use and conduct of parties while passing through neighbor lands (including sanitation, control of access, and fire protection) are formally addressed through two agreements, the Watershed Operation Agreement and the Road Use Agreement. Prior to construction of the Tolt water supply project in 1959, the City entered into these two agreements with Weyerhaeuser, which owned the tree farm at the time. The agreements are still in effect today, having presumptively passed from Weyerhaeuser to Hancock via the land sale.

Weyerhaeuser Corporation

When Weyerhaeuser sold the Snoqualmie Tree Farm to Hancock Forest Management in 2003, they appear to have reserved mineral rights to some or most of the exchange lands inside the SFTMW and all of the Snoqualmie Tree Farm. Although the legalities of this arrangement are not entirely clear at this time, this may give Weyerhaeuser right to activate subsurface mining claims in the City-owned portion of the SFTMW.

NATURAL ENVIRONMENT

Geology and Soils

The SFTMW was formed by periods of alpine glaciation, the most recent of which reached its maximum extent 20,000 years ago (Bethel, 2004). The South Fork Tolt valley generally has a U-shaped cross section with long, steep sidewalls, typical of glaciated mountain valleys. Steep sidewalls are found in many of the smaller tributary valleys as well. Slopes in most of the SFTMW range between 60 and 85 percent. Historically, the upper South Fork Tolt River flowed through this relatively broad, low-gradient glacial valley. Most lands in the SFTMW have moderate to high erosion potential because of the steep topography, though the forest cover provides some stability.

Volcanic processes have also affected the area, producing faulting and mountainous terrain. Most rocks and soils in the area are of volcanic origin. Bedrock generally underlies the side slopes of the valley and the valley is floored with glacial deposits. The soils in the SFTMW are geologically young and consist mostly of loamy sand and sandy loam with some rocky outcrops.

Aquatic Resources

The climate of this region is dominated by the North Pacific low pressure system in the winter and by the Pacific high pressure system in the summer. Most of the annual precipitation takes place in the winter, and clear mild weather prevails in summer. Precipitation during winter is enhanced by forced upward movement of air over the Cascade Range, with 150 to 200 inches of precipitation annually.

Aquatic Features

Twenty-one tributary subbasins have been delineated within the SFTMW (see Map 14). Major tributaries to the South Fork Tolt Reservoir include the main stem South Fork Tolt River (including Phelps Creek), and Skookum and Siwash creeks. Consultant, Rainbow, Horseshoe creeks and numerous unnamed drainages enter the reservoir from its north side, while Crystal, Dorothy, Siwash, Chuck Judd, Skookum, and several unnamed creeks enter the reservoir from the south. In late spring and early summer, stream flow in the SFTMW is dominated by snowmelt. At upper elevations there may be patches of snow until late summer. There are 11.6 miles of documented fish-bearing streams in the watershed (including National Forest System lands), almost all of them in lower gradient portions in the lower portion of the municipal watershed.

More than 78 percent of the total length of streams consists of small, steep (>8 percent gradient) tributaries. Adjacent landslides and soil creep combine with high flows and bank erosion in these steep gradient channels as the primary processes controlling transport and sediment delivery. Natural areas of instability are largely associated with the steep, rocky slopes of glacially carved hollows and valley sidewalls, mainly on the south side of the valley.

There are 11.6 miles of documented fish-bearing streams in the watershed, almost all of them in lower gradient portions in the lower portion of the watershed.

Reconnaissance surveys of the SFTMW indicate very few wetlands in the steep terrain of the basin. Wetland habitat is limited to areas associated with the delta area of the South Fork Tolt River at the eastern extent of the South Fork Tolt Reservoir, several small depressional wetlands on topographic benches along the south ridge of the SFTMW, and meadow systems in the headwater areas of the main stem South Fork Tolt River.

Lakes in the SFTMW include the South Fork Tolt Reservoir and Crater Lake. The South Fork Tolt Reservoir has a maximum size of about 1,080 acres at full level, which diminishes as the reservoir water level goes down. Typically, lake level is highest in the spring following snowmelt and declines through the summer, and early fall. Water level in the reservoir varies in the winter, as it is managed to balance water storage with flood control. Crater Lake is a 17-acre lake set within a glacial cirque at the eastern end of the watershed at an elevation of 3,500 feet.

Road Impacts, Landslide History, and Restoration Efforts

Streams and wetlands in the SFTMW have been impacted to varying degrees by past logging activities such as road building. These activities affected watershed processes such as sediment delivery, riparian conditions and recruitment of large woody debris (LWD), all of which directly affect aquatic habitat and resources.

The forest road system in the SFTMW has historically had a major impact on aquatic resources. In many locations, road drainage was not adequate, cross-drains were not installed to relieve ditch water, and stream crossings were too small. Inadequate hardening of slopes below culvert outfalls often contributed to erosion and gully formation. Log cribs were frequently used instead of culverts to pass water beneath roads, resulting in road failures at stream crossings when logs decayed and later failed. Roads were commonly bulldozed across steep slopes, leaving over-steepened side-cast material and roads with potentially unstable subgrades. Landings were constructed on steep slopes, often perched over streams and frequently overloaded with logging debris covered by loose fill material.

The result of these practices has been many landslides into the South Fork Tolt reservoir that continue to contribute coarse sediment, the creation of barriers to the movement of fish and wildlife, and chronic sediment delivery of road-generated fine sediment to streams and the reservoir. As such, the road network has contributed significantly to degradation of stream habitat, as well as reservoir infilling.

Since the 1990s, a wide range of restoration projects have been implemented throughout the Tolt River basin. Many of these projects were identified in the 1993 watershed analysis (Weyerhaeuser, 1993), and over 35 projects have been completed, or are in progress. These projects have included culvert replacement and repair, road decommissioning (approximately 29 miles), reconnection of side channels, construction of side channels, and riparian planting. The projects have taken place in both the main stem of the South Fork Tolt River and its tributaries. SPU has also substantially improved the road network and addressed maintenance needs to reduce the adverse impacts of the road network on aquatic resources and water quality.

The success of these restoration efforts is apparent in the SFTMW. The number of landslides and debris flows in the SFTMW has decreased significantly since the 1980s, while rates in the larger Tolt River watershed have leveled off or increased slightly (Ward, 1998). The vegetation canopy over impacted channels has closed on all but the largest tributaries, though the amount of large woody debris in affected channels will likely lag behind canopy closure due to a history of streamside riparian harvest, logging slash removal, and debris flow in these high energy streams.

Since the 1990s, a wide range of restoration projects have been implemented throughout the Tolt River basin.

The SFTMW has experienced only one known landslide since 1997, and given that the majority of previous landslides were associated with roads, the program of road closures appears to be effective in reducing and potentially eliminating most landslides. These results suggest that current landslide rates may be approaching natural or background rates in the SFTMW.

Vegetation

Forest Resources

The climate of the western Cascades supports predominantly coniferous forests in the SFTMW. These forests can be separated into elevation bands, with associated forest zones based on the dominant tree species:

- The western hemlock zone is below 2,400 feet elevation
- The Pacific silver fir zone is between 2,400 and 3,500 feet elevation
- The mountain hemlock zone is above 3,500 feet elevation.

Forests have moderate to low productivity, accumulating high amounts of biomass above and below ground, partially due to low decay rates in cold mountain climates. Old-growth forests in this environment typically reach ages between 300 and 600 years, developing complex horizontal and vertical structures, often ultimately dominated by shade tolerant species. Disturbances to the forest include infrequent stand-replacement fires and small-scale disturbances such as wind, insects, and

By the time that harvesting of old-growth forests ended in the 1990s, three-quarters of the forest in the SFTMW had been harvested.

pathogens, which interact in forests to create complex canopy structures. Understory vegetation is dominated by ferns, shrubs, and mosses. Epiphytic lichens and mosses are found in the overstory. Riparian forests occur along the streams in the valley bottom, where deciduous tree species predominate in frequently disturbed and moist sites. Steeper rocky slopes in the upper basin retain sparse conifer coverage and are dominated by shrub vegetation.

By the time that harvesting of old-growth forests in the SFTMW ended in the 1990s, three-quarters of the forest in the SFTMW had been harvested. Regeneration of secondary forests was slow, except in the valley bottom, and large areas on the south side of the basin remain in early-successional stages due to shallow soils and severe growing conditions. While most of the forest regenerated from natural seed sources, there is evidence of aerial seeding on the north side of the reservoir. The remaining old-growth forests in the City-owned portions of the SFTMW, about 400 acres, are located on steep rocky slopes in the upper reaches of the basin.

The age of second-growth forests reflects the recent harvest history, and ranges from 10-year-old stands on higher elevations sites to 55-year-old stands at lower elevations. Because of the difficult growing conditions in steep rocky areas, new trees may not have begun growing for 15 years or more following harvest.

Based on a recent inventory (Atterbury, 2006), the forest in the SFTMW can be generalized as a homogenous second-growth coniferous forest. Western hemlock, Pacific silver fir, and Douglas-fir are the dominant species. Many stands have high tree densities with little ground covering understory vegetation. This exacerbates the lack of forest complexity integral to a healthy forest habitat.

The management of forest of the City-owned portion of the SFTMW contrasts with the management of forest on neighboring lands. Lands owned by Hancock Forest Management, Inc. to the north, south, and west are intensively managed for timber products at lower tree density. The forest lands to the east are managed by the USFS and are predominantly old-growth forest and sub-alpine shrub vegetation.

Invasive Plant Species

Currently, yellow hawkweed (*Hieracium caespitosum*) and tansy ragwort (*Senecio jacobaea*) are the only invasive species documented in the SFTMW that are addressed by invasive species control regulations. However, comprehensive surveys have not been conducted for either these two species or for other invasive species.

Invasive species
Non-indigenous plant or animal species that adversely affect the habitats they invade economically, environmentally or ecologically.

Yellow hawkweed has been discovered at several locations in the SFTMW since 1998 (see Map 6). Various control methods have been employed, including the following:

- Hand pulling during flowering, prior to seeding;
- Covering with geotextile (for small patches where disturbance is unlikely);
- Herbicide application; and

- Underplanting with conifer seedlings to encourage long-term ecological control.

Site-specific conditions dictate the most effective control approach, and often a combination approach works best.

No surveys have been conducted for other invasive species in the SFTMW, but SPU staff have observed some species incidental to other work. Occasional tansy ragwort plants have been seen and pulled near the reservoir. In addition, some invasive species that could cause ecological damage, but are not legally required to be controlled, have been observed, but not mapped or controlled. These include evergreen blackberry (*Rubus laciniatus*), Himalayan blackberry (*Rubus discolor*), Scots broom (*Cytisus scoparius*), bull thistle (*Cirsium vulgare*), and Canada thistle (*Cirsium arvense*). Most of these plants have been seen along the roads adjacent to the reservoir.

Fish and Wildlife

Habitat available for fish and wildlife in the City-owned portion of the SFTMW includes young forest (the predominant habitat type), remaining old-growth forest (about 400 acres), the reservoir, and various special habitats such as rock outcrops, cliffs, talus slopes, meadows, wetlands, and shrub-dominated sites. Available forest habitat was profoundly altered from the old-growth forest conditions that would be natural for this watershed, leading to a lack of old-growth-dependent species in the SFTMW.

The South Fork Tolt Reservoir provides one of the few undisturbed lake environments in western Washington where loons can reproduce without high levels of human activity and associated disturbance.

Wildlife

Old-growth-dependent species such as northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and northern goshawk (*Accipiter gentilis*) are not known to occur on the City-owned land within the SFTMW, although the first two have been documented on USFS-owned land within the SFTMW.

While deer are known to inhabit the SFTMW, the Washington Department of Fish and Wildlife (WDFW) has no documented records of elk being present in the entire South Fork Tolt basin, either historically or at present. Deer densities are relatively higher in adjacent ownerships that are managed under commercial, short-rotation harvests than on City-owned land where the forest is presently dominated by dense conifer regeneration.

The South Fork Tolt Reservoir provides one of the few undisturbed lake environments in western Washington where common loons can nest without high levels of human activity and associated disturbance. SPU staff annually deploy and monitor an artificial nesting platform to aid the loons in overcoming the difficulties of water level fluctuations. Since 2002 the nesting platform has been used annually by a nesting pair. Although chicks have typically hatched on the platform, survival after leaving the nest for open water has not been high due to predation, or other natural causes.

A variety of amphibian species depend upon the small ponded depressional wetlands in the SFTMW for breeding and rearing habitat. No ongoing threats to habitat integrity exist at wetlands in the SFTMW.

Fish

The fish community using habitat within the SFTMW upstream of the reservoir is relatively simple, consisting of cutthroat trout (*Oncorhynchus clarki*), cutthroat/rainbow (*O. clarki/mykiss*) hybrids, and torrent sculpin (*Cottus rhotheus*).

West-slope cutthroat trout, a subspecies that is native to portions of the Columbia and Missouri river basins, was introduced to the SFTMW through stocking of Crater Lake at the headwaters of the South Fork Tolt River (Wild Fish Conservancy, 2007).

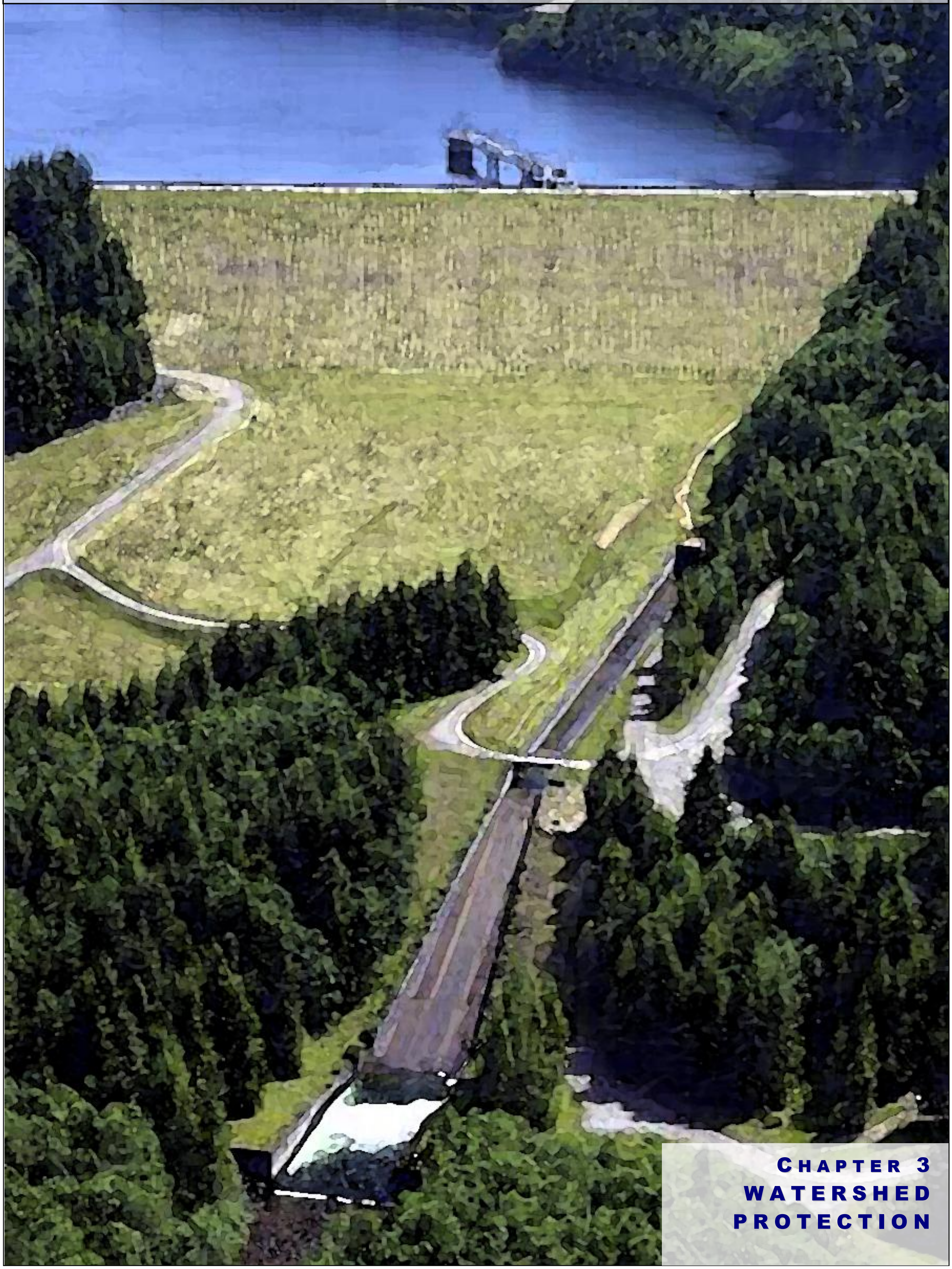
Existing survey data indicates that fish use is limited primarily to the reservoir and lower reaches of tributary streams, although the upper limit of salmonid distribution has not yet been definitively determined. Anadromous salmonids cannot use this portion of the Tolt River Watershed, as a steep gorge downstream of the dam serves as a natural barrier to upstream fish migration (Williams, et al., 1975).

Seattle Public Utilities

South Fork Tolt Watershed Management Plan

PART 2.
TECHNICAL MODULES

June 2011



CHAPTER 3
WATERSHED PROTECTION

CHAPTER 3.
WATERSHED PROTECTION

Maintaining and protecting source water quality and quantity for municipal water supply and downstream ecosystems in the SFTMW is a fundamental goal for SPU in its management of the SFTMW (Goal 1). Watershed protection includes many facets that can be generalized as the following categories:

- Fire prevention and suppression;
- Access and control to the watershed;
- Emergency and incident response;
- Monitoring source water quality and quantity; and
- Coordination with neighboring landowners.

Maps 2 and 3 show the water delivery infrastructure and security infrastructure, respectively, in the municipal watershed and downstream.

CURRENT CONDITIONS

Fire Prevention and Fire Response

SPU considers the mantle of vegetation in its water supply watersheds to be an integral component in the production and protection of the City's water supplies. As such, the City has determined that catastrophic forest fires pose substantial risks to water quality and quantity. Fire prevention and suppression are of paramount importance.

The major causes of forest fires in this region are lightning, logging operations, and unattended campfires. Risk of human-caused forest fires in the SFTMW is lowered substantially by the fact that the area is closed to the public.

Watershed protection personnel monitor weather conditions, industrial fire safety precaution levels (IFPL's), and watershed activities daily. These activities ensure that fire regulations are being followed, required fire fighting tools are on hand, and no hazardous conditions exist at the site. SPU is required to be in full compliance with Washington industrial fire protection regulations at all times. Open and broadcast burning are not allowed in the City-owned portion of the SFTMW at any time.

Fire emergencies are

Highlights

Security and protection in the SFTMW are provided by SPU's Watershed Protection Section. Current resources for security and protection do not achieve compliance with SPU and industry standards.

SPU owns about 70 percent of the SFTMW, and the City has no certainty and only limited effective control over future land use decisions on adjoining lands.

Actions recommended in this watershed management plan are as follows:

- Prepare a security and protection plan;
- Increase signage;
- Improve access and control;
- Replace nine existing gates that do not meet SPU security standards;
- Install six new security gates;
- Increase staff presence for patrols, incident response and monitoring;
- Stage a trailer with fire-fighting equipment and emergency response equipment at Vista House;
- Provide 10 semi-permanent and 10 mobile portable toilets;
- Complete the analyses of options, risk, cost, benefit and feasibility related to federal lands and associated mining claims; and
- Develop a strategy for meeting with Hancock and/or Weyerhaeuser with the intent of replacing the existing watershed operation agreement and road use agreement with a single new agreement.

handled initially by the SPU Wildland Fire Team, and then taken over by the Washington Department of Natural Resources (WDNR) or its contractors, at which time the City provides a support role, as required by WDNR. Fire-fighting aircraft are allowed to draft from water sources (such as reservoirs and lakes) in the watersheds only during critical situations and only with SPU's prior approval by SPU's Watershed Services Division Manager. SPU pays an annual Forest Patrol Assessment Tax to the WDNR for this fire protection on its lands in the watersheds. Details about fire response protocols are documented in the annual SPU Fire Response Plan and the *SPU Wildland Fire Team Handbook.*

Watershed Access Control, Sanitation Facilities, Protocols for Human Activities in the SFTMW

Gates and Boundary Marking

The SFTMW has locked gates at all roads that lead beyond administrative boundaries. Perimeter gates are kept locked at all times regardless of activity on the road system. If numerous vehicles will be passing through a gate, requiring that the gate be left unlocked, a gate guard must be provided by SPU or by the permitted party involved to provide security. This requirement is arranged prior to permit approval and typically is the responsibility of the consultant or contractor.

Watershed protection personnel are responsible for dealing with gate and lock problems as they occur. Vandalized locks, missing locks, and missing chain sections are replaced, and the gates, if damaged, are secured until repairs can be made. Watershed protection staff maintain an inventory of locks on each gate. Any lock that is added or removed from any gate is recorded in the inventory.

The Tolt system has approximately 4 miles of fenced boundary; most of it in areas close to roads, gates, or other areas with human activity. Limited fencing consists of steel or cement posts and three-strand barbed wire. Watershed inspectors inspect fence segments when possible, looking for broken posts, cut or broken wires, and trees down on the fence. Repairs are made as needed. Most of the fence lines are adjacent to or near roads inside the administrative boundary, allowing easy access for inspection and maintenance.

In unfenced areas of the SFTMW, boundaries are not clearly delineated on the ground and signs are no longer clearly visible, making it difficult to determine property lines. Due to a shortage of staff, the Tolt watershed has not been posted to adequately enforce no trespassing laws for many years or advise would-be trespassers of the property lines.

In unfenced areas of the SFTMW, boundaries are not clearly delineated on the ground and signs are no longer clearly visible, making it difficult to determine property lines.

Sanitation

No permanent septic or mobile sanitation facilities exist upstream of the City's Tolt raw water intake. Vista House, a structure located just above the South Fork Tolt Dam, has a septic system located below the dam, removing it from sanitation concern associated with the City's water supply.

Several portable toilets are stored downstream from the dam and are available for temporary placement near remote work sites in the SFTMW. A commercial contractor pumps and services these toilets on a regular basis.

Watershed protection personnel conduct sanitation education for persons with authorized access and enforce the use of SPU sanitation standards and the sanitation elements of all water quality protection plans on a very limited basis. The regular maintenance of permanent and temporary sanitation facilities is currently the responsibility of the Transmission crew assigned to the Duvall Shop.

Emergency and Incident Response

Routine security and surveillance patrols are an essential element of active defense against unauthorized public access. Patrols detect unauthorized trespassers and/or vehicles and survey for secured gates and operable locks, vandalism, fire protection, emergency situations, and any conditions that may adversely impact water quality such as plugged culverts, damage from a severe storm event, or fallen trees blocking roads. They must also monitor critical infrastructure and assets. Routine surveillance of watershed lands is conducted by foot, vehicle, boat, bicycle, and air.

Protection staff currently document incidents by a variety of methods, including a daily incident log and web-based incident management software (SPU standard). The nature of the incident determines the reporting mechanism. For example, a medical emergency requires a full report in both locations, whereas a response to a report of high turbidity in a stream would likely only be entered into the written log.

Watershed Protection staff are the first line of defense when it comes to emergency response in the municipal watershed.

To be compliant with the National Incident Management System, the City has adopted the Incident Command System (ICS) for dealing with all emergencies. In an emergency situation, ICS replaces the “normal” day-to-day organization with an emergency organization that incorporates on-hand personnel during the emergency and establishes clear lines of responsibilities and chain of command. ICS is intended to avoid conflicts among different organizations and work units during emergencies and to integrate appropriate responses by all participants, making for a more efficient and effective response. This system is widely used throughout the United States and has proven to be effective in dealing with emergencies such as fires, floods, earthquakes, malicious attacks, and hazardous material spills.

Specific plans and protocols have been established for SPU staff in order to respond to emergencies such as wildland fires, dam failure, failing or damaged treatment facility infrastructure, collapsed or eroded roads, fallen trees blocking roadways, damaged power lines, hazardous materials, and medical situations. SPU’s plan for response to wildland fires is clearly laid out in its *Wildland Team Handbook.*

Watershed Protection staff are trained in wildland fire fighting, emergency medical services, technical rope rescue, swift-water rescue, and hazardous spill response. They are the first line of defense when it comes to emergency response in the municipal watershed, especially considering its remote location, gated access and the inability of local emergency medical and fire services to provide a timely response.

Watershed protection staff patrol roads on a limited basis during storm or flood events to determine the condition of bridges and drainage structures, and to see that ditches and culverts are operating properly and are not blocked or overwhelmed. After floodwaters recede, most roads and structures are inspected for damage, and repairs are made as needed.

In protecting the raw water supply, SPU monitors watershed reservoirs and streams to detect problems and trends in water quality.

Monitoring Source Water Quality and Quantity

The primary function of SPU's municipal watersheds is the reliable production of high quality drinking water. In protecting that raw water supply, SPU monitors watershed reservoirs and streams to detect problems and trends in water quality. Long-term research provides a basis for making resource management decisions that will better protect or improve water quality. Research, monitoring, and analysis provide information for four purposes: (1) operational decision-making, (2) regulatory compliance, (3) addressing special concerns, and (4) long-term management planning. Data collection work needs to be carried out to meet FERC guidelines, provide data to SPU water operations and supply, and meet SPU dam safety policies.

FERC
The Federal Energy Regulatory Commission; FERC regulates the interstate transmission of natural gas, oil, and electricity, as well as natural gas and hydropower projects.

Routine water quality monitoring programs and hydrological data collection are typically carried out by staff from different SPU divisions, including Watershed Protection, Transmission Operations, and Water Quality. These tasks include compliance monitoring, routine sampling for fecal coliform bacteria, storm event monitoring, deep water sampling, groundwater monitoring via automated piezometer wells, SNOTEL truth sampling, daily weather data collection, and lake level readings.

Coordination with Neighboring Landowners

As discussed in Chapter 2, the City shares borders with three major neighboring landowners:

- The USFS oversees public ownership of 3,708 acres in the upper SFTMW. SPU has no specific agreements with the USFS that restrict or otherwise modify use of federal land within the municipal watershed now or in the future. In some cases, the City has had opportunity to influence the content of federal laws and regulations directly or affect the manner in which legal requirements were implemented to protect water quality. For example, when faced with the threat of oil, gas, and geothermal exploration in its municipal watersheds, the City and other local water purveyors were able to gain passage of a federal law (Public Law 97-350, October 18, 1982) prohibiting issuance of oil and gas leases on federal land in the Tolt and Cedar watersheds, and restricting sales or exchange of these lands for activities incompatible with production of drinking water.

- Hancock Forest Management, Inc. owns most of the land contiguous with the west half of the SFTMW. SPU and Hancock Forest Management still require use of each other's road systems to access their lands in and around the SFTMW. This includes a limited number of roads within the SFTMW that provide Hancock with the only practical access to some of its property.
- Weyerhaeuser Corporation appears to have reserved mineral rights to some of the land previously owned by Weyerhaeuser in the SFTMW.

LEGAL REQUIREMENTS

Legal requirements for protection of the City's SFTMW arise from several areas of federal and state regulation. The overarching requirements for protecting the drinking water supply arise from the federal **Safe Drinking Water Act**, which the Washington Department of Health administers. Numerous regulations and guidance documents have been developed to assist utilities such as SPU to provide adequate levels of protection to guard against bacterial contamination and other degradation to its water supply. Because the Cedar is a non-filtered water source while the Tolt is a filtered water source, requirements vary between SPU's two major watersheds.

Because the dam is a Federal Energy Regulatory Commission (FERC) facility, SPU must comply with FERC regulations.

Washington Department of Natural Resources (WDNR) Forest Practices Act (WAC 332-24) guides SPU fire prevention and response actions.

Homeland Security regulations require some actions by the City, such as implementing the National Incident Management System during emergencies.

Numerous laws and regulations associated with land ownership impact SPU's projection needs, constraints, and actions, including mining laws.

ISSUES

A thorough review of the current watershed protection program in the SFTMW and consideration of needs under the future management program recommended by this Plan revealed the issues presented below.

Fire Prevention

The limited forestry operations recommended under this Plan (primarily ecological and restoration thinning) will increase the risk of human-caused fires in the SFTMW. A fire prevention program, similar to that which exists in the Cedar River municipal watershed, is recommended to mitigate this increased risk as human activity increases in the SFTMW. The current facilities and level of service in the SFTMW are inadequate in the following areas:

- Industrial Fire Precaution Level (IFPL) signage does not exist at all SFTMW entry points to inform contactors of daily fire danger level.
- Staffing is not available to perform fire patrols on "Level 4" days when the WDNR has implemented a forest closure due to extreme fire danger and the

increased risk of a fire start caused by continuing activities. The lack of personnel in the South Fork Tolt watershed on such days, as well as the lack of fire-fighting equipment, leads to the inability of staff to promptly update IFPL signs, respond to fire starts, provide initial attack capabilities, and keep fires from getting out of control. Rather, personnel have to respond from the Cedar River Watershed, increasing response time by at least one hour.

Watershed Access Control, Sanitation Facilities, Protocols for Human Activity in the SFTMW

The access control infrastructure and procedures do not currently meet SPU security standards for watershed protection:

- The existing gate infrastructure that controls access to the SFTMW from the west does not meet current SPU security standards.
- There are no gates at the east end of the municipal watershed on land owned by the USFS, allowing vehicle access into the watershed and directly to the Damon Mine, which creates safety and security concerns for SPU.
- Boundary posting is absent or deteriorated to a point of being illegible in many locations throughout the SFTMW.
- Keys to South Fork Tolt watershed gates, including those on the Pipeline Road, are controlled and issued by an access control agent located in Seattle, but permits are issued via the Cedar Access Permitting System (CAPS) from Protection staff at Cedar Falls. Many users of the SFTMW are never issued a permit due to the lack of a formal procedure requiring one. Key-issuance protocols and padlock installations are not handled in a consistent manner.

Sanitation facilities are currently inadequate:

- There are no portable or semi-permanent toilets located above the dam. As the level of work upstream of the dam increases, sanitation will have to be provided above the dam to meet SPU watershed access and control regulations. SPU's sanitation control program prohibits the elimination of human body wastes directly onto watershed lands. Permanent sanitation facilities (septic systems or portable toilets) will have to be installed at locations with regular, authorized human use and at strategic locations inside the municipal watershed.
- Resource constraints have limited the ability to consistently deploy portable sanitary facilities at all work sites and to orient visitors regarding sanitation activities that could contaminate the water supply.

Emergency and Incident Response

The following issues have been identified related to emergency and incident response:

- Currently, SPU is not meeting water system industry standards for daily physical monitoring of infrastructure necessary for the delivery of water from the South Fork Tolt Reservoir.
- Increased activity in the SFTMW could lead to an increase in the number of

incidents reported to Protection staff. Such incidents would require response, investigation, resolution, and documentation through established SPU reporting procedures. The staffing currently assigned to the SFTMW is not sufficient to provide this level of service.

- Emergency response capabilities in the SFTMW are currently compromised by the following issues:
  - Local fire departments cannot provide initial response to the SFTMW in a timely manner due to poor road conditions, gated access, and the remoteness of its location. The inability to respond to medical and hazardous material emergencies, as well as the lack of adequate rescue and response equipment, puts an injured party or a threatened stream at increased risk.
  - No emergency supplies are currently located in the SFTMW to aid in performing a medical or technical rescue.

SPU is concerned about the potential for activities on USFS land within the municipal watershed that may be incompatible with the production and protection of the municipal water supply.

Monitoring Source Water Quality and Quantity

Because of resource constraints, water quality data collection in the SFTMW is not consistent with the Cedar River Watershed. This includes trained boat operators for SPU deep water sampling assistance. This presents safety concerns, when a single person is performing mid-reservoir work alone in a boat.

Monitoring duties are informally distributed among staff in the Watershed Protection group and Transmission operating unit leading to inefficiencies and increased coordination needs.

Uncertainty and Risk Associated with Future Uses of USFS Land

SPU is concerned about the potential for activities on the USFS land within the municipal watershed that may be incompatible with the production and protection of the municipal water supply. Such activities include road-building, forest harvest, mining (hard rock, aggregate, oil, gas, and geothermal), and recreation (especially motorized recreation).

Hancock Forest Management, Inc.

SPU and Hancock Forest Management still require use of each other’s road systems to access their lands in and around the municipal watershed. This includes a limited number of roads within the SFTMW that provide Hancock with the only practical access to some of its property. Historically, the Watershed Operation Agreement (WOA) and Road Use Agreement (RUA) discussed in Chapter 2 have provided a general administrative framework, but they have never been tested in a technical or legal sense. Numerous emergent issues have traditionally been resolved by verbal or written side-agreements when the agreements fail to offer clarity or guidance to the parties. Because these agreements are outdated, they have been identified as an issue for SPU management of the SFTMW.

Mining Claims

While mining claims in the municipal watershed are not currently being worked, the City has no certainty and only limited effective control over the future disposition and activity on those claims. SPU believes mining in the South Fork Tolt watershed would have significant environmental effects that could adversely impact SPU's ability to manage its municipal water supply and comply with federal and state laws regulating drinking water. The U.S. Congress recognized the importance of these watershed values when it passed Public Law 97-350, which withdrew all federal lands within the South Fork Tolt Watershed from all forms of appropriation under federal mining laws. The apparent retention of mining claims in the SFTMW by Weyerhaeuser Corporation is an issue.

Management of Watershed Protection Functions

An overarching issue related to watershed protection is a lack of clarity about policies, procedures, roles, and responsibilities associated with watershed protection services for the SFTMW. Examples of this are provided above related to all categories of protection activities. This lack of organizational clarity results in inefficiencies in handling problems and leaves the potential gaps in watershed protection.

Additionally, while the scope for the *South Fork Tolt Municipal Watershed Management Plan* only addresses the City's lands above the dam which is administered by the Major Watersheds business area of SPU, the City's land and facilities below the dam are not currently supported by a similar protection program.

CONSIDERATION OF OPTIONS

The appropriate level of service for watershed protection was evaluated based on the following factors:

- Remote location of SFTMW;
- SFTMW access and neighboring land uses/owners;
- Level of activity and nature of activities in the SFTMW; and
- Operational considerations, including staff and infrastructure locations.

With regards to neighboring landowners, the Steering Committee considered options pertaining to acquisition of the USFS land and applicability/potential problems with the agreements that guide shared use with Hancock Forest Management, Inc.

While having nearly 30 percent of the watershed under separate ownership (USFS) creates some concern for SPU, it does not appear that the risk is high enough to warrant immediate action to acquire this land. The Steering Committee considered the probable land use, risks, and potential costs to acquire this land. Evaluation of value for the USFS land is incomplete at this time.

In evaluating the relationship and shared facilities with Hancock Forest Management, Inc., the work group researched the agreements, obtained a legal opinion regarding validity and application of the agreements, and interviewed staff about actual day-to-day interactions with Hancock Forest Management, Inc.

All other aspects of watershed protection were discussed and evaluated, item by item, with the Steering Committee and Watershed Services Division Director. The recommended actions represent a conservative approach to bringing watershed protection service levels in line with SPU standards, while at the same time acknowledging the remote location of the SFTMW and low level of management activities that will take place within the SFTMW.

RECOMMENDED ACTIONS

Security and Protection Plan

Recommendation WP1—There is a need for a comprehensive Tolt Water Supply Security and Protection Plan that includes all facilities from the Kelly Road Gate and beyond (including the regulating basin, treatment facilities, etc.) jointly managed by SPU Security Manager and Watershed Protection Manager. A comprehensive evaluation will clarify department policies and procedures, minimize responsibility ambiguities, eliminate redundancies, and promote more efficient methodologies that support the overall mission of watershed protection activities.

The recommended actions represent a conservative approach to bringing watershed protection service levels in line with SPU standards, while acknowledging the remote location of the SFTMW.

Fire Prevention

Signage

Recommendation WP2—To keep contractors informed of changing fire conditions, IFPL signs should be installed at access gates on the 50 and 70 Road entrances to the municipal watershed. This will ensure that current IFPL levels are current, thus ensuring appropriate hours of operation, fire watch hours, and closures of any activity necessitated by the WDNR. This additional signage will also indicate to all forest operators the need for proper spark arresting equipment on power tools and the potential for hazardous weather conditions.

Fire-Fighting Equipment Staging

Recommendation WP3—There is a need for wildland fire-fighting equipment to be staged at the SFTMW, specifically a fire trailer permanently stationed at the Vista House above the dam, equipped with a 300-gallon water tank, 13-horsepower pump, and a minimum of 300 feet of hose. The trailer should be stored in a simple shelter or garage to reduce its exposure to weather and ensure proper operation of pumps and equipment for immediate fire response.

Watershed Access Control, Sanitation Facilities, Protocols for Humans in the SFTMW

Cyber-Locks

Cyber-locks are programmable, key retention padlocks that have can be used when no power or communication is available at remote locations. The operation of a cyber-lock involves a corresponding cyber-key that electronically connects with the padlock upon insertion to allow or deny access via the padlock. The data is retained in the cyber-lock and downloaded at a later time by security personnel.

Recommendation WP4—Centralized key and padlock administration that is consistent with SPU key-management policies, combined with the requirement that all users of the municipal watershed obtain and display a valid permit, will help ensure the security of the SFTMW. Unlike the Cedar, cyber-keys will be issued to a number of non-SPU employees such as Hancock Forest Management Corporation and USFS staff.

Installation of cyber-locks on all gates from the Kelly Road to the municipal watershed boundary and establishment of two cyber-key authorizers to provide convenient and accessible locations to update cyber-keys will improve the ability to track users.

Gates

Recommendation WP5—Replacement of nine existing gates to meet current SPU security standards, similar to those recently installed at the Cedar watershed, will physically harden security at all access locations and deter illegal vehicle entry. In addition, the following new gates should be installed:

- Gates at both the north and south ends of the Tolt Dam to meet SPU Dam Safety, FERC, and Homeland Security guidelines.
- Damon Mine entrance, and possible decommissioning of National Forest Service road beyond that point.
- Gates/locked entrances at the openings of the Damon and Morning Star Mines to deter access and reduce safety concerns related to individuals entering the mines.
- A gate on Money Creek Road to restrict vehicle access to roads within the municipal watershed, though it will not restrict other types of recreation.

Proper signage that conforms to current SPU standards will need to be installed on all newly constructed gates. Gates on National Forest System lands would need to be approved through a cooperative agreement for installation and future maintenance.

Boundary Posting

The current gates at Damon Mine are easily pushed aside, making this a popular, and potentially dangerous, destination.

Recommendation WP6— In order for SPU to continue to enforce trespass within the boundaries of the municipal watershed and to provide a deterrent to hunting, fishing, and trespass, "No Trespass" signs should be posted every 100 feet around the perimeter of the City-owned land within the South Fork Tolt watershed, a length of about 20 miles. The immediate area surrounding the dam should also be posted. The posting line will then require yearly maintenance to protect appearance and replace weather-damaged signs.

Sanitation Facilities

Recommendation WP7—Semi-permanent portable toilets should be installed and maintained at remote locations of the municipal watershed above the dam, and portable toilets need to be ready and available to meet the need of mobility. Approximately ten portable toilets, set on poured concrete pads, and covered by lumber protective structures, will meet SPU's obligations to ensure that human waste is not deposited in the forest, compromising source water quality. Another fleet of portable toilets on trailers will address the need for work-site locations that are not near semi-permanent locations.

Ongoing Sanitation Control Program

Recommendation WP8—SPU's sanitation control program prohibits the elimination of human body waste directly onto watershed lands. All individuals entering the SFTMW need to be advised of their obligation to comply with SPU watershed access and control regulations, which include the requirement for sanitary facilities to be installed at all work sites and prohibit sanitation activities that could contaminate the water supply.

Emergency and Incident Response

Patrols

Recommendation WP9—Proactive infrastructure checks should be conducted to identify problems as they arise.

Incident Response

Recommendation WP10—Incident response, investigation, resolution, reporting, and follow-up capabilities should increase to meet SPU security and emergency management policy.

Emergency Equipment Staging

Recommendation WP11—Personnel trained and available to respond to any hazards in the municipal watershed need a readily available supply of equipment to expedite emergency response. A properly outfitted 12-foot rescue cache trailer, similar to the one at the Cedar watershed, should be staged at the Vista House. It should contain an inventory of medical supplies, rescue equipment, emergency survival supplies, lighting, communication, food, water, and spill response supplies. In addition, 55-gallon spill response drums should be purchased and deployed at the six bridge crossings surrounding the reservoir.

Uncertainty and Risk Associated with Future Uses of USFS Land

While current management mandates on federal lands in the SFTMW restrict road-building, forest harvest, mining, and recreational development, the City has no certainty and only limited effective control over future land use decisions on these lands. Historically, ownership of municipal watershed lands has proved to be one of the most effective watershed control and protection strategies for the City.

Recommendation WP12—SPU is currently analyzing the potential for exchanging federal lands in the South Fork Tolt watershed to City ownership as a means to reduce the risk of future incompatible land uses. However, significant costs are associated with the negotiation, acquisition, and management of such additional lands. SPU will evaluate the City's options for managing the risk of incompatible land uses in the municipal watershed and will assess the costs, benefits, risks, and feasibility of implementing such actions. Results of that analysis will be used to support SPU's decision-making on this issue.

Hancock Forest Management, Inc.

The two existing landowner agreements between SPU and Hancock Forest Management, Inc. are now outdated. While the significance of the WOA has been greatly reduced because Hancock owns very little land within the municipal watershed, the RUA remains an important tool for regulating access. Numerous shortcomings were identified with the RUA however, including the following:

- Assignment of the agreements to Hancock from the previous landowner, Weyerhaeuser Inc., is not clearly stated.
- Exhibits to the agreements do not reflect current ownerships or road access.
- Many provisions of the agreements no longer apply (due to land and road ownership changes, for example), or no longer meet the City's current management and policy standards.
- The RUA does not currently provide the City with access to its North Fork Tolt properties.
- Weyerhaeuser's reservation of mineral rights and associated access are not referenced.

Recommendation WP13—The RUA and WOA should be updated. All parties (SPU, Hancock, and possibly Weyerhaeuser) are expected to benefit from a new agreement that captures what is still relevant, clarifies areas that are unclear, and provides all parties with greater certainty. It is probable that Weyerhaeuser would need to be consulted because of its reserved property interests. The City might consider a separate agreement with Weyerhaeuser that nullifies the company's interest in the original agreements and only addresses access to its reserved mineral rights inside the municipal watershed.

All parties (SPU, Hancock, and possibly Weyerhaeuser) are expected to benefit from a new agreement that captures what is still relevant, clarifies areas that are unclear, and provides greater certainty.

Mining Claims

Recommendation WP14—SPU is assessing the status and location of mining claims reported by the U.S. Bureau of Land Management to be active on federal lands in the municipal watershed. As part of this review, SPU will determine whether any claims were improperly classified as active because they were filed after the effective date of the mineral withdrawal mandated by Public Law 97-350. SPU will also evaluate the City's options for managing future risk associated with active claims and will assess the costs, benefits, risks, and feasibility of implementing such actions. Results of these analyses will be used to support SPU's decision-making on this issue.

CHAPTER 4 FOREST RESOURCES

CHAPTER 4. FOREST RESOURCES

A management plan was developed for the upland and riparian forests in the SFTMW to align the management of forest resources with the following SPU goals for the SFTMW:

- **Goal 1**—Maintain and protect source water quality and quantity for municipal water supply and downstream ecosystems
- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the SFTMW
- **Goal 4**—Manage the SFTMW based on social, environmental and economic considerations.

FOREST RESOURCE INVENTORY

In 2006, a forest resource inventory was performed for the entire SFTMW, including City and National Forest System lands (Atterbury, 2006). Forests under City ownership were classified and accessible areas were sampled, with inventory plots covering 5,024 acres of forest. Approximately 3,737 acres of forest under City ownership is inaccessible and was not inventoried. USFS forest lands (covering 3,697 acres) was classified to stand type but not inventoried with sample plots.

Forest Structure and Composition on City-Owned Land in the SFTMW

Forest Age Class Distribution

Most of the forest lands under City ownership in the SFTMW were historically clear-cut harvested, and the forest age distribution (Figure 4-1, Map 7) reflects that harvest history. Of the forested net acres under City ownership in the SFTMW (7,015 acres, excluding roads, landings, facilities, and the reservoir), 93 percent is managed forest and 7 percent is old-growth forest, mostly in steep rocky areas. The second-growth forests became established through planting, natural regeneration, and advanced regeneration (trees that became established under the canopy of preceding forest stands). Some forest stands were pre-commercially thinned by the prior landowner, and a small amount of commercial thinning may have occurred.

Forest age for previously harvested areas ranges from 10-year-old stands on higher

Highlights

The forests in the SFTMW are mostly young, second-growth stands established after clear-cut harvesting, with youngest stands at higher elevations. A limited area of old-growth forest remains on some steep rocky slopes. The young second-growth forests lack the diversity of features to provide all the benefits of an older, more diverse forest.

Four forest-management options, representing varying levels of timber harvest and habitat development were evaluated for this plan. The option with the greatest emphasis on habitat development was selected as the preferred forest management plan. This plan includes the following:

- Focus on the long-term development of late-successional forests;
- Obtain revenue for management activities through the sale of surplus timber from thinning to offset costs;
- Prioritize restoration treatments based on identified management zones, site productivity and stand condition, and the potential for coordinating with other management actions in the municipal watershed;
- Employ various forms of thinning and planting to create the desired forest diversity; and
- Complete the proposed program in stages over 70 years.

Forest Resources
The uses and values associated with, attainable from, or closely tied to, forested landscapes; they include aesthetics, fish, forage, recreation, soil, timber, water, wilderness, and wildlife.

Figure 4-1. Age Class Distribution of Forest

elevation sites to 55-year-old second-growth stands at lower elevations. As a legacy of the harvest history, stand age declines with increasing elevation. On exposed slopes and along ridge tops, sites may be found with relatively young forest featuring small trees and shrubs. Although sites at higher elevations were harvested 25 years ago, they may only have 10-year-old trees because stand establishment may take several decades on these low-productivity sites.

Stand
A group of forest trees of sufficiently uniform species, composition, age, and condition to be considered a homogeneous unit for management purposes.

Forest Species Composition

The sampled stands on the City-owned lands in the SFTMW are dominated in number by western hemlock and Pacific silver fir trees. By board-foot volume, western hemlock is the dominant species (51 percent), and Douglas-fir is the second (31 percent; see Table 4-1). Board-foot volumes in the 40- to 55-year-old stands range from 8,000 board-feet per acre to 37,000 board-feet per acre, with the highest volumes appearing on the lower third of the watershed's slopes, near the reservoir.

Conifers are the primary species in 99 percent of the stands; deciduous trees dominate the canopy in the few riparian areas at the valley bottom. Most of the forest stands are dense with a single canopy layer (most of the foliage is distributed in the upper forest canopy); they support little understory vegetation.

Forest Productivity

Site class is an index of forest productivity and is measured by the height of dominant trees at 50 years of age; Site Class I represents the highest productivity and Site Class V represents the lowest productivity.

Table 4-2 shows the distribution of site class by acres of forest on City lands in the SFTMW. The 2006 inventory found that these forests are dominated by Site Classes III, IV, and V. Site class generally decreases with elevation. The relatively low productivity in the SFTMW is comparable to other sites in the west-central Cascades.

TABLE 4-1.
DOMINANT TREE SPECIES DISTRIBUTION BY BOARD FOOT VOLUME

Dominant Tree Species	Percentage Volume
Western hemlock	50.8%
Douglas-fir	30.9%
Pacific silver fir	13.6%
Red alder	1.7%
Other species (e.g., big leaf maple, cottonwood)	3.0%

Forest Structure and Habitat

The forests in the SFTMW are dominated by young second-growth stands in the competitive exclusion stage of forest development. Forests in this stage of development are relatively simple in structure and are dominated by a single age class and have a dense single canopy layer. The dense forest canopy effectively captures light and limits understory development in the lower strata. The crowded stand conditions and dominance of shade-tolerant species (such as western hemlock) result in intense competition for light, water, and nutrients and have caused growth declines, especially where western hemlock predominates.

Old-growth forest remaining on City lands in the municipal watershed exist almost exclusively on steep rocky slopes. These areas have multiple age classes and multi-layered canopies, with high numbers of large snags and weathered live trees. Most of these stands are in the middle to upper elevations of the watershed and provide high habitat value for species that depend on late-successional forest structures. USFS data put these stands in the range of 600 to 800 years of age.

Approximately 3 percent of all inventoried trees are snags (standing dead trees), which results in about 1 snag per 10 acres. Snags in the managed stands are generally small and arise from competition mortality due to the crowded growing conditions; large snags are

TABLE 4-2.
DISTRIBUTION OF SITE CLASS BY ACRES IN THE MUNICIPAL WATERSHED

Site Class	Site Index[a]	Inventoried Acres	% Forested Acres[b]
I	136+	—	0
II	116—135	12	0.2
III	96—115	1,777	25
IV	76—95	2,067	29
V	56—75	1,168	16
Total		**5,024**	**70**

a. Site index is the average height of dominant trees at age of 50 years .
b. Calculated as percent of 7150 forested acres in 2006.

Young, dense stands in the "competitive exclusion" stage of forest development result in intense competition for light, water, and nutrients and have caused reduced tree diameter growth.

rare in the managed stands. The average snag is 9 inches in diameter and 30 to 40 feet tall. Seventy-eight percent of the snags are either western hemlock or Douglas-fir. Old-growth snags average 23 inches diameter and 45 feet tall.

Downed wood is abundant in most stands, although the distribution is variable and the size classes are generally small. Downed wood is distributed with highest concentrations in the draws and near former yarding corridors and landings. Most of the larger down wood is in lengths of 12 to 40 feet rather than whole trees and is in advanced stages of decay, with the exception of western redcedar (*Thuja plicata*). Most of the 12-inch and smaller material represents slash from pre-commercial thinning. Approximately 44 percent of the down wood is 12 inches or less in diameter, 46 percent is 13 to 24 inches and 10 percent is over 24 inches.

Indicators for forest habitat structure types as classified by Johnson and O'Neill (2001) are shown in Table 4-3. The area of each structure type in Table 4-3 was determined from the 2006 forest inventory. Map 8 shows the habitat classes by tree size and canopy layers.

Forest Disturbances

No large-scale natural disturbance, damage, or disease agents were noted during the inventory. Small areas of fir-fireweed rust are infecting some of the younger stands of silver fir. Dwarf mistletoe is not extensive, but does infect some stands and is heavy in small areas. On the lower, south facing slopes where Douglas-fir is more common, laminated root rot is starting to show as pockets of dead trees. Armillaria root disease is also present in small amounts. The most commonly observed tree damage is due to black bear cambium feeding or severe weather. Pistol butting due to snow creep is common in the higher elevation stands, as is red flagged foliage from winter desiccation. Douglas-fir was inappropriately planted in some higher elevation stands where it is growing in extremely poor forms due to snow damage.

TABLE 4-3.
FOREST HABITAT CLASSES BY FORESTED ACRES

Habitat Class	Tree Diameter (inches)	Tree Canopy Cover (%)	Tree Canopy Layers	Forested Acres
Grass/Forb				
Open	NA	<10	NA	37
Closed	NA	<10	NA	6
Shrub/Seedling				
Open	<1	<70	1	83
Closed	<1	>70	1	0
Sapling/Pole				
Open	1-9	10-39	1	81
Moderate	1-9	40-69	1	323
Closed	1-9	>70	1	3057
Small Tree, Single Story				
Open	10-14	10-39	1	0
Moderate	10-14	40-69	1	538
Closed	10-14	>70	1	1543
Medium Tree, Single Story				
Open	15-19	10-39	1	0
Moderate	15-19	40-69	1	0
Closed	15-19	>70	1	0
Large Tree, Single Story				
Open	20-29	10-39	1	0
Moderate	20-29	40-69	1	227
Closed	20-29	>70	1	0
Small Tree, Multi-Story				
Open	10-14	10-39	>2	0
Moderate	10-14	40-69	>2	75
Closed	10-14	>70	>2	660
Medium Tree, Multi-Story				
Open	15-19	10-39	>2	0
Moderate	15-19	40-69	>2	0
Closed	15-19	>70	>2	0
Large Tree, Multi-Story				
Open	20-29	10-39	>2	50
Moderate	20-29	40-69	>2	387
Closed	20-29	>70	>2	68
Giant Tree, Multi-Story	>30	>40	>2	0

Source: Johnson and O’Neil (2001); Forested acres from 2006 Forest Inventory.

USFS Land within the SFTMW

The forest cover on National Forest System lands is in many respects similar to that of the SPU-owned lands except that there is substantially less of this area in very young forest and more in old-growth. Steep rocky areas make up a larger percentage of the National Forest System lands than the municipal watershed as a whole. The old-growth forests in this area are typical of the very old, multi-age Pacific silver fir and western hemlock dominated stands of the Cascade Mountains. This forest type provides the late-successional habitat elements, such as complex canopy structure and decadence. Not far above the valley floor, Alaska yellow cedar becomes a significant forest component on National Forest System lands, although it was not found in the inventory on the City-owned part of the SFTMW. At higher elevations, mountain hemlock becomes common. Higher on the south facing slopes, sub-alpine fir is found in open talus areas. In previously harvested young forest at lower elevations, it appears that no pre-commercial thinning has occurred.

Downed wood is abundant in most stands, though only 11% is over 24 inches in diameter such as that shown in this photo.

LEGAL REQUIREMENTS

The Washington State Forest Practices rules (WAC 222) regulate forest activities in the SFTMW. SPU must follow these rules when conducting forest management activities including timber harvest, reforestation, use of forest chemicals, road building, and any work in riparian corridors.

ISSUES

Past forest management has drastically disturbed forests in the watershed and altered natural ecosystem functions in the watershed, such as forest habitat, productivity, and water cycle regulation. While the primary management goal for the SFTMW is to provide domestic water, the City also has a strong commitment to provide other ecosystem services, such as habitat and carbon sequestration. The restoration of late-successional forest conditions could significantly improve many ecosystem functions that provide those services.

The clear-cut harvesting of old-growth forests has dramatically changed the watershed landscape, which now supports a forest age class distribution dominated by young forest stands with remnants of old-growth forest. The tree species distribution has a preponderance of shade-tolerant species that maintain dense forest canopies and reduce biological diversity. Studies from elsewhere have shown that young forest ages and limited tree species composition results in homogeneous forest structural conditions that have lower habitat value, biodiversity and summer base flows in the tributary streams (Perry 2007).

Clear-cutting the old-growth forests also reduced the number of large residual standing and down dead trees. These residual structures provide important ecosystem functions, such as habitat, nutrient cycling, and development of soil organic matter. The low biological diversity resulting from these changes in the forest landscape may reduce the resilience of the ecosystem to withstand or recover from further disturbance or adapt to gradually changing environmental conditions that occur from climate change.

Many of the roads that were constructed to harvest the old-growth forest in the basin have been removed because of their continued sediment production from the disturbed hill slope. In particular, the removal of mid-slope roads and roads on steep slopes in the southeast portion of the basin create operability constraints for possible forest management. These areas must be excluded from active management or are considered for hands-only restoration treatments.

The setting of the SFTMW between industrial forest lands and National Forest creates a strong contrast in forest age distribution and structure on the landscape. This situation places a greater importance on the management of SFTMW forest lands to create a landscape more effective in fostering biodiversity and providing resilience in the face of environmental changes and disturbance.

OPTIONS ANALYSIS

The full range of forest management options from passive management to timber management was modeled in order to provide information for decision-making. Four forest management options were evaluated based on ecological, economic, and social criteria.

- **No-Action**—This option would continue the current approach of no active management. Watershed forests would be passively managed and would eventually develop into late-successional habitat.
- **Habitat Development**—This option would facilitate the recovery of ecosystem functions and develop late-successional forest attributes more quickly than the No-Action alternative by improving forest habitat through thinning, canopy gap creation, snag creation, down wood augmentation, and planting. The goal would be to increase habitat for species dependent on late-successional forest structures. Old-growth forest remnants, inaccessible areas, and unstable slopes would not be manipulated under this option. The sale of timber from thinning operations would subsidize restoration treatments to a limited extent.

- **Sustainable Harvest and Habitat Development**—This option would develop uneven-age forest structures to sustain timber harvest over time and develop forest habitat complexity. Forest structures would be changed through group selection, matrix thinning, and longer rotations (i.e., harvesting forest patches at older ages than normally done under commercial forest management). Habitat complexity would be increased by changing forest structures and planting to increase species composition. Thinning would increase future timber yield and revenue possibilities. Areas would be excluded from timber extraction for habitat development, access limitations, hydrologic concerns, environmental impacts, and economic feasibility of timber harvest.
- **Sustained Timber Yield Management**—This option would maintain even-aged forest structures and a balanced age class distribution (all forest ages distributed on the landscape), with goals to maintain or increase timber yield over time and generate revenue from commercial timber harvest. Young stands would be thinned to increase timber yield and select for commercially desirable species. Stands would be regenerated through clear cutting where possible and planted. Rotation age would range from 70 to 100 years, depending on site productivity. Some areas would be excluded due to access limitations, hydrologic concerns, and economic feasibility of timber harvest.

The options were modeled using the OPTIONS Model and Stand Projection System Forest Projection Systems (DR Systems, Nanaimo, B.C.) for post processing and economic analysis. Results were evaluated based on the following factors:

- Structural classification of forest types
- Timber harvest volumes
- Projected habitat elements (deciduous species, tree size)
- Projected revenues
- Projected costs
- Management limitations and opportunities
- Fire hazard analysis and risk management recommendations
- Carbon sequestration opportunities and limitations.

Each management option was projected over 200 years in 10-year intervals to evaluate sustainability of the silviculture regimes and structural development of forests. Each model included the following management constraints:

- Management Zones—Four management zones were delineated. Under each modeled option, these zones were managed with a consistent balance between late-successional reserve and active forest management (see Map 9).
- Maximum Disturbance Levels—Each subbasin was assigned a maximum area of open canopy and thinned canopy per decade in order to minimize the adverse effects of rain-on-snow events.
- Riparian Management Zones—Treatments in riparian management zones were assigned by stream type to balance the positive and negative effects of thinning and harvesting on aquatic

TABLE 4-4.
FOREST RESTORATION TREATMENTS
AND FOREST STAND TYPES TO WHICH THEY APPLY

Treatment	Description	Forest Stand Type or Element
Restoration Thinning	Thinning to 150 - 250 trees per acre, creating canopy gaps	Young dense forest 15 to 40 years old and 15 to 40 feet tall
Ecological Thinning (Type 1 and 2)[a]	Variable density thinning to 100 - 240 trees per acre, including canopy gaps and unthinned skips	Older dense forests with closed canopy
Planting	Planting 200 site-specific trees per acre of western redcedar, red alder, big leaf maple or other appropriate species	Canopy gaps
Understory Thinning	Thinning to 250 trees per acre	Young dense trees in understory
Habitat Enhancement	Top or girdle clusters of 4 large trees per acre	Older dense forests with few snags

a. Ecological Thinning Types 1 and 2 differ in stand condition to which they are applied and also in thinning intensity. See Appendix A, Table 1 for details.

habitat and water quality, and to comply with WDNR Forest Practices Rules.

- Adjacency Rules—In the “Sustainable Harvest and Habitat Development” and “Sustained Timber Yield Management” options, harvest scheduling was restricted to minimize the extent of adjacent harvest units, based on WDNR Forest Practices Rules.
- Harvest Levels—A maximum sustainable 10-year harvest level was assigned to each option. Harvest level in the “Sustained Timber Yield Management” option was highest, followed by the “Sustainable Harvest and Habitat Development” and “Habitat Development” options. No harvest was scheduled in the “No-Action” option. Actual annual harvest levels were allowed to fluctuate within the remaining management constraints.
- Treatment Prescriptions—Detailed prescriptions for regeneration, stocking density control, and habitat enhancement were assigned for each option (see Table 4-4 and Appendix A, Table 1). The prescriptions were adjusted to accommodate stand dynamics in different species groups and site classes.
- Buffer Zones—Non-forest habitat was buffered (i.e. no forest management activity) to reduce effects of harvest activities on headwater streams, wetlands, rock outcrops, old-growth forest, and the reservoir. These buffer zones are distinct from Riparian Management Zones, which allow management activity in different options.
- Operability Zones—Regeneration and ecological thinning treatments were allowed only in areas that could be accessed by ground-based equipment, cable yarders, and helicopter yarding. Restoration thinning (in forests between 15 and 40 years old) was allowed in the

remaining hand-equipment only areas where there was no access for other equipment types.

Revenue flows were based on 2007 implementation costs and timber values. Fire hazard rating was based on topography and forest structure. Carbon sequestration was calculated from live and dead tree biomass and on-site and off-site decay. Sequestration rates for the “Sustained Timber Yield Management” option were subtracted from the other three options to determine how much increased sequestration would be achieved if forest management entailed harvest below a level consistent with the regulatory standard).

Habitat development over the projection period was based on the forest structure types by Johnson and O’Neil (2001) (Table 4-3). Forest habitat was assumed to change with increasing tree size, changing canopy cover, and development of canopy layers. Canopy cover was calculated and used in the model based on its relationship with relative stand density. A deterministic model for the development of multiple canopy layers was developed based on regeneration treatments, overstory density, and forest age. Results of the model projections are summarized in Appendix A.

RECOMMENDED ACTIONS

The SFTMW lies within the King County Forest Production District, and forest products remain an important element of the agricultural sector of the regional economy. The triple bottom-line potential for continued industrial forestry in the SFTMW is limited, however, in the face of current anticipated harvest costs and foregone potential ecosystem services. Based on the modeling and evaluation of forest management options, a policy decision was made to proceed with detailed development of the “Habitat Development” option. This option is considered to be the most consistent with other City environmental policies and management strategies. Additional modeling work has been conducted to evaluate differences between the “Habitat Development” option and the “No-Action” option regarding net costs to the City and net gains on ecosystem services, such as habitat functions and carbon sequestration. The remainder of this section describes the recommended actions under the “Habitat Development” option.

Forest Restoration Approach

The forest management approach under the “Habitat Development” option focuses on restoration of forest habitat and the long-term development of late-successional forest structures. Protection and enhancement of hydrological processes are supported under this approach through road decommissioning, riparian protection, limiting canopy gap size and frequency, and creating resilient forest structures. The active restoration approach would facilitate the interaction of forest development processes with small-scale disturbances such as wind, insects, and pathogens for the long-term development of late-successional forest conditions. This option would obtain revenue from selling surplus timber from thinning and gap creation to support the cost of management activities, while retaining and augmenting snags and down wood to fulfill ecological functions. Specific management objectives are as follows:

- Promote the development of late-successional forest structures through reducing tree competition, initiating canopy layers, increasing spatial heterogeneity, retaining down wood, and promoting decadence.
- Provide wildlife habitat elements by increasing tree size variation, developing more foliage layers within stands, retaining down wood and dead standing trees, and promoting and planting minor species.
- Sell surplus trees, after downed wood and snag retention standards are met in thinning treatments of commercial size trees, to offset costs of restoration activities.
- Maintain reserve areas including non-managed remnants of old growth, inaccessible areas of the watershed, and unstable slopes.

Decision Model for Restoration Treatments

Recommendation FOR1—While most of the second-growth forests in the SFTMW would benefit from restoration treatments, certain areas will be prioritized because they are more likely to respond to restoration treatments or will provide greater functional value once restoration has taken effect. Treatments for specific areas will be determined through the following steps:

- Using defined management zones with particular restoration goals
- Identifying areas of potential productivity that will respond differently to restoration
- Identifying stand conditions that will respond to restoration treatments.

Management Zones

Four management zones were delineated at the landscape scale (Map 9). Forests in the Connectivity and Valley Bottom Management Zones will be prioritized for forest restoration treatments because they are nearest to existing old-growth forests on the National Forest System lands. Developing forests with greater habitat values, such as vertical and horizontal heterogeneity and increased species diversity, will most effectively create habitat connectivity with residual old-growth forests. Forests in the West End Management Zone in the western part of the municipal watershed are surrounded by young forests on industrial forest lands and would provide fewer habitat connections, so this management zone is lower priority for treatment. Previously harvested areas in the Reserve Zone are mostly inaccessible to equipment access but would likely benefit from restoration thinning once appropriate stand structures have developed.

Productivity

Research has shown that structural elements resembling late-successional forest conditions develop sooner in higher productivity second-growth forests, regardless of intervention (Larson et al. 2007). Consequently, forests on lower productivity sites (Site Class IV and V) should be prioritized for restoration. Currently, most forests on low productivity sites are young (15 to 40 years) and will be prioritized for restoration thinning.

Stand Condition

Forest structure and composition at the stand level will determine whether restoration is indicated and whether the forest community is going to show the desired response to restoration treatments. Detailed structural indicators that would trigger restoration planning are given in Table 4-4 and in Table 1 of Appendix A. Young stands of shade tolerant western hemlock and Pacific silver fir are likely to undergo prolonged phases of competitive exclusion with reduced habitat and biodiversity values. Such stands are likely to respond to restoration thinning during stages of maximum height growth (age 15 to 40 years) with increased diameter growth, crown development, and retention of higher levels of plant species diversity; these young stands will be prioritized for treatment.

Ecological Thinning Thinning treatments for stands with closed single-layer canopies and high stand density, designed to reduce tree competition and increase structural complexity. The new canopy gaps are planted with minor species (western redcedar, red alder, and big leaf maple) to increase canopy layers.

At later stages of stand development, high tree density and closed canopies slow the transition of stands into structurally diverse multi-layered canopies. Depending on forest structural conditions in older second-growth stands, one of two ecological thinning treatments may be implemented (Appendix A, Table 1):

- **Ecological Thinning 1**—Stands that approach maximum stand density and have undergone crown differentiation can be thinned to reduce competition, release understory trees, and open canopy gaps to introduce new canopy layers. These stands have higher priority for Ecological Thinning (Ecological Thinning 1, Appendix A, Table 1).
- **Ecological Thinning 2**—Stands that show less crown differentiation but approach high stand density will benefit from thinning of smaller trees (thinning from below) to reduce competition but are less likely to develop multiple canopy layers. These stands will be thinned in high priority areas to increase crown development and introduce new cohorts in canopy gaps.

Forest Restoration Treatments

The forest habitat restoration treatments (Map 10) are designed to improve forest habitat conditions, nutrient and water cycle regulation, productivity, and biodiversity. Habitat restoration treatments are based on a body of knowledge that is described in depth in the *Upland Forest Strategic Plan for the Cedar River Municipal Watershed* (LaBarge et al. 2008). These treatments include planting minor tree species, thinning young dense stands of conifers, variable density thinning in older forests, understory thinning, and habitat enhancement through retention and creation of standing dead and down wood.

Given the current forest age-class distribution in the municipal watershed, forest restoration treatments will be scheduled over a period of 70 years to achieve the desired treatment level. Silviculture prescriptions are described in Table 4-4 and in more detail in Appendix A. These prescriptions were used in the OPTIONS modeling analysis and will be applied to all eligible second-growth forests in the watershed. However, the prescriptions may be adapted to site-specific conditions by a restoration project team during plan implementation. The proposed area for each type of restoration treatment is summarized in Table 4-5. The following sections provide further detail for each treatment type.

Coordination with Other Activities

Recommendation FOR2—Forest restoration treatments will be coordinated in different ecosystems and among other management activities such as road decommissioning and aquatic restoration, similar to how forest restoration is planned in the Cedar River Municipal Watershed (Erckmann et al. 2008). Such coordination will help to reduce operational constraints, such as when riparian thinning is coordinated with upland thinning. Therefore, forest restoration in the second-growth forests adjacent to streams in the Valley Bottom and Connectivity Zones are prioritized where riparian and aquatic restoration work is planned. Forests in the Skookum Creek drainage will be prioritized for forest restoration treatments to coordinate with road decommissioning and aquatic restoration schedules.

Multi-disciplinary teams with representatives from a variety of disciplines, including forest ecology, fish and wildlife ecology, hydrology, engineering, and operations, should be formed whenever appropriate to participate in the planning and implementation of all restoration projects proposed for the municipal watershed.

Restoration Thinning

Recommendation FOR3—Restoration thinning treatments are designed to reduce the density of trees in young stands (less than 40 years) and create irregular patterns of tree distribution by incorporating canopy gaps. This type of stand structure has been shown to increase tree diameter growth, increase cover and diversity of understory vegetation, and retain enough trees for future functional dead wood. Increasing tree diameter growth during early stand development stages has been shown to reduce the risk of wind and snow damage.

Selective thinning by species provides the opportunity to change competitive pressure on minor species including deciduous trees, thus maintaining tree species diversity throughout forest development.

Of the 3,350 acres of stands currently under 40 years of age, 1,114 acres are planned to receive restoration thinning (see Table 4-5). The remaining young stands have lower tree density, are in reserve areas, or will be older than 40 years by the time they can be thinned. Sixteen percent of the total forested area will be treated with restoration thinning (where no trees are cut), the majority of which is planned for the first two decades, following the decision model for restoration treatments. This front-loaded thinning schedule will allow more young stands to develop under low density conditions with more diverse species composition. Restoration thinning units are located mostly in young stands on the south side of the reservoir.

Restoration Thinning
Reduction of tree density in young stands and creation of irregular patterns of tree distribution by incorporating canopy gaps. This has been shown to increase tree diameter growth, increase cover and diversity of understory vegetation, and retain enough trees for future functional dead wood.

Ecological Thinning

Recommendation FOR4—Ecological thinning treatments are planned in stands with closed single-layer canopies and density of more than 260 square feet basal area per acre (see Appendix A, Table 1). Variable density thinning treatments, including both ecological thinning 1 and 2, (See Recommendation FOR1) are designed to reduce canopy tree competition and increase structural complexity over 60 percent of each treatment area, removing between 30 and 45 percent of the standing tree volume.

TABLE 4-5
ACRES OF RESTORATION TREATMENTS PLANNED BETWEEN 2011 AND 2080

	Ecological Thinning 2	Ecological Thinning 1	Planting	Restoration Thinning	Riparian Thinning
2010-2015	389	186	113	451	133
2016-2026	539	175	124	292	83
2027-2036	204	285	134	11	17
2037-2046	579	22	67	54	24
2047-2056	463	146	105	0	12
2057-2066	587	106	101	165	7
2067-2076	564	52	77	67	6
2077-2086	10	25	11	71	0
Total Acres	**3,336**	**996**	**732**	**1,114**	**282**
Percent of Forest	47%	14%	10%	16%	4%

The remaining 40 percent of the treatment area will be equivalent amounts of canopy gaps 0.5 to 1 acre in size (where nearly all trees are cut) and unthinned skips (where trees are cut) to retain high density patches. The canopy gaps will be planted with minor species (western redcedar, red alder, and big leaf maple) to increase canopy layers in the total treatment area. Forest stands with high stem density and low average stem diameter will be treated with lower thinning intensity (fewer trees removed) to reduce competition and retain stand structural stability against wind disturbance.

There are currently 3,000 acres of forest eligible for ecological thinning, in the City-owned portion of the watershed, ranging in age from 41 to 70 years, and another 1300 acres of forest will develop into forests eligible for future ecological thinning. A minimum tree size and density condition is required to make this treatment feasible (Appendix A, Table 1). Due to the current structure and species composition, most of the stands eligible for ecological thinning are dominated by Douglas-fir and are planned to be thinned during the first two decades of restoration activities. This is reflected in the priority for treatment for stands in the Valley Bottom and Connectivity Management zones.

Beginning in the second decade of treatments, more of the hemlock dominated stands will have reached stand densities and volumes that will make them eligible for ecological thinning. Currently young stands dominated by Pacific silver fir and noble fir (true firs) will increase in density and tree size and become eligible for ecological thinning during the third decade of implementation (see Appendix A, Table 2). Most of the true fir stands will have received restoration thinning treatments during younger stand ages. A total of 4,300 acres of ecological thinning is planned over 70 years, reaching 61 percent of the forest area (Table 4-5).

Planting and Understory Management

Recommendation FOR5—Many thinned stands are expected to naturally initiate a new cohort of shade-tolerant understory trees (e.g., western hemlock, Pacific silver fir) following thinning. However, canopy gaps will be actively planted to introduce less tolerant species (e.g. Douglas-fir, western redcedar). The combination of planted species will vary among sites with different potential productivity and will include deciduous trees. Ten percent (732 acres) of the total forested area will be planted following gap creation during ecological thinning over 70 years. Subsequent understory thinning may be necessary to reduce competition from naturally regenerated shade-tolerant trees, both in the planted gaps and in the thinned areas.

Forest habitat restoration treatments are designed to improve forest habitat conditions, nutrient and water cycle regulation, productivity, and biodiversity.

Riparian Thinning

Recommendation FOR6—Riparian thinning is planned in subbasins where improved riparian functions will have an effect on stream processes. The treatments are designed to retain shade to the stream and increase current and future in-stream large woody debris (LWD). By felling trees directly into the stream, the added LWD will provide immediate benefit by reducing sediment transport yield. A total of 282 acres of riparian thinning is planned, most of which will occur during the first two decades of plan implementation. Riparian thinning applies to the riparian management zones (RMZ) along streams, which change in width and treatment depending on stream type (Table 4-6).

Restoration thinning is planned in the Inner and Outer RMZ, as well as in the 50 foot Core Zone, outside the channel migration zone. In stands younger than 40 years, restoration thinning treatments will focus on reducing competition to increase individual tree growth and shorten the time until the riparian forest will produce LWD of functional size. Riparian thinning of stands younger than 40 years is included in the restoration thinning acreage.

Ecological thinning without yarding of up to 20 percent of the stand volume is allowed under Forest Practices Rules in a 50-foot RMZ along perennial streams in order to augment coarse woody debris (CWD). Thinning and yarding 20 percent of the volume plus thinning 20 percent of stand volume for CWD is allowed in a 100-foot RMZ along fish-bearing streams, shorelines of the state, and wetlands. An 80-foot wide reserve zone along the reservoir is excluded from all forest restoration treatments.

TABLE 4-6.
RESTORATION TREATMENTS IN RIPARIAN MANAGEMENT ZONES

	Approximate 50-Foot Outer RMZ	Approximate 50-Foot Inner RMZ	50-Foot Core Zone
Wetlands and Type F and Type S streams	Restoration and Ecological Thinning	Restoration Thinning and Cut-and-Leave 20% Volume for LWD	Restoration Thinning Only, No Gaps
Type Np Streams	No Action Planned	Restoration Thinning and Cut-and-Leave 20% Volume for LWD	No Action Planned
Type Ns Streams	No Action Planned	No Action Planned	Restoration Thinning Only, No Gaps

Type F Streams = fish-bearing streams
Type S Streams = shorelines of the state
Type Np Streams = perennial streams
Type Ns Streams = seasonal streams
RMZ = riparian management zone
LWD = large woody debris

PREDICTED MANAGEMENT OUTCOMES

Development of Forest Structure Classes

In order to evaluate habitat improvement, the development of forest structure in the model projections was evaluated using the forest habitat structure classes by Johnson and O'Neil (2001). Each forest stand delineated during the inventory was assigned a forest structure class based on average tree diameter, number of canopy layers, and canopy closure. Tree growth and stand development were then modeled using the OPTIONS Model and Stand Projection System (SPS), and stands were reclassified after each projection period. Map 8 shows the current distribution of structure types (year 2007). Figure 4-2 shows the projected development of forest habitat types over the 200-year projection period following restoration management.

While natural forest development ultimately leads to structurally diverse forests that provide habitat for species dependent on late-successional forest conditions, this development may not occur before 300 years in some forest types. Reaching these complex structural conditions depends largely on small-scale natural disturbance from wind, pathogens, and insects, and its timing is relatively unpredictable. In order to set forest stands on a trajectory of understory development and vertical differentiation, ecological thinning treatments are applied to lower canopy density, encourage crown development, and stimulate natural regeneration of understory. The expected transition from single-layer stands to multi-layer stands is shown in Figure 4-3. Planting canopy gaps will increase the area of mixed coniferous-deciduous forest over time, providing important elements of biodiversity.

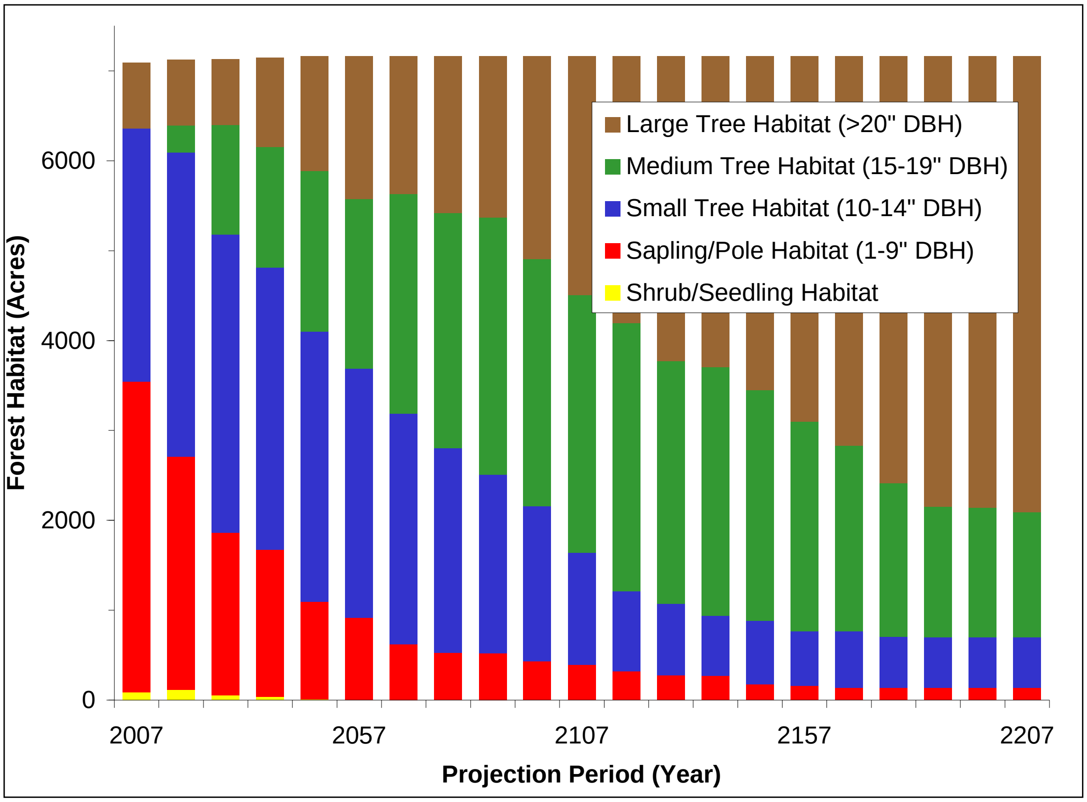


Figure 4-2. Projected Development of Forest Habitat Types.

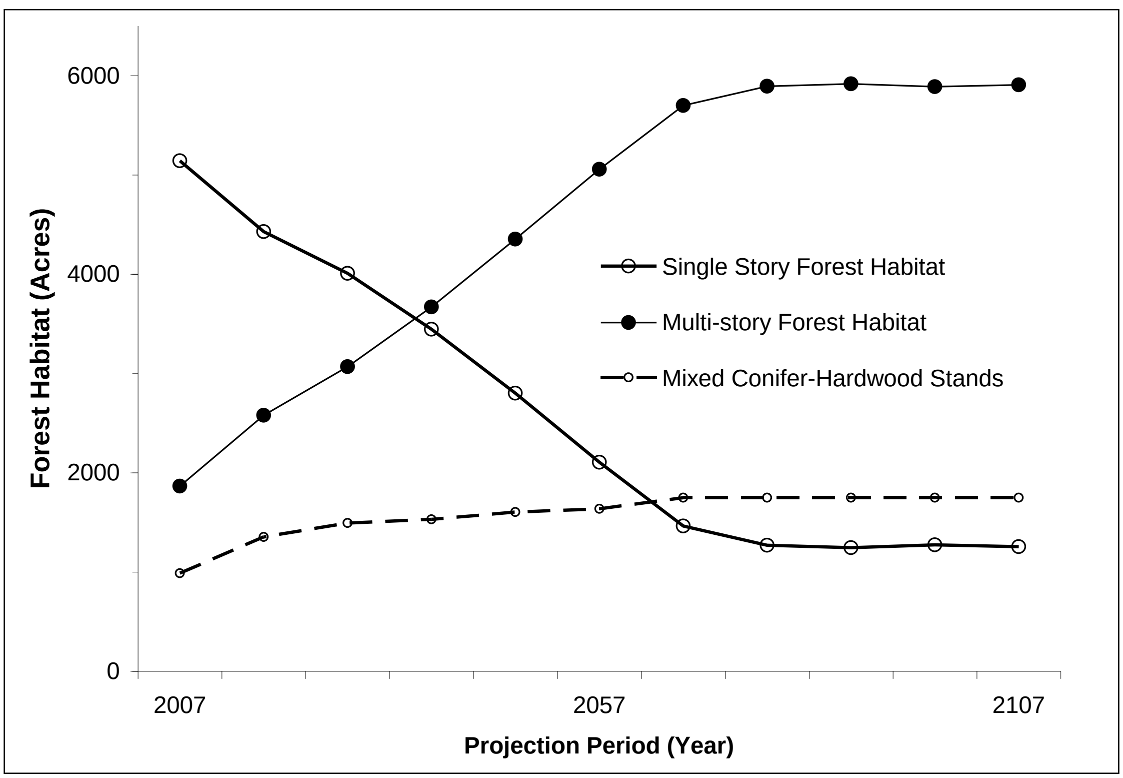


Figure 4-3. Expected Transition from Single to Multi-Layer Canopies During the Next Century with Treatment.

The modeling projection shows the area of mixed forests to increase by 77 percent, from 990 acres in 2007 to 1,750 acres in 2087. This projection does not include the assumption that many stands that are currently of mixed species will revert to coniferous stands.

Carbon Sequestration

Carbon sequestration, which offsets greenhouse gas emissions from human activities, was estimated over the projection period. Sequestration rates were based on changes in forest biomass volume over time, timber harvest, and emissions from on-site decomposition of slash and off-site emissions of forest products. The analysis used methodology described in Smith (2004).

The “Sustained Timber Yield Management” option was used as a baseline and carbon credits were calculated as the difference in net sequestration between the baseline and other management options. Net sequestration is calculated as total sequestration minus emissions from slash and forest products. The “Habitat Development” option had an annual net sequestration rate of 4.43 metric tons of carbon dioxide equivalents (CO2e) per acre per year, compared to the baseline of 3.41 metric tons. This amounts to 1,994 tons of net carbon per year above the baseline for the total forested area. The net sequestration rate of the “Habitat Development” option was second only to the “No-Action” option (5.45 tons CO2e per acre per year).

Differences in carbon sequestration among management options should be evaluated in context of the full suite of benefits the forests in the SFTMW provide. According to Batker (2005), the forests in the Tolt Watershed provide significant ecosystem services such as habitat disturbance prevention, water and nutrient cycle regulation, aesthetic values, and many others. Despite lower carbon sequestration rates estimated for the “Habitat Development” option than for the “No-Action” option, active restoration in the SFTMW forests would create a net benefit in ecosystem services, primarily because of this option’s positive impact on sediment process and habitat development. More detailed information on the Ecosystem Service Valuation is provided in Appendix A.

Fire Hazard

Disturbance through forest fire poses a risk to water supply management in the SFTMW. The natural fire regime in the watershed is characterized by very infrequent high intensity fires of large extent. Despite the fact that natural and human caused ignition sources are rare in the watershed and severe fire weather conditions occur only during brief periods in the summer, certain stand structural conditions can increase fire hazard, such as increased ground and ladder fuels.

As part of the forest management options analysis, fire hazard conditions were estimated for steep south-facing slopes where topography and fuel moisture conditions are most likely to propagate active crown fires. Despite the accumulation of slash after restoration thinning and creation of ladder fuels after ecological thinning, no areas of high fire hazard were identified, and the average increase compared to the No-Action option was only 118 acres of moderate fire hazard during the management period. It was determined that this change in fire hazard conditions did not warrant deferring from the "Habitat Development" option.

ADDITIONAL CONSIDERATIONS

Adaptive Management

The forest restoration approach in the SFTMW follows guidance from the Cedar River Municipal Watershed (CRMW) Habitat Conservation Plan forest habitat restoration program. The *CRMW Upland Forest Habitat Restoration Strategic Plan* (LaBarge et al. 2008) describes this program and its implementation within an adaptive management framework. While funding exists in the CRMW for research and monitoring in an adaptive management framework, a less resource intensive strategy is built into the SFTMW Plan for monitoring. Knowledge gained through the CRMW forest restoration program will be applied to the SFTMW as forest habitat restoration proceeds.

While the SFTMW forest restoration recommendations rely upon current detailed forest inventory information, they also draw heavily from the OPTIONS model growth projections. There is uncertainty associated with modeling exercises in general, but the trend of improving forest habitat with silvicultural interventions is well documented in the forest research literature. Future data acquisitions in the SFTMW will be leveraged to update forest development model projections to ensure that adaptive forest management occurs. These data acquisitions include restoration project compliance monitoring data that is collected to ensure implementation contract compliance, as well as new inventory data that is collected for the purposes of conducting project appraisals. A portion of these data collection points will be sampled periodically into the future, thereby establishing a low-intensity set of permanent inventory points to track long-term forest development across the watershed.

Another important issue is the uncertainty regarding how forests will respond to ongoing climate change. SFTMW and CRMW watershed ecologists will identify key ecosystem elements and processes to monitor to detect changes. For example, annual monitoring of mortality trends may be conducted in collaboration with Washington State Department of Natural Resources. Potential mitigation strategies include planting of diverse tree species and creating a more heterogeneous age structure to improve forest resilience in the face of climate change.

Further details on data collection and a flow chart for the adaptive management cycle are available in Appendix A.

Large Scale Disturbances and Potential Impacts from Neighboring Properties

The effects of large-scale disturbances such as fire, insects and introduced pathogens on forest resources were not included in this analysis. The forest management activities of adjacent landowners create a fire risk for the SFTMW by actively managing young dense forest on the border of the municipal watershed. Forest insect populations in temperate forests have had unprecedented population dynamics in recent years and may pose a risk to forests in the basin. Past and present introductions of forest pathogens have significant effects on forest communities, and future impacts are difficult to predict.

A change in forest resource management on neighboring properties could affect the current designation of management zones in the SFTMW. A shift from industrial timber management toward ecosystem management could affect the landscape-scale priorities for restoration treatments outlined above. However, anticipating forest land management decisions on neighboring properties is not in the scope of this management plan and was not considered in the analysis. Similarly, the restoration activities described here assume access to remote sites, sometimes through neighboring properties. Restoration priorities may change if access through neighboring properties should become restricted.

Revenue Projections

Revenue from the sale of surplus timber may fluctuate due to changing prices for forest products in regional markets. In recent years, some forest products have seen increasing prices while others have declined. It is therefore uncertain if the projected revenue flow from the sale of timber from ecological thinning activities will be achieved. Analysis of future log markets, however, lies outside the scope of this management plan analysis, and 2007 mid-year timber values were used for the projections.

CHAPTER 5
AQUATIC RESOURCES

CHAPTER 5. AQUATIC RESOURCES

The protection of stream banks, reservoir shorelines, wetlands, and fish habitat is fundamental for long-term watershed sustainability and is consistent with the following SPU goals for the SFTMW:

- **Goal 1**—Maintain and protect source water quality and quantity for municipal water supply and downstream ecosystems
- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the SFTMW
- **Goal 4**—Manage the SFTMW based on social, environmental and economic considerations.

The goal of future management of South Fork Tolt aquatic resources is to cooperatively protect, preserve, enhance, and restore essential aquatic resources. The actions listed in this chapter focus on the management and preservation of aquatic resources, with an emphasis on the maintenance and protection of current and future fish habitat as well as headwater streams and wetlands. Watershed processes that threaten the management and longevity of the reservoir are also evaluated and addressed.

Protection of drinking water quality and protection of aquatic habitats both require protection of vegetation near water bodies and minimization of sediment delivery to streams from upland activities. Streams, lakes, ponds, and wetlands function as an interrelated system that provides water and aquatic habitat for a variety of animals. Protection of aquatic habitats requires protection of associated riparian habitats. The riparian zone is the area adjacent to surface waters and areas of high groundwater levels, where the terrestrial system both influences and is influenced by the aquatic system (Bilby, 1988).

This chapter summarizes the key findings of the report *Aquatic Conditions for the South Tolt Management Plan* (Aquatic Conditions Report), which was finalized in June 2007 (Raines, 2007a & 2007 b; Bretherton, 2007; HydroLogic Services Co., 2007; Dube, 2007; Chapin et al., 2007; White, 2007). The report includes assessments of fish distribution and habitat, channel and wetland processes, mass wasting (the downslope movement of soil, rocks and other materials), riparian conditions, road erosion, hydrology, and water quality. These assessments provide an understanding of aquatic resources, the processes critical to their maintenance, and the extent to which they may be affected by historical, current and future management.

Highlights

A thorough analysis of aquatic resources (lakes, streams, wetlands and riparian areas) was conducted for the watershed management plan. The analysis identified areas most likely to have experienced impacts from past forest management practices in the municipal watershed, as well as areas that are most susceptible to adverse consequences from those impacts.

The key issues for aquatic resources related to these past practices are increases in sediment loads to water bodies, a lack of large woody debris (LWD) to enhance aquatic habitat, increases in peak stream flows, and barriers to fish passage in streams.

The following actions are recommended:

- LWD placement in floodplain channels of the upper South Fork Tolt main stem;
- Directional riparian thinning in various headwaters areas;
- Thinning deciduous riparian forests and underplanting conifer trees along larger fish-bearing streams; and
- Improving or decommissioning roads as appropriate to reduce sediment input to streams and remove barriers to fish passage.

Aquatic Resources Uses and values associated with, attainable from, or closely tied to, fresh water bodies. They include aesthetics, fish, recreation, water, and wildlife.

The Aquatic Conditions Report is a review and update of information presented in the *Tolt River Watershed Analysis*, which was prepared for the Weyerhaeuser Company in 1993 and updated by WDNR in 1998. Additional field data was collected in 2006 and updated analyses were conducted for each aquatic resource.

Identification of Critical Resources

Identification of critical aquatic resources required a determination of the following:

- **Impacted Areas**—Areas where key processes are most likely to have been impacted by forest management
- **Sensitive Resources**—Areas that are most sensitive to the impacts of forest management
- **Linkages**—The overlap between impacted areas and sensitive resources, indicating resources that likely have been severely degraded as a result of past management activities.

Impacted Areas

Landslides

The 1993 *Tolt River Watershed Analysis* (Weyerhaeuser, 1993) noted that post-harvest and road-related debris flows during the period from 1964 to 1990 affected almost every major tributary and many smaller streams that drain directly to the reservoir. The majority of these slides were triggered by poorly constructed or inadequately maintained forest roads on steep valley slopes.

A GIS-based slope stability model, SMORPH (Shaw and Johnson, 1995), was used to identify slopes of moderate and high

This 1960s photograph shows forest roads on steep valley slopes that trigger landslides.

instability, where landslides are likely. The model was calibrated using recently updated landslide inventory data as well as 10-meter digital elevation modeling (DEM) information. Table 5-1 shows how landslide hazard ratings were assigned to slopes within the municipal watershed based on the steepness and curvature of the slope. Within the SFTMW, differences in underlying geology did not appear to be a major factor in historical landslides. Map 12 shows the moderate- and high-risk landslide potential areas identified by this analysis.

For the purposes of modeling forest options within these areas (described in Chapter 4), the following general prescriptions were used.

- **Moderate Hazard Potential Areas**—No patch cuts. Thinning to maximum of 10-foot spacing between stems. No equipment entry or ground disturbance. No new road construction.
- **High Hazard Potential Areas**—No harvest. No equipment entry or ground disturbance. No new road construction.

Fine Sediment Delivery

Road-generated surface erosion is a common source of fine sediment entering streams; additional sources include road-related mass wasting, culvert washouts, and gullying. The WDNR's Watershed Analysis Surface Erosion Methodology was used to analyze road surface erosion in the South Fork Tolt Municipal Watershed. Using this approach, a complete field inventory of the road system was conducted in 2006 and predictions of sediment delivery were made using the Washington Road Surface Erosion Model (WARSEM; Dube, 2007), as shown on Map 12. This analysis also helped in the identification and prioritization of roads for future road work, including improvements and decommissioning, as discussed in Chapter 9 of this watershed management plan.

Sediment
Soil particles suspended in water; when elevated above normal levels, sediment can reduce water quality and habitat health.

Though previous road surface erosion assessments in the SFTMW (Raines, 1993; WDNR, 1997) were based on extrapolation of road conditions from a few miles of surveyed roads, their methods and assumptions were similar to those of the current assessment, allowing a comparison of road surface erosion predictions over time. These estimates based on model results should be used as relative indices rather than absolute values.

The 1993 estimate of surface erosion from

**TABLE 5-1.
MATRIX USED TO ASSIGN LANDSLIDE HAZARD RATINGS FOR SLOPES IN THE MUNICIPAL WATERSHED**

	Landslide Hazard Potential		
Slope Gradient Class	Convex Slope	Planar Slope	Convergent Slope
Class A (0 to 57% slopes)	Low	Low	Low
Class B (57 to 62% slopes)	Low	Low	Moderate
Class C (62 to 72% slopes)	Low	Low	High
Class D (72 to 82% slopes)	Low	Moderate	High
Class E (>82% slopes)	Moderate	High	High

roads within the SFTMW was 2,400 tons per year, and the 1998 estimate was 1,100 tons per year—a 55-percent reduction. The current estimate is 240 to 330 tons per year, an 85- to 90-percent reduction from the 1993 estimate. The estimated reduction in road erosion between 1993 and 2006 likely reflects road improvements, including grading and surfacing, as well as decommissioning and reductions in road use.

Alteration of Peak Flows Driven by Rain-on-Snow Processes

Timber harvest creates large openings within the transient snow zone, between roughly 2,000 and 3,500 feet in elevation, facilitating the establishment of deep snow packs, which are then prone to rapid melt during heavy winter storms. Map 13 shows the rain-on-snow zone in the municipal watershed. During such storms, this increase in snowmelt translates into higher stream flows, which may increase bed scour and contribute to increased erosion of exposed stream banks. Conditions that are likely to enhance flows generated by rain-on-snow events include conversion of mature stands with greater than 70-percent canopy cover to less than 10-percent cover. In addition, mass wasting and other disturbance processes that create large canopy gaps in the transient snow zone may also increase the frequency and/or duration of flows driven by this process.

An analysis of subbasin sensitivity to this process (HydroLogic Services Co., 2007) predicts that the following subbasins in the municipal watershed are potentially highly or moderately sensitive to significant reductions in forest canopy (see Map 14):

- Subbasins with high peak-flow sensitivity:
  - Consultant Creek
  - North Shore West
  - North Shore Central
  - North Shore East
  - Phelps Creek
  - South Shore Southwest
  - South Shore West
- Subbasins with moderate peak-flow sensitivity:
  - Rainbow Creek
  - East Shore
  - South Shore East
  - Skookum
  - South Shore Southeast
  - Chuck Judd
  - Siwash
  - Crystal Creek

Rain-on-snow-generated peak flows in the other subbasins are relatively insensitive to changes in forest canopy. Lack of subbasin sensitivity to this process generally reflects less area in the transient snow zone relative to higher elevation bands where snow packs are more persistent.

Tree Recruitment Processes

Recruitment of large trees is critical to the maintenance of riparian and in-stream habitat in many of the SFTMW’s streams. The functional role that wood plays in a stream depends on a variety of factors, as described in the Stream Channel Assessment (Raines, 2007b). The size of wood necessary for stability in a stream channel dramatically increases with stream size and width. Trees greater than 24 inches diameter at breast height (dbh) are needed to provide stable, functional elements in large streams. Therefore, riparian timber harvest along larger, low-gradient streams has a greater, longer-lasting impact on tree recruitment because it requires many more years to grow adequately sized trees to provide stability for these streams.

In the SFTMW, 63 percent of the riparian stands consist of 12- to 24-inch dbh conifer and mixed-composition stands, and 11 percent are dominated by <12-inch dbh conifers and mixed species (Bretherton, 2007). While tributaries in the municipal watershed are generally small and adjacent riparian corridors are composed of conifers of sufficient size to be hydraulically stable upon recruitment, historical timber harvest coupled with active wood removal from these streams has resulted in very low wood levels in most streams (Raines, 2007b). Active restoration involving directional felling of riparian trees into these small tributaries is a viable option, since most riparian trees are of sufficient size to provide stable in-stream structures.

Felling of trees into small streams is beneficial to habitat.

Headwater Sediment Storage Capacity

The supply of coarse sediment to lower-gradient tributaries has increased over the last 50 years due to several factors:

- An increase in the frequency and size of shallow, rapid landslides associated with road construction and timber harvest (Raines, 2007a);
- Harvest of stream-adjacent forests, which triggered extensive bank erosion; and
- Reductions in the sediment storage capacity of headwater channels due to the removal of large trees needed to create dams.

A simple sediment budget was constructed to estimate quantities of coarse sediment being transported through each subbasin naturally and as a result of land management since the 1960s (Figure 5-1). When averaged over the period of record, roughly 50 years, the following subbasins stand out as producing large quantities of coarse sediment:

- Subbasins with high overall coarse sediment input:
  - Chuck Judd
  - Consultant
  - East Shore
  - North Shore East
  - Phelps

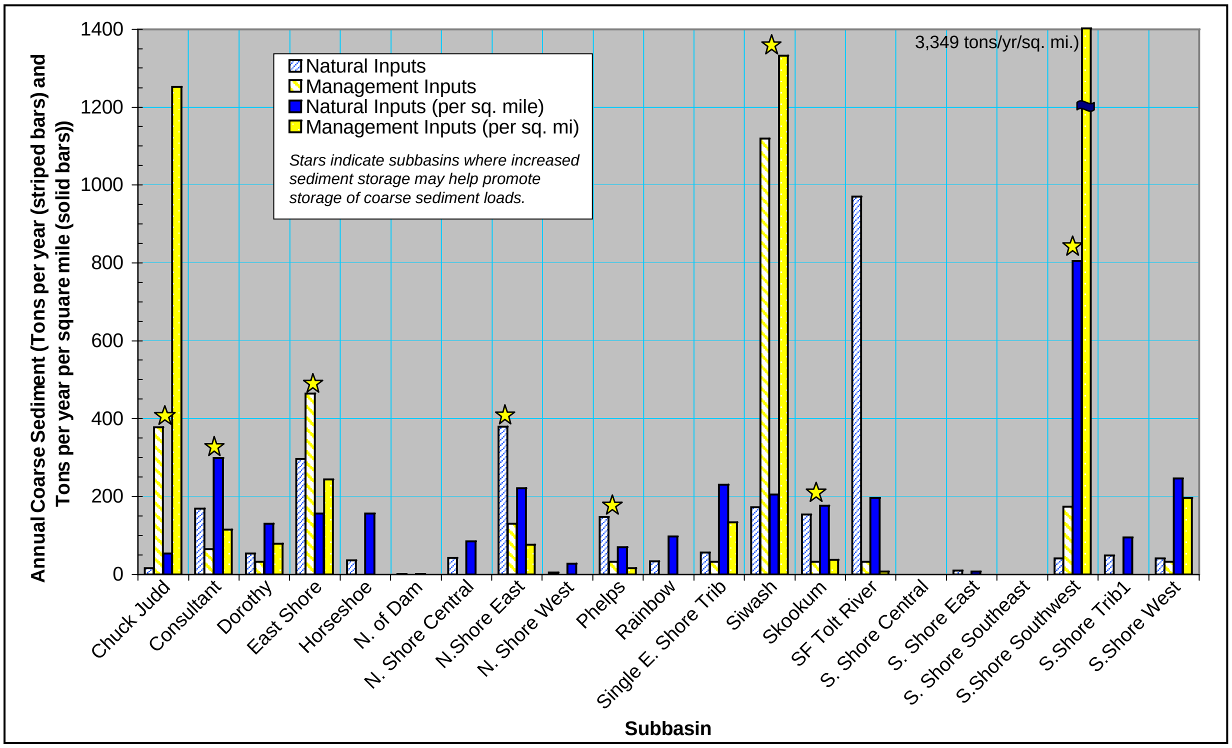


Figure 5-1. Estimates of Annual Coarse Sediment Transport (tons per year) by Subbasin.

- Siwash
- Skookum
- USFS/South Fork Tolt River
- South Shore Southwest

• Subbasins with high management-related coarse sediment input:

- Chuck Judd
- East Shore
- Siwash
- South Shore Southwest

• Subbasins with high natural coarse sediment input:

- Consultant
- East Shore
- North Shore East
- Phelps
- Siwash
- Skookum
- USFS/South Fork Tolt River

With the exception of USFS/South Fork Tolt subbasin, which drains a disproportionately large area and is largely in an undisturbed state, all subbasins that are generating large volumes of coarse sediment could benefit from restoration efforts, which enhance sediment storage in headwater channels. With few exceptions, these channels are steep headwater channels convergent topography, as shown on Map 11.

Other Human Alterations

Activities associated with reservoir construction—timber harvest, stump pulling, burning, and subsequent flooding within the inundation zone of the reservoir—resulted in the most significant and obvious changes to channel conditions in the SFTMW. Pre-dam clearing of the reservoir area is described in the 2007 *South Fork Tolt Fish Habitat Assessment* (White, 2007). Over 3.5 miles of main stem and many miles of tributary stream were flooded, and the lower portions of Consultant and Crystal creeks were diverted. Crystal Creek has been diverted into the 50 Road ditch to drain away from the immediate area of the dam. The pre-dam configuration of Consultant Creek is not included in a historical reference to the diversion of that creek. Prior to dam completion in 1962, a natural falls just below the dam prevented access to these waters by anadromous salmonids.

Sensitive Resources

Although the entire stream and wetland network provides for nutrient transport and migration corridors for wildlife species, a portion of the network may provide the greatest benefit and is therefore classified as sensitive aquatic resource. The vast majority of streams in the municipal watershed (84 percent) have slopes steeper than 20 percent and generally do not provide fish habitat. Map 11 shows the classification of streams and wetlands in the SFTMW.

Stream reaches in the lower-gradient classifications are vulnerable to impacts associated with fine sediment deposition and are likely to see significant habitat improvements from LWD inputs. Only 4 percent of streams mapped fall into a "response reach" category, where active restoration efforts are likely to significantly benefit fish habitat (alluvial fan, moderate width floodplain, narrow floodplain, and placid flow channel types; see Map 11). These are low-gradient streams (slopes <4 percent) with wide valleys and sufficient flows to mobilize sediment and wood. They primarily lie on the floodplain where the South Fork Tolt River flows with the Tolt Reservoir, between the reservoir and the 70 Road crossing. They include the main stem, main stem side channels, and tributary streams occupying the margins of the larger valley.

Most response reaches are small tributaries immediately downstream of high energy reaches through which hillslope disturbances are propagated. As a result, changes in sediment loads from historical management activities have adversely impacted most low-gradient tributary reaches, resulting in loss of pool habitat and channel complexity in fish-bearing streams.

Sensitive Resources
Portions of the stream and wetland network that provide the greatest benefits in terms of nutrient transport and wildlife migration corridors.

Main-Stem Processes

Moderate gradient (4- to 8-percent) reaches are not common in the SFTMW, and are largely restricted to Phelps Creek and parts of the main stem. Most have experienced elevated sediment loads or debris flow scour in addition to riparian harvest, leading to localized channel incision, bed coarsening, and a decrease in channel complexity. Other manifestations of disturbance include increases in bank erosion and lower frequencies of pools and LWD. While the level of incision and channel widening is variable, the critical functions that large wood provides in these streams, coupled with the dominance of young riparian trees along these reaches, suggest that the time needed for recovery of natural channel functions in these reaches is likely on the order of 50 to 100 years.

Metzler (1993) quantified the disturbance in the main stem channel for the period of 1942 through 1987, prior to and following floodplain timber harvest by 1958 and reservoir filling in 1962. Metzler estimated that 85,000 cubic yards of sediment was eroded in the channel widening that occurred between 1958 and 1964. Since then the active channel has gradually narrowed, and it now

Response Reach
A stream segment where active restoration efforts are most likely to benefit fish habitat because the stream channel responds to changes in watershed processes.

appears to have returned to its pre-harvest size. Stream surveys in 1993 found no pools in this reach, consistent with the lack of mature wood available for recruitment, the coarse substrate, and the recovering but unstable channel. Consistent with those trends, a stream survey in the fall of 2006 found pools forced by banks and root wads eroded from stream banks in this segment, indicating that wood recruitment, pool frequency, and spacing are slowly recovering in this portion of the main stem channel.

One area, located in the upper watershed on USFS land, has been a source of debris and sediment input to the main stem channel above the reservoir since it was first inventoried in 1982, although the area and length of downstream channel disturbance is diminishing (Raines, 2007a). Metzler (1993) noted a similar debris flow in the headwaters of Phelps Creek prior to 1964, with little change in the open channel through 1987, a period that included riparian harvest. The upper Phelps Creek channel still appeared "bright" and visible in 2001, suggesting a naturally open condition with chronic sediment movement exacerbated by the riparian harvest.

Wetlands

The steep topography in the SFTMW does not present abundant opportunity for wetland habitat, and only a few depressional wetlands, one lacustrine fringe wetland, and one riverine wetland are present within City-owned land, as shown on Map 11 (Chapin et al., 2007). Several depressional wetlands located on benches along the south ridge boundary of the SFTMW provide ponded water and small meadow systems for a variety of species, including amphibians. Although past timber harvest altered the forests surrounding these wetlands, they are not currently threatened by land management practices. A lacustrine fringe wetland and a riverine flow-through wetland at the eastern margin of the reservoir at the confluence of the South Fork Tolt River are seasonally inundated as the reservoir is filled and lowered. These areas provide conditions for wetland vegetation and fish and wildlife habitat.

Several depressional wetlands located on benches along the south ridge boundary of the SFTMW provide ponded water and small meadow systems for a variety of species, including amphibians.

Sensitivity to Inputs of Fine Sediment

The Stream Channel Assessment (Raines, 2007b) includes a detailed discussion about the likely impact posed by fine sediment for each channel type. Streams where increases in fine sediment are likely to have significant impacts over an extended period of time include Floodplain (FP) and Narrow Floodplain (FPN) channel types. Streams with a slightly lower sensitivity to fine sediment include Alluvial Fan (AF and AFd), Floodplain Delta (FPd), and Moderate Gradient and Width (MM) channel types. Large chronic inputs into moderately sensitive channel types are likely to produce relatively short-term effects on in-stream habitat. Map 12 shows the streams in the SFTMW that are most likely to exhibit adverse impacts from increases in fine sediment.

Sensitivity to Peak Flows

Channel types that are likely to exhibit the most significant, long-term adverse impacts in response to an increase in the duration or frequency of peak flows include the Floodplain (FP), Floodplain Delta (FPd), Alluvial Fan (AF), and Alluvial (debris) Fan (AFd) channel types. Adverse impacts are likely to include extensive gravel scour, bed coarsening, greater bank erosion, or channel incision. Channels with a moderate sensitivity to this process include Moderate Gradient and Width (MM), Moderate Gradient Narrow (MMN), and Steep Foot-Slope (SC) channel types. Significant variability likely exists, depending on local armoring of the bed and banks and the capacity for lateral dispersal of high flows. Map 14 shows the streams in the SFTMW that are most likely to exhibit adverse impacts from increases in peak flows.

Sensitivity to Landslides and Debris Flows

In steep headwater tributaries, extensive scour with localized deposits of debris has reduced the streams' capacity to store and regulate the transport of sediment, water, and nutrients to downstream fish-bearing reaches and the reservoir. While the recovery of these reaches can be relatively quick, the recurring nature of these disturbances, coupled with the cumulative effect associated with low amounts of in-stream wood and potentially elevated peak flows, suggests that recovery is likely to occur more slowly and in localized reaches. Streams prone to chronic scour and disturbance as a result of these processes include Very Steep Headwater Channels (in convergent and planar topography), Steep Headwater Channels, and Alluvial Fan (AF) and Alluvial (debris) Fan (AFd) channel types (Map 11).

Low-gradient reaches into which landslide debris has been routed have exhibited dramatic channel widening, localized incision, extensive bank erosion, and loss of pool habitat.

Low-gradient (response) reaches into which landslide debris, largely sediment, and wood, has been routed have exhibited dramatic channel widening, localized incision (disconnection with adjacent floodplain surfaces), extensive bank erosion, and loss of pool habitat. Streams most prone to extensive, long-term destruction of habitat as a result of this process include Floodplain (FP), Floodplain Delta (FPd), Alluvial Fan (AF) and Alluvial (debris) Fan (AFd) channel types.

Fish Barriers

Current knowledge about fish usage is described in Chapter 6, and appears to be primarily cutthroat trout and cutthroat/rainbow trout hybrids. Lower-gradient reaches of streams relatively close to the reservoir are the primary habitat areas, with little/no use of the steep headwater reaches of the SFTMW (Map 15).

Linkages of Past Impacts and Sensitive Resources

Resources that likely have been severely degraded as a result of past management activities can be identified by coupling the identification of areas that have likely been impacted by past practices with the identification of sensitive resources. An examination of these linkages was facilitated using ArcGIS, which can provide, for example, overlays showing the following combinations of information:

- High sediment generating roads, as modeled using a road sediment model and road inventory data, that are delivering directly into fish-bearing reaches where fine sediment is likely to deposit; this information can be used to prioritize roads for decommissioning or improvement.
- Stream reaches where channel morphology is strongly controlled by large woody debris and where the current adjacent riparian forest is too young or altered to provide functional wood to those streams in the near term; this information can be used to identify riparian restoration projects.
- Riparian zones dominated by conifers exceeding 12 inches dbh that are adjacent to steep-gradient channels in subbasins predicted to be transporting large quantities of coarse sediment; this information can be used to identify headwater restoration projects.

The synthesis of this information contributed to the identification of management-specific issues and recommended actions discussed in the following sections.

LEGAL REQUIREMENTS

Aquatic restoration activities recommended for this management plan include thinning in riparian forests and placement of LWD in stream channels, both of which are regulated by state laws. Riparian forest thinning is subject to state regulations under the state Forest Practices Act (WAC- 222), and LWD placement is subject to requirements of the state Hydraulic Code (WAC-220-110).

The Forest Practices Act (FPA) restricts forest management activities, which includes restoration and ecological thinning, within Riparian Management Zones (RMZ). The prescriptions for restoration and ecological thinning that would be used to meet any aquatic or restoration objectives were developed to be in compliance with the Forest Practices Act, as described in Chapter 4 and in Appendix A. If any thinning project did not meet FPA requirements for management activities within the RMZ, SPU would obtain approval of an “alternative plan” from WDNR, as specified in WAC-220-110.

Recommended aquatic restoration activities include thinning in riparian forests and placement of LWD in stream channels, both of which are regulated by state laws.

Because LWD placement in streams of the SFTMW would alter the flow of water in state waters, a Hydraulic Permit Application (HPA) is required to be in compliance with the state Hydraulic Code. SPU would obtain an HPA for any proposed LWD placement projects in the SFTMW prior to implementation.

ISSUES

Past and recent resource assessments provide the foundation for the following list of issues. These issues, organized by type of disturbance, represent the most significant situations where current conditions and management activities are adversely impacting or impeding the recovery of sensitive aquatic resources.

Issues Associated with Timber Harvest

LWD Recruitment

There is poor near-term LWD recruitment potential in large, low-gradient, fish-bearing streams. Timber harvest in the SFTMW has left a legacy of riparian areas with smaller conifers and some deciduous dominated stands. LWD recruited from current and future riparian forests should be functional in smaller streams, but larger streams will be deficient in LWD large enough to provide stable, functional elements within the active channel for many decades, even with restoration.

Peak Flows

Future timber harvest could lead to a greater frequency of rain-on-snow generated peak flows. Approximately 26 percent of the SFTMW is within the transient snow zone where the effects of timber harvest on rain-on-snow generating processes are likely the greatest. For example, within Phelps Creek subbasin where recent timber harvest has significantly reduced current canopy cover, the likelihood of increasing the frequency and magnitude of rain-on-snow generated peak flows is high. If future timber harvest were to result in large clear cuts within the transient snow zone in any of the North Shore (Central, West, and East) or South Shore (Southwest and West) subbasins, the frequency and duration of rain-on-snow generated peak flows would likely increase significantly.

Issues Associated with Road Construction

Fine Sediments

Fine sediment is being delivered to streams from some portions of the SFTMW road system. The road system, built to manage the basin as a water supply and to extract timber, has much less traffic since timber harvest is no longer occurring, and fine sediment delivery has decreased substantially from historical levels. However, there are some stream crossings where fine sediment delivery is still a problem and that are out of compliance with state regulations.

Wetland Impacts

Roads within or adjacent to wetlands can act as barriers to movement of amphibians using these wetlands as habitat. Although there are few depressional wetlands in the SFTMW, some of these wetlands are bordered by active or decommissioned roads. Because revegetation of the decommissioned roads has been slow, they may still be acting as barriers to amphibian movement.

Fish-Passage Barriers

Improperly installed or poorly maintained culverts represent fish-passage barriers on streams. An intensive fish survey in 1995 (Tappel and Tappel., 1995) identified two culverts—on Siwash Creek and what was referred to as Stream N12—as barriers to fish passage. The upstream extent of fish usage has not yet been established in all tributaries using current Forest Practice Board Protocols, however, and fish have been documented in other watersheds in streams up to 35 percent in slope. Current water typing within the SFTMW has only been done for streams up to 16 percent in slope (using pre-emergency ruling protocols), and it is possible that a few additional culverts are barriers to fish passage in streams with slopes between 16 and 35 percent.

Compliance with Forest Practices Regulation

There are some roads in the SFTMW that remain out of compliance with WDNR forest practices regulations. Although roads in the SFTMW are not currently being used for forest management, some roads constructed for past timber harvest retain a legacy of issues, such as log culverts, over-steepened fill slopes, soft fill-slope shoulders, water running across road tread, and side-cast berms. These problems need to be remedied in order to bring the roads into compliance with state regulations.

Although roads in the SFTMW are not currently being used for forest management, some roads constructed for past timber harvest retain a legacy of issues, such as log culverts, over-steepened fill slopes, soft fill-slope shoulders, water running across road tread, and side-cast berms.

Issues Associated with Timber Harvest and Road Construction

Stream Channel Impacts

Timber harvest and road construction have resulted in bank instability, channel widening, and turbidity within the reservoir. These effects have occurred in two types of streams: moderate gradient streams subject to debris torrents (e.g., Skookum and Phelps creeks) and lower gradient streams with broad floodplains (i.e., main stem of South Fork Tolt River). The negative effects of bank instability and channel widening have diminished in recent years, but the South Fork Tolt main stem remains an area of concern due to its high aquatic habitat value and sensitivity to further disturbance.

Landslides

Timber harvest and road building in the SFTMW can result in an increase in the frequency of landslides, which deliver sediment to fish-bearing streams and the reservoir. Past timber harvest and road construction in unstable areas greatly increased the frequency and size of shallow rapid landslides within the SFTMW. With the cessation of these management activities as well as the decommissioning of roads in unstable areas, landslide frequencies have decreased and are approaching background levels expected for unmanaged watersheds in steep, forested terrain. If extensive timber harvest and road reconstruction or building were to occur in unstable areas in the future, the frequency and size of shallow rapid landslides would likely increase.

Additional Considerations

The following water resource issues are not within the scope of this watershed management plan, but they are presented for separate consideration by SPU:

- Reservoir management that results in more frequent and prolonged exposure of unvegetated shorelines over extensive areas of the reservoir may result in more frequent turbidity events.
- More frequent and intense draw-downs can cause disconnection of reservoir and stream habitat.

Consideration of Options

Sediment impacts on the City's source water were a primary consideration in formulating recommended actions related to aquatic resources. Sediment contribution to the reservoir negatively impacts the City's water supply through reservoir infilling as well as higher filtration costs. Restoring aquatic resources will hasten recovery of the disturbed system to a more natural level of sediment contribution and prolong the lifespan of the reservoir.

Aquatic restoration is also a natural component of the forest management approach selected for the SFTMW. In formulating its recommendations, the Aquatic Resources work group considered two options: restoration only in lower stream reaches; and additional limited restoration in headwater areas to address sediment loading originating from these areas. Based on sediment budget calculations using available data, and historical observations about sediment transport through the stream systems, the Steering Committee selected the option that included limited aquatic restoration in headwater areas. Aquatic restoration projects have been prioritized to a very limited area within the SFTMW where both short- and long-term benefits to the City's water supply can be ensured.

Aquatic restoration projects have been prioritized to a very limited area within the SFTMW where both short- and long-term benefits to the City's water supply can be ensured.

Recommended Actions

Many streams in the SFTMW are still recovering from a legacy of road building and intensive timber harvest. Several restoration and management actions are recommended to protect streams and other aquatic resources from further degradation and to accelerate their recovery. These actions fall into four general project types: LWD placement projects, headwater riparian forest projects, riparian treatments along fish-bearing streams, and road decommissioning and improvements.

LWD Placement Projects

Recommendation AQ1—The main stem South Fork Tolt River between the reservoir and the 50 Road bridge was destabilized by LWD removal, loss of riparian vegetation, and lack of LWD recruitment following timber harvest. The destabilized, braided channel system in this reach (Channel Segment 102) has recovered substantially over the past 20 years, losing its braided character and developing a vegetated floodplain. However, some floodplain channels (FP and FPN channel types) tributary to this segment and or the reservoir (Channel Segments 301, 530a, and 531) are still threatened by management-related channel instability and lateral scour within Segment 102. These channels provide cutthroat trout spawning and rearing habitat. Construction of engineered log jams to deflect flow away from these floodplain channels would reduce the likelihood of main stem channel avulsion and partial or complete scour of the floodplain channels while allowing the natural channel migration processes to continue in this reach. Addition of LWD to one of these floodplain channels (Channel Segment 530a) would also improve fish habitat by creating cover and promoting pool development.

Headwater Riparian Thinning

Recommendation AQ2—Riparian thinning involving directional felling toward steep gradient, high sediment producing streams would create needed sediment storage sites, thereby reducing the chronic disturbance to downstream habitat, as well as moderating the release of sediment into the reservoir. Riparian thinning would also increase the growth rate of trees, resulting in the recruitment of larger trees into these streams over the next 50 years. As the capacity for sediment storage behind woody debris is proportional to the square of the trees diameter, larger trees equate to significantly increased storage capacity.

Treatment of riparian areas along non-fish bearing streams in headwater areas will be prioritized separately in conjunction with upland forest restoration treatments. Riparian areas will be selected for cut-and-leave thinning where they can be cost-effectively included within larger upland treatments and where they offer the most benefit to sediment retention and bank stability, namely within Very Steep Headwater Channels (in convergent topography) and Steep Headwater Channels.

Riparian Treatments on Fish Bearing Streams

Recommendation AQ3—As a result of timber harvest, the future recruitment potential of large trees to fish-bearing streams has been reduced. Current riparian forests along fish bearing streams are commonly dominated by either deciduous trees or small to medium-sized conifer trees, some of which are too small to create stable, high quality fish habitat in larger streams such as the main stem South Fork Tolt River and Phelps Creek. Also, LWD from red alder decays rapidly and thus does not function well in streams. Increasing the growth rate of existing conifer trees by thinning and by under-planting conifer trees in deciduous dominated riparian stands will increase future LWD recruitment potential. To address this issue, riparian zones associated with the larger fish-bearing streams will be further evaluated to assess the efficacy of active restoration involving riparian thinning and under-planting.

Prioritizing fish-bearing stream reaches for riparian treatments to increase future LWD recruitment potential is based, in order of importance, on three criteria:

1. **Current functional level (amount of LWD currently present in channel) and successional trajectory of riparian forest for future LWD recruitment—** The level of key functions is examined first, because current versus expected future condition is fundamental to

determining whether restoration is even needed.

2. **Potential response to restoration actions**—Potential response to restoration is considered next in order to ensure that possible restoration actions have a reasonable chance of achieving desired benefits.

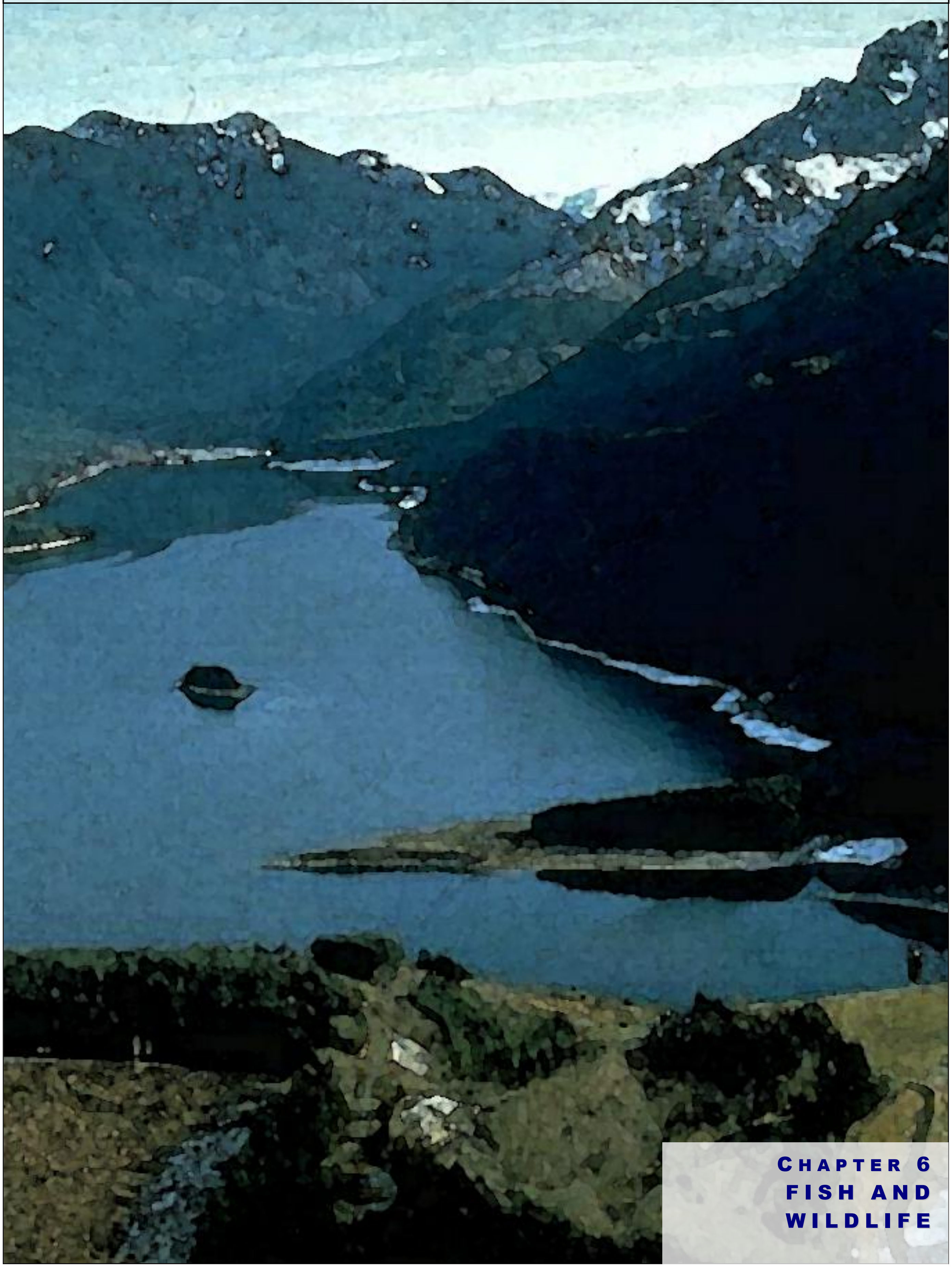
3. **Importance of LWD to the stream reach**—Importance of key functions is then examined to evaluate the potential benefit of implementing a restoration action.

Finally, project sites will be prioritized so as to coordinate with other technical areas, ensuring that work requiring access by a specific road network is completed in a given time period and any needed road improvements or decommissioning can occur in a timely manner. Completed headwater riparian treatments and in-stream LWD placement in the Skookum Creek sub-basin are a good example of this prioritization and coordination.

Road Decommissioning and Improvements

Roads constructed to support timber harvest activities have been responsible for increased sediment delivery and debris flow frequency in the SFTMW. A substantial amount of these roads have been decommissioned or improved, and the impacts on aquatic resources have diminished significantly in the past 15 years. However, remaining roads continue to deliver sediment to streams, and decommissioning any unnecessary roads and improving remaining roads would further reduce these impacts. In addition, there are a few stream crossings where roads are likely blocking fish passage, which need to be addressed to comply with state regulations. A prioritized schedule for recommended road work is provided in Chapter 9. This schedule addresses the following general actions:

- Continue decommissioning roads no longer needed. Priority roads for decommissioning include roads within unstable terrain (55 Road) and those delivering sediment to fish habitat and sensitive wetlands.
- Reduce hydrologic connectivity of roads. Hydrologic connectivity can be reduced by installing ditch line traps, settling basins, or ditch vegetation to trap and filter sediment on roads that parallel the reservoir and have high connectivity to aquatic areas.
- Improve drivability of steep, rough road sections that must be kept open. This can be accomplished by directed grading efforts to remove side-cast berms (unless they are specifically needed to prevent water drainage to steep, unstable slopes).
- Implement a program of regular inspection and maintenance, particularly of problem roads and during storms.
- Fix existing fish barriers at stream crossings, generally by replacing blocking culverts with new, properly installed and sized culverts.



CHAPTER 6
FISH AND WILDLIFE

CHAPTER 6. FISH AND WILDLIFE

BACKGROUND

The vast majority of old-growth forest habitat in the western Cascade Mountains has either been lost to development or converted by industrial forestry to young forest with relatively simple habitat structure and substantially reduced species diversity. Consequently, wildlife populations dependent on complex old-growth forest conditions have decreased dramatically, with some species, such as northern spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*), being listed as threatened by both federal and state government. The South Fork Tolt Municipal Watershed is located near late-successional forest on U.S. Forest Service lands to the east. This proximity provides a unique opportunity to decrease the habitat fragmentation caused by past forest management activities in the municipal watershed and increase the total amount of late-successional forest habitat for these at-risk species.

Fish and other wildlife are key ecosystem components. Restoration of a naturally functioning ecosystem with all its component elements is consistent with the following SPU goals for the SFTMW:

- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the SFTMW, and
- **Goal 4**—Manage the SFTMW based on social, environmental and economic considerations.

CURRENT CONDITIONS

Forest Habitat

The current forest in the SFTMW is dominated by sapling/pole and small tree single story-closed habitat classes. This relatively structurally simple forest provides poor wildlife habitat for most wildlife species. The small amount of old-growth forest consists of small, fragmented patches, providing habitat for some species, but minimal or no habitat for wildlife species with large home ranges. Forest habitat is described in greater detail in Chapter 4.

Aquatic Habitat

The aquatic habitat in the SFTMW consists of the SF Tolt Reservoir and Crater Lake, the SF Tolt River, and several smaller named and unnamed streams. As

Highlights

Habitat for fish and wildlife in the SFTMW has been severely impacted by the history of timber harvest in the watershed. Only a small portion of the forest remains as old-growth habitat, and stream habitat for fish has been degraded. No formal surveys of wildlife in the watershed have been conducted, but the presence of several important species, such as the common loon and the threatened spotted owl and marbled murrelet, has been documented.

The following actions are recommended:

- Perform complete mapping of special habitats, with ground verification.
- Require assessments of key habitat features as part of the planning phase for projects in the municipal watershed.
- Perform surveys for common loon, marbled murrelet and amphibians.
- Continue monitoring and providing nesting platforms for the common loon.
- Perform an assessment of habitat quality for the northern goshawk.
- Protect any found nest sites of listed or sensitive species
- Leave large woody debris found on the reservoir delta in place, and stockpile large woody debris removed from the reservoir for use in stream restoration.
- Decommission all forest roads not needed for maintenance, resource protection or water quality.

discussed in Chapter 5, few wetland features exist in the SFTMW. The rarity of these aquatic habitats in the SFTMW increases their importance to a variety of wildlife species. Aquatic habitat is described in greater detail in Chapters 2 and 5.

Special Habitats

Non-forested special habitats such as rock outcrops, cliffs, talus slopes, meadows, wetlands, and shrub-dominated sites are generally limited in extent and found primarily in the southeastern portion of the SFTMW (Map 16). The current preliminary classifications were generated from aerial photo interpretation and require field verification. Additional special habitats, such as snag clusters, also need to be mapped if they are visible above the forest canopy. Because these special habitats can support unique flora and fauna and are limited in extent, it is critical that they be identified and protected during any management activities, including restoration projects.

Impacts on Habitat from Past and Ongoing Management Activities

A history of clear-cut timber harvest has reduced or degraded forest habitat for wildlife species in the SFTMW. Over the past 50 years, the municipal watershed has undergone conversion of structurally diverse old-growth forest in upland areas to early-successional forest with small trees, which has greatly reduced available habitat for old-growth dependent species, such as northern spotted owl and marbled murrelet. Sediment

Phelps wetland.

input from roads directly associated with timber harvest has degraded habitat for fish and other aquatic species.

The forest road network present in the municipal watershed accesses most forest habitats, traverses many streams and riparian corridors, and either traverses or is immediately adjacent to other types of special habitat in several areas. Forest roads result in fragmentation of both terrestrial and aquatic habitats, create migration and dispersal barriers for many fish and wildlife species, create disturbance relative to types of use and traffic levels, and have the potential to degrade stream and other aquatic habitat quality due to alteration of natural hydrologic regimes and/or the delivery of fine sediments to these systems (see Transportation and Aquatic Resources chapters). Human activity and disturbance associated with forest roads (e.g., equipment operation, construction, blasting, vehicle traffic) is generally identified as causing significantly modified behavior and/or direct mortality to a wide variety of wildlife species. Several sections of individual forest roads and/or portions of road systems have been decommissioned in recent years. These roads are currently reverting to forest cover and previous adverse impacts to fish and wildlife have either been removed or significantly diminished. Road segments in the SFTMW currently identified as having potential adverse impacts on fish and wildlife are indicated in Map 16).

There are potential impacts to wildlife habitat from invasive plant species, particularly yellow hawkweed, which could invade open habitats such as meadows. Refer to Chapter 7 on Invasive Plant Species for detailed discussion of these potential impacts.

FISH AND WILDLIFE SPECIES

Old-Growth-Dependent Species

To date, no surveys for spotted owls or marbled murrelets have been conducted within the City-owned portion of the SFTMW, and no documentation of their presence is available. However, both spotted owls and marbled murrelets have been documented using the unharvested, mature forest in the USFS-owned portion of the SFTMW. The most recent spotted owl sighting was in 1998, about 6 miles due east of the SPU property boundary on USFS land. Murrelets were documented within 1 mile of City land in the SFTMW in 2000 and 2002. If these populations persist, they could serve as source populations to recolonize forest in the City-owned portion of the SFTMW once the forest habitat is restored to late-successional conditions and appropriate habitat is again available. Late-successional forest already present to the east, and potentially to be established in the future within City lands should also provide habitat for many other old-growth dependant species of flora and fauna. Northern goshawk (*Accipiter gentilis*) could currently be nesting in the large tree habitat class in the southeastern portion of City land (Map 9), as well as in the old-growth forest habitat to the east. No surveys for this species have been conducted in the area. Wolverine (*Gulo gulo*) have been recently documented in the vicinity of Snoqualmie Pass, approximately 20 miles southeast of the SFTMW. Although wolverine are extremely rare in the state of

The early-successional forest, with small trees, has greatly reduced available habitat for old-growth dependent species, such as northern spotted owl and marbled murrelet.

Washington, it is possible that they could occur in the SFTMW, given their occurrence elsewhere in the central Cascade Mountains. However, because they are likely to be restricted to old-growth forest habitat, they would not likely be found in second-growth forest of City-owned lands within the watershed.

Elk and Deer

The history of timber harvest in the SFTMW and the ongoing intensive commercial harvest in adjacent ownerships to the north, west, and south has resulted in substantial early-successional forest habitat over most of the area. Despite the availability of this large amount of early-successional habitat, which is particularly favored by ungulate species such as black-tailed deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus*), the Washington Department of Fish and Wildlife (WDFW) has no documented records of elk being present in the entire South Fork Tolt basin, either historically or at present. Deer densities are relatively higher in adjacent ownerships that are managed under commercial, short rotation harvests than on City-owned land within the SFTMW where the forest is presently dominated by dense conifer regeneration.

WDFW, as the agency responsible for management of wildlife throughout the state, including game species such as elk, has no management focus on elk within the South Fork Tolt basin. The SFTMW is included in

Game Management Unit #460, where hunting seasons for both elk and deer, including modern firearm, archery, muzzleloader, and special hunts (deer only) are established by State of Washington regulations. It is, however, unlawful to trespass on private lands, including for the purpose of hunting. "Entry onto any lands which are fenced, posted, cultivated, or used for commercial agricultural crops or aquaculture without permission is considered trespass." (State of Washington 2007). Elk are unlikely to disperse into the SFTMW or to establish a viable population anytime in the near future due to the lack of a nearby source population and the fact that little early-successional habitat will be created from forest restoration projects in the municipal watershed.

Common Loons

Washington state is on the southern edge of the breeding range for the common loon (*Gavia immer*), and the density of nesting pairs has presumably never been as high in Washington as in more northern areas. With the loss of most undisturbed lowland lake habitat to development, however, there are now only about 12 to 15 active breeding sites (in any given year) remaining in the entire state. The South Fork Tolt Reservoir provides one of the few undisturbed lake environments in western Washington where loons can reproduce without high levels of human activity and substantial associated disturbance. However, its primary function as a municipal reservoir does present difficulties for nesting loons because rapid fluctuations in lake levels can flood or strand nests built on natural sites at the lake edge. To mitigate for the reservoir operations, SPU staff annually deploy and monitor a floating artificial nesting platform. Several platform locations have been tried, but the only successful location has been in the protected inner area of Consultant Creek bay. All other locations were unsuccessful because high winds and waves washed the nests from the platforms or dislodged platforms from anchorage. The Consultant Creek platform was first deployed in 2001. Starting in 2002 it has been used annually by a nesting pair. Although chick survival has not been high, the causes of mortality have not been related to the artificial nest platform.

Amphibians

A variety of amphibian species depend upon the small ponded depressional wetlands for breeding and rearing habitat. Although extensive breeding surveys were not conducted, during surveys for wetlands several species were documented using the SFTMW: Pacific tree frog (*Hyla regilla*), Cascades frog (*Rana cascadae*), western toad (*Bufo boreas*), northwestern salamander (*Ambystoma gracile*), and rough-skin newt (*Taricha granulosa*). It is highly likely that long-toed salamander (*Ambystoma macrodactylum*) is also present at these sites. During fish surveys in 1994, Pacific giant salamander (*Dicamptodon tenebrosus*) and tailed frogs (*Ascaphus truei*) were observed in stream aquatic habitat (Tappel and Tappel, 1995). No ongoing threats to habitat integrity exist at wetlands in the SFTMW. As forests surrounding the depressional wetlands mature and develop late-successional characteristics, the value of these areas as migration pathways and foraging sites for amphibians will improve.

Other Wildlife Species

There have been no surveys conducted for any wildlife species in the SFTMW. Because the predominantly small tree, single story forest habitat currently provides little complex structure or species diversity, and thus few habitat niches, the number of species present and the number of individuals of most species would be limited. However, if appropriate habitat conditions are present, most wildlife species commonly found in coniferous forest in the western Cascade Mountains could be present in the SFTMW or in adjacent basins. Wildlife species expected to be found in or near the SFTMW are listed in Appendix B.

Fish

The only species of fish documented in the South Fork Told Reservoir is cutthroat trout.

To date, the only species of fish documented in the South Fork Tolt Reservoir is cutthroat trout (*Oncorhynchus clarki*). Cutthroat trout was the only species captured in the reservoir during studies conducted in 1976 and 1977 (Congleton et al., 1977), in 1994 by Seattle Water Department personnel and Fisheries Consultants (Tappel and Tappel, 1995), and in 2007 by Seattle Public Utilities staff (Seattle Public Utilities, 2007). Small fish such as sculpin, however, would not have been detected in the reservoir by the survey methods used in any of the studies to date (i.e., gill nets, angling). No bull trout (*Salvelinus confluentus*) or other char were found in the reservoir during any of these investigations.

The fish community using stream habitat within the SFTMW is relatively simple, and as surveys show, consists of coastal cutthroat trout (*Oncorhynchus clarki clarki*), cutthroat/rainbow (*O. clarki/mykiss*) hybrids, west-slope cutthroat (*Oncorhynchus clarki lewisi*), and torrent sculpin (*Cottus rhotheus*). West-slope cutthroat trout, a subspecies that is native to portions of the Columbia and Missouri river basins, was introduced to the SFTMW through stocking of Crater Lake at the headwaters of the South Fork Tolt River (White, 2007).

The main focus of the 1994 study (Tappel and Tappel, 1995) was the distribution of salmonid species in the lower reaches of several tributaries to the South Fork Tolt River and the reservoir (Map 15). These include small streams with limited habitat immediately north and south of the reservoir and Skookum Creek, Phelps Creek, and the South Fork Tolt River, which have substantially more potential habitat. Salmonids were found in only six of the small streams north and south of the reservoir and only in the lower reaches. Surveys conducted in more favorable habitat upstream of the reservoir in Skookum Creek, Phelps Creek, and the South Fork Tolt River documented salmonids at approximately 2,500, 3,000, and 8,000 feet upstream, respectively, from the mouths of each stream. Although this study documented an approximate upper limit of salmonid distribution in smaller tributaries to the reservoir, the upper limits of fish presence in Skookum and Phelps creeks and the South Fork Tolt main stem have not yet been definitively determined.

Cutthroat trout typically spawn in spring and summer in most streams in western Washington. Newly constructed redds were documented by the Wild Fish Conservancy conducting fish habitat surveys for SPU in mid-October 2006 in a small tributary of the South Fork Tolt River upstream of the reservoir (White, 2007). The seasonal timing of these redds suggested that bull trout might be present in the municipal watershed. Upon further investigation in the fall of 2007, SPU determined that adult cutthroat in the reservoir were in spawning condition and likely spawn in the municipal watershed in the fall (Seattle Public Utilities, 2007). Surveys of rearing salmonids near the site of the 2006 redds did not detect any young bull trout as would be expected if the redds were constructed by bull trout. Only cutthroat trout of varying size classes were present.

Cutthroat trout or cutthroat/rainbow trout hybrids have been observed in a large portion of the north slope reservoir tributary streams. The vast majority of fish documented in these smaller streams are of younger age classes, while the larger fish (age 2 and older) reside in the reservoir and to an unknown degree in the South Fork Tolt River. Fish are present in several south slope basins, including Siwash, Skookum and Phelps creeks, where lower-gradient reaches provide some habitat.

Cutthroat trout are known to spawn in the main stem South Fork Tolt River and associated low-gradient floodplain channels. These habitats provide the appropriate-sized gravel and flow conditions needed to successfully spawn and incubate. While spawning likely occurs in other tributaries feeding the reservoir, the majority of current spawning habitat likely falls in the South Fork Tolt River and immediate floodplain

SPU wildlife biologists building a nesting platform for the common loon.

habitat. Other slightly steeper stream reaches likely provide rearing and feeding habitat for other life stages of fish.

Legal Requirements

A variety of laws and regulations restrict impacts to fish and wildlife or their habitat, but only a few are likely to pertain to activities occurring in managing the SFTMW. These include the federal Endangered Species Act, state Shoreline Management Act, state Forest Practices Act, and state Hydraulic Code. Meeting the requirements of these laws and regulations by the City in implementing this management plan is important for protecting fish and wildlife populations and habitats, as well as to ensure the City is in full legal compliance.

The federal Endangered Species Act (ESA) protects species listed as threatened or endangered from "take." Northern spotted owl and marbled murrelet are the only federally listed species known to be in the SFTMW, although neither has been documented within City lands in the watershed. The term 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. 1532(18)). The U.S. Fish and Wildlife Service has further defined "harm" to mean "an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 C.F.R. 17.3).

Northern spotted owl and marbled murrelet are the only federally listed species known to be in the SFTMW, although neither has been documented within City lands in the watershed.

The state Shoreline Management Act (SMA, RCW 90.58), administered through the King County Shoreline Program (KCC Title 25), restricts activity within lake and stream shorelines of designated waters (generally 200 ft landward of the ordinary high water mark). The SMA protects aquatic and riparian areas, which are important habitat for a variety of fish and wildlife species. State shorelines in the SFTMW include the South Fork Tolt Reservoir and the South Fork Tolt River downstream of National Forest System lands in the MBSNF. Actions occurring within the SFTMW that are regulated by the Shoreline Management Act primarily pertain to forestry practices.

The state Forest Practices Act (FPA, WAC-222) is intended to protect both aquatic and upland habitat for fish and wildlife species from adverse impacts stemming from forest management activities and associated roads. The FPA also protects individuals of special status species, such as northern spotted owl and marbled murrelet, that are known to be present where forest management activities are occurring. Requirements for the FPA are addressed in Chapter 4 as they relate to forest practices, Chapter 5 as they relate to aquatic restoration actions, and Chapters 9 as they relate to watershed roads.

The state Hydraulic Code (WAC-220-110) restricts activities within stream channels and helps to protect aquatic habitat from adverse impacts. The law is administered by the Washington State Department of Fish and Wildlife and requires that any construction activity that will use, divert, obstruct, or change the bed or flow of state waters must do so under the terms of a permit (called the Hydraulic Project Approval, or HPA). In addition, the state Hydraulic Code requires that culverts on fish bearing streams not impede the passage of all fish life stages.

Issues

Status of Watershed Fish and Wildlife Habitat and Populations

The following issues relate to the need for greater information about the habitats and populations for fish and wildlife in the watershed in order to manage them effectively:

- Current habitat conditions are not well known. Some information about the amount and distribution of important habitats and special habitat features such as meadows, rock outcrops, talus, cliffs, snags, and downed wood was collected during data collection for this plan; however, detailed documentation of special habitat conditions has not yet been generated.
- Occurrences of most fish and wildlife species are not well known. Some fisheries surveys in the SFTMW have been completed, but there is little known about the presence and distribution of most terrestrial species, such as northern spotted owl, marbled murrelet, northern goshawk, and amphibians.

Preservation of Habitat Integrity

The following issues relate to preserving habitat in the SFTMW:

- Special habitats and special habitat elements are rare, but are important contributors to biological diversity.
- Habitat associated with known locations of species are in need of protection. Although there is little late-successional habitat in City-owned portions of the watershed, this habitat, important to many species, will increase as SFTMW forests recover from past disturbance and forest restoration projects are implemented. Other critical habitats include wetlands and aquatic areas.
- SFTMW management should not exacerbate natural disturbances. Disturbances, such as floods, forest fire, wind-throw and landslides, are natural components of the watershed ecosystem and are important in creating and maintaining habitat for many species of concern. However, land-use practices that increase the frequency, intensity, or extent of these disturbances are typically detrimental to fish and wildlife.
- The effects of climate change on the SFTMW ecosystem are uncertain. As the

Although a forest inventory and an assessment of aquatic conditions were recently conducted, the amount and distribution of many important habitats and habitat features have not been well documented.

SFTMW recovers from past human disturbance, it will do so under a climate regime that is different from that under which pre-disturbance ecosystems developed. The impact of these changing and uncertain conditions on species and their habitats are important to consider in managing the SFTMW into the future.

- There is uncertainty whether landscape conditions outside the SFTMW will remain constant. The City has little control over areas outside its ownership in the SFTMW and adjacent lands outside the SFTMW. Habitat conditions on these neighboring lands affect landscape-scale habitat connectivity for some species. Uncertainty about future conditions and activities on neighboring lands needs to be considered in managing land within the City-owned portion of the SFTMW with respect to species of concern.

Restoration of Ecological Processes

The following issues relate to restoring essential ecological processes in the SFTMW:

- Past management activities, such as clear-cut timber harvest and road construction, have resulted in negative impacts on forest, riparian and aquatic habitats. A variety of restoration actions are available to improve habitat conditions or accelerate the development of higher quality habitat for at-risk species.

The effects of climate change on the SFTMW ecosystem are uncertain. As the SFTMW recovers from past human disturbance, it will do so under a climate regime that is different from that under which pre-disturbance ecosystems developed.

- Late-successional forest habitat is limited and many associated species are at-risk; therefore the forest habitat within the watershed should be managed primarily for late-successional forest structure and processes.
- Aquatic and forest restoration should focus on areas such as migration pathways between existing old-growth or late-successional forest habitat, corridors between ponds and upland forests, and connectivity between wetland habitats. Restoration of these areas will help to reconnect habitat for wildlife species and remove barriers to natural dispersal.
- Special habitat elements such as snags, downed wood, and large branches in forests and large woody debris in streams may be insufficient to support some species. Restoration actions to increase the abundance of these elements would benefit a variety of species of concern.
- Invasive plant species threaten habitat quality for wildlife species. Actions to assess the current status of invasive species in the watershed and to reduce their extent and potential for invasion would be of substantial benefit.
- Minimizing or reducing existing road impacts by decommissioning and road improvements would benefit a variety of species. Road impacts on terrestrial and wetland habitat include habitat fragmentation, creation of barriers, and degradation of habitat quality

Additional Considerations

Reservoir operations are outside of the scope of this plan but they affect several fish and wildlife species. Specifically, common loon nesting on the reservoir is significantly affected by changes in reservoir water level and on the amount of human activity around or on the reservoir. In addition, low water levels in the reservoir may disconnect stream habitat from reservoir habitat, which could reduce the movement of cutthroat trout between the two types of habitat.

Consideration of Options

Fish and wildlife recommendations were developed following an evaluation of legal requirements, consistency with SPU goals for the SFTMW, and consistency with other Plan components. Unlike in the Cedar River Watershed, the ESA is not a major driver for a big increase in fish and wildlife-related actions in the SFTMW, however it is prudent to conduct limited surveys and habitat assessments to ensure that SPU has the baseline information to enable response to potential future ESA listings. In general, the accelerated restoration of the forest to late-successional conditions in the SFTMW will have a substantial beneficial effect on old-growth-dependent wildlife such as the northern spotted owl and the marbled murrelet. The recommendations presented below represent a minimal level of service related to fish and wildlife resources of the SFTMW.

Unlike in the Cedar River Watershed, the Endangered Species Act is not a major driver for a big increase in fish and wildlife-related actions in the SFTMW.

Recommended Actions

Many of the objectives of the watershed management plan are directed toward protecting and restoring habitats that are needed to sustain populations of a variety of fish and wildlife species. The forest resource and aquatic resource components of this plan address recommended actions focused on habitat, the implementation of which should benefit the species of concern discussed in this section. The proposed forest restoration projects will be designed to increase both forest structural complexity and plant species diversity. Numerous studies have shown that this should increase both the number of wildlife species and the populations of each species (Carey and Wilson, 2001, Hayes et al. 1997, Humes et al., 1999). In addition to the measures discussed in other sections, the recommendations presented below would further help to protect and improve conditions for fish and wildlife species in the SFTMW.

Habitat Assessments

Special Habitats

Recommendation FW1—Special habitats in the SFTMW include wetlands, meadows, and rock outcrops. These habitats are disproportionately important as contributors to biological diversity within the watershed and provide a variety of resources to species of concern. Wetland areas have been mapped, but mapping of other special habitats is only preliminary. Ground verification of a special habitats map should be completed.

Habitat Features

Recommendation FW2—Forest habitat elements, such as snags and downed wood, are important to many species. It is recommended that the presence and quantity of such features be assessed during project planning in all proposed treatment areas in order to protect these features and to potentially increase their abundance.

Surveys for Species of Concern

Recommendation FW3—Surveys for species of concern are useful in order to assess current population status, protect existing populations and individuals from management impacts, and plan restoration actions. We recommend continuation or expansion of surveys for the following species of concern:

- **Common loon**—Annual monitoring of common loon is important for assessing reproductive success regionally and state-wide, protecting nesting pairs and their offspring from management impacts, and evaluating the effectiveness of maintaining artificial nest platforms. Providing artificial nesting platforms and common loon monitoring is recommended to be continued.
- **Marbled murrelet**—Although there has been no documentation of murrelet use of habitat in the City-owned lands within the SFTMW, and suitable habitat is minimal at best, marbled murrelets are likely using old-growth forest on National Forest System lands to the east for nesting. Radar surveys are an effective method to detect marbled murrelet presence and are recommended to be conducted early in plan implementation. If murrelets are flying over the reservoir en route to nesting sites in the USFS land at the head of the basin or on City lands within the City-owned portion of the SFTMW, they should be detectable using radar. Knowing if marbled murrelets are present in the SFTMW would be essential to implementing appropriate disturbance restrictions and in designing restoration strategies to benefit this species.
- **Amphibians**—A reconnaissance-level survey of pond-breeding amphibians was conducted in 2006 in depressional wetland areas of the watershed. Surveys of pond-breeding amphibians in other wetlands and of stream-breeding amphibians in headwater streams are recommended, in order to provide a more thorough inventory of amphibian species and their distribution in the watershed.

Special habitats are disproportionately important as contributors to biological diversity within the watershed and provide a variety of resources to species of concern.

Surveys for the following species of concern are **not recommended**, as they are unlikely to be informative or cost-effective:

- Northern spotted owl—No surveys for spotted owls are recommended at this time. There does not appear to be sufficient late-successional habitat within City-owned portions of the SFTMW to support a spotted owl pair, and it will be many decades before requisite forest structure develops. Spotted owl surveys on Forest Service lands to the east within the basin would be informative, but this area is outside City jurisdiction.

- Northern goshawk—No general surveys for northern goshawk are recommended, but project specific surveys and habitat quality assessments are recommended (see below).
- Bull trout—Past fish surveys and recent investigation of fall spawning in a small tributary to the South Fork Tolt River upstream of the reservoir do not indicate bull trout presence in the basin above the dam. Although these surveys do not definitively determine whether bull trout are present in the watershed, using state and federal protocols to provide that determination are not recommended at this time.
- Cutthroat trout—Previous fish surveys in the watershed have identified cutthroat trout presence in the reservoir and several of its tributaries. Additional surveys are not recommended.
- Wolverines— No surveys for wolverines are recommended at this time because they are not likely be found in second-growth forest of City-owned lands within the watershed. However, the planned forest habitat restoration activities are consistent with providing habitat for wolverines, should they occur in the City-owned portions of the SFTMW. SPU follows State rules and regulations and meets or exceeds all standards. In the event that a currently listed species is found on City lands, or, in the event that a currently unlisted species becomes listed in the future, SPU will comply with the ESA.

Species Protection

Common Loon

Recommendation FW4—Continuation of ongoing efforts to monitor and provide common loon nesting platforms in the reservoir is recommended.

Northern Goshawk

Recommendation FW5—An assessment of northern goshawk habitat quality is recommended to identify areas where this species could occur. Where projects and other management activities (e.g., rock pits) are located in areas of possible northern goshawk occurrence, surveys for northern goshawk should be conducted prior to the project to determine if protection of any individuals or nests is necessary.

Nest Sites

Recommendation FW6—If found, nest sites of spotted owl, marbled murrelet, and other listed or sensitive species (e.g., common loon, peregrine falcons) should be protected by implementation of noise and disturbance restrictions within minimum distances of nest sites or occupied stands, depending on the species. For northern spotted owl and marbled murrelet, disturbance should be restricted within a minimum 0.25-mile radius of nest sites (owl) or occupied stands (murrelet) during nesting and rearing. For northern goshawk, disturbance restrictions should be applied to a 0.50-mile radius of nest sites. Protection for other species of concern should also be developed and implemented wherever and whenever appropriate, as such circumstances are identified.

Habitat Management

Large Woody Debris in Reservoir and the South Fork Tolt River Delta

Recommendation FW7—It is recommended that pieces of large woody debris occurring on the reservoir delta be left in place, and cabled if necessary. Large woody debris taken from the reservoir in order to protect the dam should be stockpiled for use in stream restoration.

Disturbance to South Fork Tolt River Delta

Recommendation FW8—Disturbance to the delta from heavy equipment should be completely avoided or minimized. Prior use of heavy equipment on the delta has been associated with large woody debris removal and such use would no longer be necessary if wood is no longer removed from the delta.

Road Decommissioning

Active roads create movement barriers for several species, and vehicle use of the roads can increase the risk of fine sediment being delivered to streams and can disturb nesting or denning animals. In general, the larger the roadless area, the greater the benefit to wildlife species. All forest roads not necessary for resource protection, water quality and supply, and facility maintenance should be decommissioned. Once roads needed temporarily to conduct forest and stream restoration activities become unnecessary, we recommend that they be decommissioned as soon as is feasible. These priorities have been reflected in the road schedule described in Chapter 9.

Disturbance to the delta from heavy equipment should be completely avoided or minimized.

Chapter 7
Invasive Plant Species

CHAPTER 7. INVASIVE PLANT SPECIES

Invasive species (including terrestrial and aquatic plants, pathogens, insects and other animals) pose significant risks to native biodiversity, fish and wildlife habitat, and basic ecological functioning. Some invasive aquatic plants, such as algae, threaten water quality. Climate change is expected to further increase the risks posed by invasive plants because changed disturbance regimes and higher carbon-dioxide content in the atmosphere have been shown to favor invasive species over native plants.

The invasive species control program described in this chapter is part of a larger SPU Invasive Species Management Program for the Utility's major watersheds. This program is consistent with all of the goals established for management of the SFTMW:

- **Goal 1**—Maintain and protect source water quality and quantity for municipal water supply and downstream ecosystems.
- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the municipal watershed.
- **Goal 3**—Protect the cultural resources of the municipal watershed.
- **Goal 4**—Manage the municipal watershed based on social, environmental and economic considerations.

LEGAL REQUIREMENTS

In order to deal with the threat of invasive species, Washington State and King County have compiled lists of invasive species that landowners are legally required to either eradicate or control. The following key requirements address the issue of invasive species:

- **State and County Law**—Washington State and King County statutes require 32 noxious weed species to be eradicated (Class A) and 56 species to be controlled and contained (Class B and some Class C) in King County. Of these, two Class B species are known to occur in the SFTMW, but surveys have not yet been conducted for other species that could occur there.
- **SPU Policy**—SPU's adopted corporate

Highlights

Non-native invasive plant species pose a significant threat to the functioning of local ecosystems.

No comprehensive surveys of invasive species in the SFTMW have been conducted, but two species designated for control measures under existing regulations—yellow hawkweed and tansy ragwort—have been documented.

A separate effort, completed in 2010, established an invasive species management program for major watersheds, including the SFTMW.

The recommended management plan for invasive species in the SFTMW calls for early detection and rapid response to control infestations. It includes the following specific actions to be taken as part of the planning project for the invasive species management program or incorporated into the program itself:

- Perform annual invasive-species surveys of portions of the watershed's high-risk area, covering all high-risk areas over several years.
- Take steps to prevent seed dispersal during projects and maintenance work in the watershed.
- Tailor control treatments to the species and site-specific conditions.

environmental objectives include an objective to "implement strategies and actions to achieve and exceed goals and expected outcomes of environmental laws" and one to "lead on regional environmental issues, working cooperatively with other organizations to promote common environmental goals and objectives." SPU has both legal and policy requirements to control or eradicate Class A, B, and some Class C invasive species found within SPU-owned lands.

- **County Recommendations**—In addition to the species legally required to be controlled, King County recommends controlling an additional 36 noxious weed species. These species pose significant ecological risks, but are not legally required to be controlled because they are already widespread in the county. Five of these species are known to occur in the greater Tolt Watershed, but comprehensive surveys have not yet been completed.

BACKGROUND

SPU Major Watersheds Invasive Species Management Program

In 2007 the SPU Asset Management Committee approved a four-year planning project that will culminate in a strategic management plan for an ongoing Invasive Species Management Program for SPU's three major watersheds (Cedar, Tolt, and Lake Youngs).

Early Detection/Rapid Response Protocol

It is more effective and less expensive to treat a small infestation or population than a large one. Eradication is possible for small populations, but continual (and expensive) control may be the only option if an infestation is allowed to expand. Experience since 2002 in the Cedar River Municipal Watershed and the SFTMW has demonstrated the rapid expansion potential of some invasive plant species, as well as the associated increase in costs, if treatment is delayed. The rapid expansion of non-native insects and pathogens in forested settings is also well-documented. Experts in invasive species control recommend that all landowners use an early detection/rapid response protocol to deal with invasive species on their properties. This protocol involves surveying a portion of the ownership each year, rotating through the land area over a period of several years. Any new infestation or population found is to be treated immediately. Using this protocol should ensure that a new invasion will be detected early enough in its population expansion that it will still be small and thus easier and more cost effective to eradicate.

CURRENT CONDITIONS

Current information of populations of invasive species can be found in Chapter 2.

Planned Work

The SPU Major Watersheds Invasive Species Management Program addresses upcoming work activities and focus areas for invasive species control in the SFTMW.

Currently, yellow hawkweed is one of two invasive species documented in the SFTMW that are addressed by invasive species control regulations.

Yellow Hawkweed Control

SPU will continue annual control of yellow hawkweed with methods the same as or similar to those used in 2007. The long-term goal is to eradicate most patches where feasible. SPU will control patches that cannot be eradicated using ecological methods such as densely planting conifer trees (see Map 17).

Surveys

Surveys for all species legally required to be controlled were conducted by expert botanists in the summer of 2008 as part of the four-year planning project to develop an ongoing Invasive Species Management Program. Survey areas included all high-risk sites, such as active roads, gravel pits, and frequently disturbed areas near the Vista House, as well as a sample of decommissioned roads. In addition, in 2009 SPU staff began surveying and mapping of species not legally required to be controlled but that pose ecological risk.

New infestations of legally designated species discovered by the botanists were mapped in late 2008. If any new infestations of legally required species are found, they will be treated immediately. Infestations of other species that are considered to pose significant ecological risk will be evaluated on a case by case basis. They may be treated as part of the experiments designed to evaluate the most suitable control methods.

A survey schedule has been designed to implement the early detection/rapid response protocol for not only terrestrial plants, but also aquatic plants, insects and pathogens, and invasive animals. Surveys will be more frequent in areas at high risk of invasion and near already known infestations, and less frequent in other areas. A rotating panel design will be used, with complete coverage anticipated every four to five years.

Integrated Pest Management

SPU will use principles of integrated pest management principals to minimize the risk of invasion and to control any invasive species detected. SPU will evaluate all routine activities for the risk of introduction of new infestations. An example of such an activity is road work. Road maintenance involves grading, delivery, and stockpiling of road material, and subsequent transport of the material to the work site. All of these steps can contribute to weed dispersal. SPU will coordinate invasive species survey and control efforts with road system maintenance to help minimize the risk of dispersal.

Integrated pest management requires an evaluation of each invasive species patch or population to determine the most effective and cost-effective control methods. It is expected that these will vary by species and site-specific conditions. SPU will always attempt to use ecological controls such as changing the growing environment to favor native plants over invasive species. This can take long periods of time, however. For example, it may take 10 to 20 years for conifers to grow sufficiently to shade out invasive plants. In the interim, some species may require aggressive control techniques to ensure that they do not spread to other areas.

SPU will continue to use herbicide only if absolutely necessary and will continue to apply it strictly according to state law and all recommendations (e.g., apply the minimum effective dose under conditions of no rain or wind). SPU will continue to explore options, with the goal of finding more effective chemicals that require smaller doses and pose minimal risks to native fish and wildlife.

ISSUES

Large-Scale Natural Disturbances

Large-scale natural disturbances (e.g., stand-

Legally required surveys for tansy ragwort will be conducted by SPU botanists.

replacing fire) would increase the risk of infestation by invasive plants, especially if there is a nearby seed source, as well as insects and pathogens that could threaten the remaining forest. Because events like this are effectively unpredictable, it is difficult to plan for them.

Conditions on Neighbor Lands

Changing management strategies on neighboring properties could significantly alter the risk of invasion by new non-native species. If adjacent land use changes from commercial forestry to suburban development, the risk of invasion will increase significantly.

Ground Disturbances

Any ground-disturbing work within the watershed will increase the risk of invasion by non-native plants, especially if it is located near an existing plant infestation that could serve as a seed source.

Climate change

How global climate change will affect local weather patterns is unknown. Variables include the extent and direction of temperature and precipitation change, the annual timing of the change, the time course in years over which the change will occur, and the specific effects on ecosystem function and invasive species. Climate change is predicted to create conditions that will favor invasive species over native plants because of increased disturbance and higher carbon-dioxide levels in the atmosphere. Increased temperature could increase the risk of non-native algal blooms, threatening water quality. Climate change could also cause stress for native trees, increasing the risk of invasion by non-native insects and pathogens. However, the extent to which these scenarios may happen within the SFTMW is unknown.

Impacts on Fish and Wildlife Habitat

Another key unknown is the actual impact of specific invasive species on habitat for fish and wildlife species, and potentially on the species themselves. Little research on this topic has been conducted in the western Cascade Mountains.

Consideration of Options

The SPU Asset Management Committee performed a benefit-cost analysis for the four-year planning project and approved the use of the early detection/rapid response protocol in all major SPU watersheds. Because this protocol has already been approved, it was the only option considered for this plan.

Recommended Actions

Early Detection-Rapid Response

Recommendation IS1—Implement early detection/rapid response protocol, surveying a portion of the SFTMW every year, with a complete survey every five years. Surveys will initially include terrestrial plants and forest pathogens, with methodology to be developed to include aquatic plants, insects and other animals. This process would have the lowest ecological risk, lowest long-term costs, and highest ecological, social, and economic benefits.

Methods

Use a rotating panel survey design to ensure all high risk areas are surveyed at appropriate intervals, with lower risk areas surveyed at longer intervals.

Focus surveys in areas that are already infested and areas with ground-disturbing activities.

Monitor any changes in local and neighbor land use; and if significant changes occur, modify its survey schedule in response.

SPU Invasive Species Program

Recommendation IS2—Encompass all invasive species survey and control in the South Fork Tolt Municipal Watershed within the larger Invasive Species Program for SPU's major watersheds.

Surveys

Recommendation IS3—Complete regular, periodic plant surveys.

Recommendation IS4—Undertake invasive plant experimental control efforts as necessary.

Integrated Pest Management

Recommendation IS5—Utilize Integrated Pest Management principles.

Methods

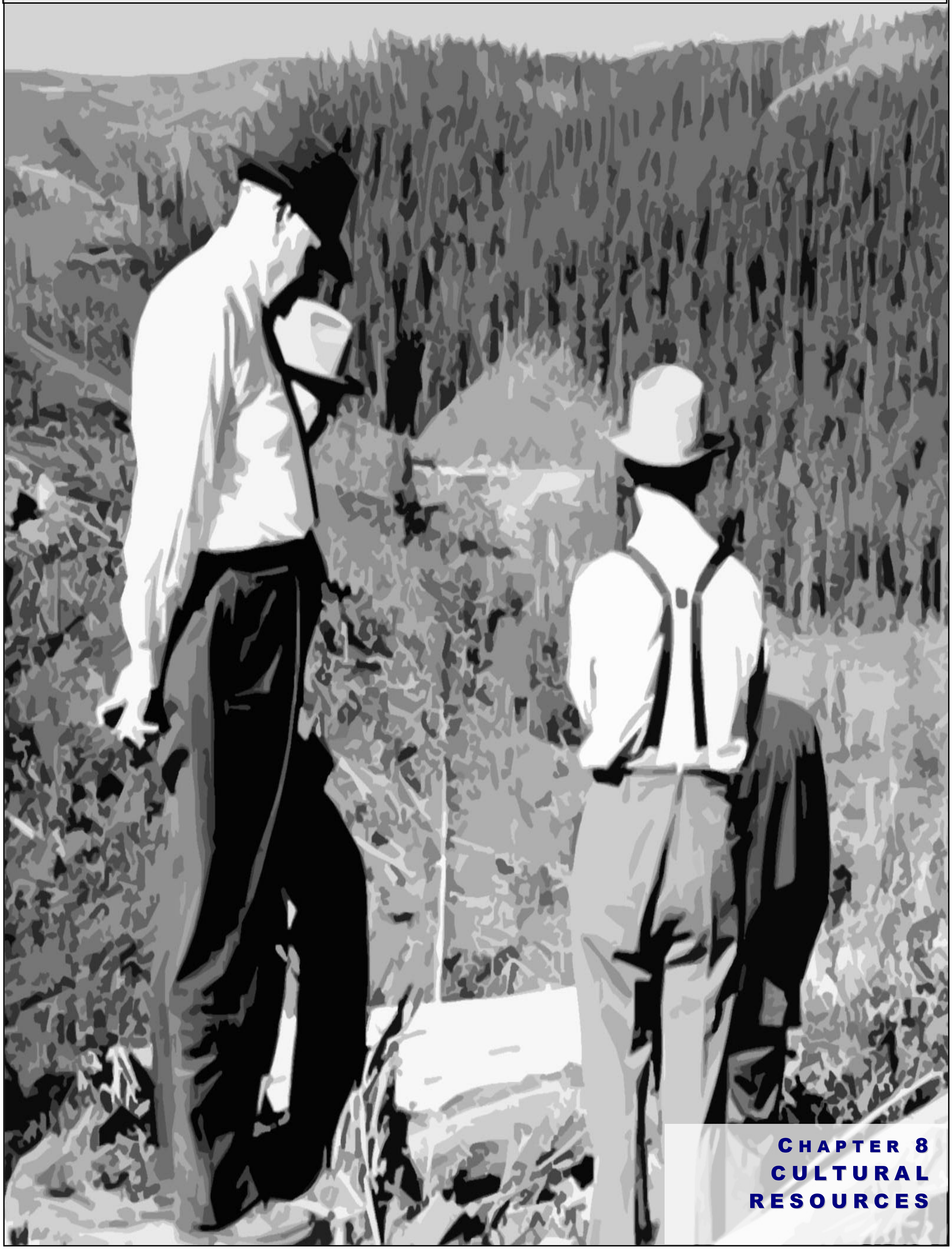
Tailor control treatments to the species and site-specific conditions.

Continue to monitor literature to ensure that the most current available data are used for management decisions.

Actions

Reduce the risk of seed dispersal through the actions below:

- Coordinate with road system maintenance to help minimize weed dispersal through grading, delivery, stockpiling, and transport of road material.
- Ensure that all seed sources near a ground-disturbing project are controlled.
- Effective control of local seed sources will also guard against increased infestation prompted by large-scale natural disturbances. Fire prevention recommendations presented in Chapter 3 will also minimize this risk.



CHAPTER 8 CULTURAL RESOURCES

CHAPTER 8. CULTURAL RESOURCES

BACKGROUND

Cultural resources in the SFTMW (see Map 18) are best understood within the context of the larger Tolt River Watershed. The recent technical report *Cultural Resources Data Compilation and Map of Archaeological Sensitivity Zones for the Tolt River Watershed* (HRA, 2006) includes a compilation of information on known cultural resources and a map of archaeological sensitivity zones for the Tolt River Watershed. It provides a baseline cultural resource inventory that SPU is using to inform the cultural resource management recommendations included in this watershed management plan.

The cultural resources actions recommended in this chapter fulfill a primary goal for SPU's management of the SFTMW:

- **Goal 3**—Protect the cultural resources of the municipal watershed.

A cultural resource management plan (CRMP) for the Cedar River Municipal Watershed established procedures in 2004 to limit and reduce potential conflicts between SPU's primary mission activities and applicable regulations governing cultural resource protection. Developed over a number of years, with input from regulating agencies and affected Indian tribes, that plan has proven to be an effective management tool that has the continuing support of all interested parties. Although the SFTMW is much smaller and contains fewer known and potential cultural resources, the similarity of cultural resource management issues supports incorporation of the standards and protocols established in the CRMP for the Cedar into the recommended actions in this plan for the SFTMW.

LEGAL REQUIREMENTS

Federal, state, and local laws and regulations dictating SPU's responsibilities regarding the management of cultural resources are listed below.

Federal

The following Federal laws address the management of cultural resources within the context of environmental impact assessment and historic preservation:

- The National Environmental Policy Act of 1969 (NEPA), implemented by regulation issued by the Council on Environmental Quality (40 CFR 1500-08)

Highlights

The SFTMW has a record of cultural resources. One trail crossing the municipal watershed has been documented as an historic use site, and dozens of archeological and historic sites have been documented in the larger Tolt River Watershed.

This management plan presents guidelines and protocols for management of cultural resources in the municipal watershed, including the following:

- Adapt management standards from the federal *Standards and Guidelines for Archeology and Historic Preservation*.
- Update the existing GIS database for known and potential cultural resource information.
- Consider protection and management of cultural resources in planning for projects or maintenance work in the SFTMW.
- Follow established protocols for discovery of cultural materials, treatment of human remains, response to vandalism, and emergency response.
- Provide mitigation of any action with potential negative effects on cultural resources.

- The National Historic Preservation Act (NHPA) of 1966 (as amended)

Washington State

The State of Washington has enacted the following laws to protect cultural resources:

Cultural Resources
Areas, places, buildings, structures, outdoor works of art, natural features, and other objects having a special historical, cultural, archaeological, architectural, community, or aesthetic value.

- State Environmental Policy Act (SEPA; Chapter 43.21C)
- The Forest Practices Act (RCW 76.09; WAC 222)
- Chapter 27 of the Revised Code of Washington (RCW)

King County

Chapter 20 of the King County code establishes standards and procedures for a landmark program similar, but not identical, to the National Register of Historic Places. The age criterion for King County landmarks is 40 years, in contrast with the 50-year requirement for the National Register.

City of Seattle

City of Seattle ordinances and regulations implement federal and state laws and address the management of cultural resources. Chapter 25.05 of the Seattle Municipal Code, Environmental Policies and Procedures, outlines the City's compliance with SEPA.

Issues

Recommended actions are proposed to resolve the following issues:

- Formal guidelines are lacking for compliance with federal, state and city ordinances to provide protection of cultural resources.
- Protocols regarding unanticipated discovery of cultural resources, treatment of human remains, response to vandalism, and emergency response do not exist for the SFTMW.
- The GIS database is incomplete for known and potential cultural resource information in the SFTMW. This information is needed for cultural resource protection during planned activities, such as bridge replacement or road decommissioning, as well as emergency responses to flooding, fire, and earthquakes.
- Formal guidelines are lacking for information sharing and confidentiality.
- Formal guidelines are lacking for the curation of cultural material.
- City maintenance staff have not been oriented and trained in their responsibility to protect cultural resources and in identification of cultural material that they might encounter.
- No formal system exists to educate contractors and other visitors to the SFTMW about cultural resource protection requirements.

Consideration of Options

The Cultural Resource Management Plan (CRMP) for the Cedar River Municipal Watershed provided a model for the SFTMW. That plan has proven to be an effective management tool that has the continuing support of all interested parties; the extension of these standards and protocols to the SFTMW was considered the only reasonable option.

Recommended Actions

General Management Approach

Recommendation CR1—Recommended management standards for the municipal watershed are adapted from the U.S. Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation*, as summarized in Appendix C. These are not regulatory, but provide technical advice about archaeological and historic preservation practices and methods. They are widely used by regional, state, and local governmental agencies throughout the United States. SPU endeavors to apply the standards in a reasonable manner, considering the economic and technical feasibility of implementing the standards within the context of its responsibility for the overall management of the watershed and its other resources. The standards are summarized in Appendix C, which also provides the proposed approaches for consultation with other parties, the management of cultural resource information and collections, and public education activities.

Cultural Resources Database

Recommendation CR2—The existing GIS database for known and potential cultural resource information needs to be updated as new information becomes available. SPU is currently conducting a traditional cultural property survey; the results of this survey will be incorporated into the GIS database when complete.

Coordination with Project and Maintenance Work Planning

Recommendation CR3—All SPU staff are required to consider protection and management of cultural resources in planning for projects or maintenance work in the SFTMW, especially for projects such as ecological thinning of second-growth forest, road maintenance, road decommissioning, and habitat restoration that may involve ground disturbance or vegetation modification. Routine operations such as road maintenance and culvert replacement have the potential to adversely affect cultural resources.

Staff members will review the SFTMW GIS database during the planning stages of any proposed activities to determine if the proposed project area includes identified cultural resources and to determine the area's potential for unrecorded cultural resources. The results of this review will determine the level of required survey and protective measures. Detailed discussion of the required level of effort and the standards for

> *The U.S. Secretary of the Interior's* Standards and Guidelines for Archeology and Historic Preservation *are not regulatory but provide technical advice about archaeological and historic preservation practices and methods. They are widely used by governmental agencies throughout the United States.*

conducting surveys is provided in Appendix C.

Cultural Resource Protocols

Recommendation CR4—Recommended protocols have been developed for the following circumstances:

- Unanticipated discovery of cultural materials
- Treatment of human remains
- Response to vandalism
- Emergency response.

In the event of any of the above situations, staff will consult and follow the appropriate protocol, provided in Appendix C.

Mitigation Options

Recommendation CR5—Mitigation is an action taken in response to a negative effect and is intended to reduce the severity of the effect. Mitigation of effects upon cultural resources may include archaeological data recovery, recordation of standing structures, and other measures.

Archaeological data recovery often serves as mitigation in instances where a significant site cannot be avoided or preserved. Data recovery seeks to recover the information the site contains through a controlled archaeological excavation and the subsequent analysis of recovered material. The Advisory Council on Historic Preservation's *Recommended Approach for Consultation on the Recovery of Significant Information from Archaeological Sites* (64 FR 27085-87, 18 May 1999) provides guidance on this issue.

Recordation of standing structures is a standard approach used to mitigate effects upon architectural resources. Recordation is generally undertaken in accordance with the standards and specifications promulgated by the Historic American Buildings Survey (HABS) and the Historic American Engineering Record (HAER). Documentation may include written narrative, large-format black-and-white photography, and measured drawings. The HABS/HAER standards are available from the regional office of the National Park Service.

CHAPTER 9
TRANSPORTATION

CHAPTER 9. TRANSPORTATION

A functioning road system is an integral element of the SFTMW. The basic guiding principle for the future of this road system is to manage the balance between access and impact. The road system provides access for all types of management activities. The road system is also a source of negative impacts on habitat and water quality. The roads must be managed to provide access while reducing the negative impacts as much as possible. The road system is in place to serve management activities and is not a valuable asset in itself aside from this service. The recommendations provided in this chapter address the following goals for SPU management of the SFTMW:

- **Goal 1**—Maintain and protect source water quality and quantity for municipal water supply and downstream ecosystems.
- **Goal 2**—Protect and restore the natural ecosystem processes and resources of the municipal watershed.
- **Goal 4**—Manage the municipal watershed based on social, environmental and economic considerations.

BACKGROUND

The historic road network accessed most of the area within the SFTMW, however, many roads in the watershed were decommissioned following acquisition of lands from Weyerhaeuser (see Map 19). The remaining roads are in a variety of conditions, affecting drivability and stability, and will need ongoing repairs, maintenance and decommissioning. Extensive road network improvements have been performed since 1993, including decommissioning, surfacing and reduced usage, and these improvements have significantly reduced many of the adverse impacts of the SFTMW road system (see Chapter 2 for more discussion).

A road classification system comparable to that used in the Cedar River Municipal Watershed was developed and used to classify each road in the SFTMW based on the extent, type, and timing of road access required to implement management plan goals. Map 19 shows the road classification system. Each road in the SFTMW was classified into one of four categories—Core, Temporary, Non-essential, and Decommissioned—based on identified future needs. Approximately 83 miles of unpaved roads within the SFTMW are classified as follows:

Highlights

Roads in the SFTMW are used primarily by SPU for water system maintenance and by Hancock Timber Company for continued timber harvest on its lands.

In recent decades, several miles of roads in the municipal watershed have been improved, and at least 24 miles have been decommissioned.

Management of the road system must balance access requirements against the impacts caused by roads.

This management plan establishes standards for road maintenance, improvement and decommissioning. It identifies specific roads for improvement (Map 19):

- Before 2014: The 30.1, and 71 roads; and
- 2014 and later: The 70, 50, 71.4, 52, 70.4, 30.3, 30.4 and 30 roads.

It also identifies specific roads for decommissioning:

- Before 2025: The 70.5, 30,8, 50.7, 52.2, 52.21, 70.8, 50.60, 50.61, 50.9, 71.1, 71.42 and 71.43 roads;
- After 2025: The remaining segment of the 55 Road;
- After 2030: The 52 and 30.6 roads;
- After 2040: The 73 and 30.5 roads; and
- After 2060: The 30.3 and 30.4 roads.

- **Core Roads**—These roads are needed for long-term use. They provide access to critical infrastructure and support land management and protection activities. Core roads also include those used for access to adjacent properties. Activities on these roads will be governed by Road Use Agreements. There are 40 miles of core roads in the SFTMW.
- **Non-Essential Roads**—There are two sub-categories of non-essential roads: current and future. The first are roads identified as providing no current or future access needs. They will be scheduled for decommissioning to a standard that will eliminate potential adverse environmental impacts from the road. Roads with the highest potential to adversely affect water quality, because of steep slopes, high landslide potential, or other conditions, will be decommissioned first. All roads must be kept in a stable condition until decommissioning. Three miles of roads are currently classified as currently non-essential.

The second sub-category of future non-essential roads will be needed to provide access only for a limited time to implement projects developed under this watershed management plan. These activities include stream restoration, forest habitat restoration projects, environmental studies, or invasive species removal. When the project has been completed and the road is no longer needed, it will be reclassified as nonessential and scheduled for decommissioning. These “temporary” roads will be maintained for various lengths of time from just five years until as late as 2060, or any time in between. Therefore, some of the longer-term “temporary” roads will still be in place several decades from now. These future

non-essential roads must be maintained in a stable condition until they are eventually decommissioned. There are 8 miles of future non-essential roads in the SFTMW.

- **Decommissioned Roads**—These former roads have been decommissioned to stabilize them and reduce future impacts on water quality and habitat. They no longer provide access and will require no further maintenance. There are about 32 miles of decommissioned former roads in the SFTMW.

ROAD INVENTORY AND ASSESSMENT

A key source of information for this chapter was a comprehensive road inventory that provided a relatively complete catalogue of current conditions, structural attributes, potential problems, and road attributes currently having adverse impacts on water quality and ecosystem health. Other critical input included the identification of access needs by SPU staff as well as a comprehensive watershed analysis that identified the type and location of critical and sensitive habitat and the degree to which current and future road/land management has contributed to the degradation of those resources. Current road conditions in the SFTMW are documented in the following reports:

- Watershed Analyses—Road erosion, mass wasting, stream channel, and fish habitat assessments completed in 2006 as well as previous assessments conducted by the Washington Department of Natural Resources (WDNR) in 1993 and updated in 1998. Assessments included the identification of landforms sensitive to road construction, identification of road-generated landslides, and estimates of fine sediment production from road-generated surface erosion. Aquatic resource conditions were also examined and the extent to which historical and current road management activities have impacted these resources was assessed.

Decommissioning
The physical treatment of a roadbed to restore the integrity of associated hill slopes, channels, and floodplains and their related hydrologic, geomorphic, and ecological processes and properties.

- Comprehensive Road Inventory—An inventory was completed in 2006 as part of the Road Erosion Assessment. A modified WDNR road monitoring protocol (SPU, 2005) was used to conduct a detailed inventory of road attributes and conditions, including road surfacing, stability and structural concerns, drainage attributes, and the extent of connectivity to surface water.

- Washington Roads Surface Erosion Model (WARSEM)—Using the comprehensive road inventory completed in 2006, WARSEM (Washington Forest Practices Board, 2004) was used to model sediment delivery from roads.

- Road Inventory and Work Plan—Initially developed in 1995 and updated annually, this road inventory describes field marks, road features, and problems associated with each road in the SFTMW. Past priority rankings, recommended solutions, and schedules are also summarized in this spreadsheet.

- Fish Barrier Inventory—As part of a 1994 fisheries survey (Tappel and Tappel, 1995), culverts and bridges upstream of the reservoir were evaluated with respect to fish passage.

Roads in the SFTMW are currently used primarily by SPU for water system maintenance and by Hancock Forest Management, Inc. for continued timber harvest on its lands in adjacent watersheds. Future needs for roads in the SFTMW include the following:

- Long-term (Core)
  - Water management (boat launch, dam access, piezometers, stream monitoring)
  - Security (boundary access, fire protection)
  - Adjacent landowners
- Short-term and Medium-term (Temporary)
  - Projects developed by the South Fork Tolt Municipal Watershed Management Plan, including forest restoration, habitat improvements, invasive species removal

Road Density

Road density is a common and readily quantifiable metric of road impacts on watershed functions and processes (Table 9-1). Road density in the SFTMW is relatively high at 3.2 miles per square mile, but varies widely among subbasins. Subbasins with sparse road networks and low road densities include South Fork Tolt River, Phelps and Chuck Judd Creek Subbasins. Subbasins where overall road impacts are likely greater include smaller catchments such as South Shore Southwest, South Shore West and South Shore Central, which flank the reservoir.

TABLE 9-1.
ROAD DENSITY BY SUBBASIN IN THE SFTMW

Subbasin	Road Density (miles per square mile)	Subbasin	Road Density (miles per square mile)
Chuck Judd Creek	0.379	Single East Shore Tributary	1.146
Consultant Creek	4.285	Siwash Creek	1.017
Dorothy Creek	1.793	Skookum Creek	1.630
East Shore	1.776	South Fork Tolt River[a]	0.185
Horseshoe Creek	6.927	South Shore Central	11.581
North of Dam	2.335	South Shore East	0.488
North Shore Central	2.799	South Shore Southeast	4.157
North Shore East	3.881	South Shore Southwest	17.828
North Shore West	3.397	South Shore Tributary 1	5.693
Phelps Creek	0.328	South Shore West	21.783
Rainbow Creek	3.666	***Watershed Average***	***1.809***

a. Most of the South Fork Tolt River Subbasin is in USFS ownership in the headwaters of the SFTMW

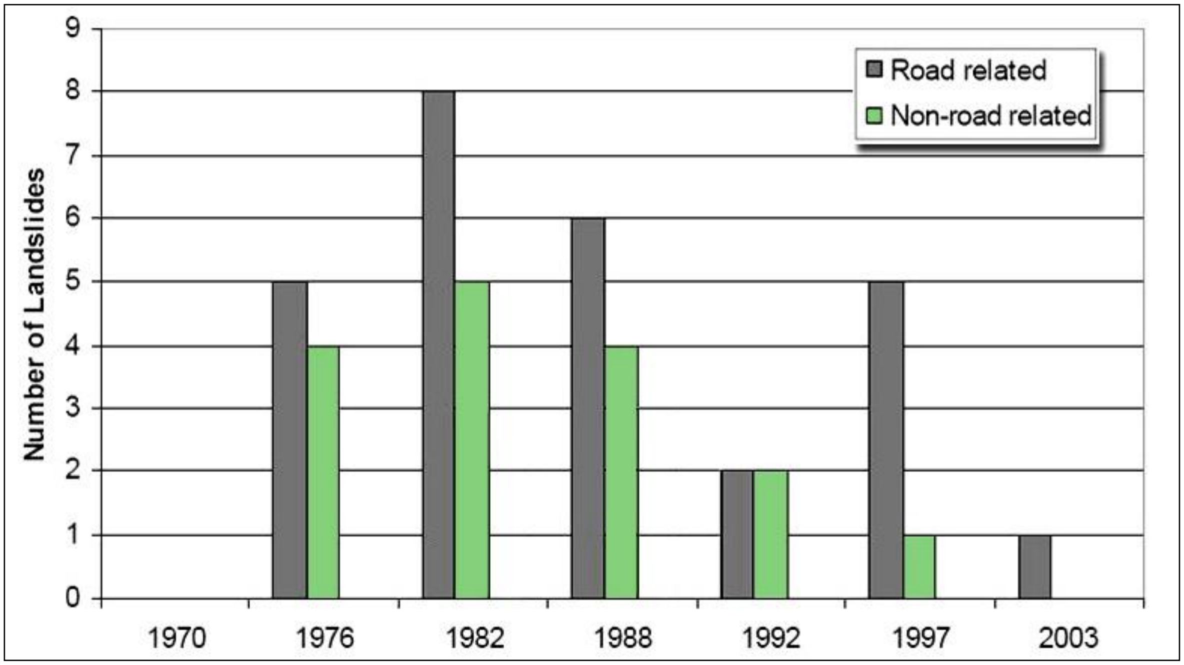


Figure 9-1. Landslides in the South Fork Tolt, by Land Use.

Road-Related Landslides

Forest road networks like those in the SFTMW affect natural physical processes across the landscape by altering hill slope hydrology and sediment production. Changes in these processes often have direct local and off-site effects on channel and wetland function and morphology and water quality. Roads affect hill-slope hydrology by mechanisms including generation of overland flow on relatively impervious road surfaces, interception and concentration of subsurface flow, and diverting or rerouting water from historical flow paths. Road ditches intercept cross-slope flow and concentrate it before sending it through culverts and down-slope. When changes in hill-slope hydrology are combined with activities such as road construction, maintenance, and traffic, sediment production from the following sources often exceeds natural levels:

- Surface erosion from the road prism
- Erosion of the road ditch and fill
- Gullying of hill slopes
- Landslides caused from misdirected road drainage or failure of cut-banks, fill-slopes or fill at stream crossings.

The majority of past landslides in the SFTMW have been associated with roads on steep slopes (see Figure 9-1). Conditions contributing to road failures include over-steepened or soft fill slopes, inadequate or improper road drainage, inadequate road maintenance, and poor locations on naturally unstable slopes. The frequency of road-related landslides has declined in large part due to the decommissioning of the 72, 73 and 54 roads and sections of the 55 and 56 roads. While a few active erosion features can still be found associated with roads on the south side of the SFTMW, many of these roads were decommissioned by SPU following the land exchange with Weyerhaeuser.

Road-Generated Fine Sediment

Table 9-2 shows predicted sediment loads from major roads in the SFTMW as well as the percent of the road length that drains directly to surface water. The 50, 50.3, 71, and 71.4 roads produce the most sediment because they are relatively long or have a high connection to water bodies. Overall, 50 percent of the active roads in the watershed deliver directly to streams.

This is an unusually high percentage compared to other watersheds; it is attributable to the long lengths of road paralleling the reservoir that deliver directly to the reservoir (the 50 and 70 roads). The location of these roads makes it difficult to prevent delivery of sediment. The relatively low traffic levels, low gradients, and gravel surfacing on these roads helps to reduce erosion.

TABLE 9-2.
SEDIMENT PRODUCED BY MAJOR ROADS

Road	Percent Direct Delivery	Estimated Sediment under Low-High Traffic Scenarios (tons/year)
30	21%	8
50	86%	40-80
50.3[a]	95%	40-80
52.2	35%	21
55	84%	36
70	67%	17-35
71	21%	42-83
71.4	100%	57
73	19%	18
All Roads	50%	240-328

a. The 50.3 Road is downstream of the dam.

Recent Road Decommissioning and Improvement Work

In the past two decades, at least 24 miles of roads have been decommissioned in the SFTMW. The first decommissioning began in 1986 with work by Weyerhaeuser Timber Company. In 1996, the Tolt Fish Habitat Restoration Group, a group comprised of the Seattle Water Department (later SPU), Weyerhaeuser, the US Forest Service, and Washington Trout began several years of decommissioning work in the municipal watershed. Decommissioned roads include the 72 Road, 73 Road, spurs on the north slope, the 54 Road, the 55 Road, and sections of the 56 road. Since efforts began in 1995, several miles of roads have been improved. The improved roads include most of the higher use core roads and several other roads. Work has involved removing berms, installing cross-drains and stream crossings, grading, shaping, applying and compacting surface rock, removing deep fills and unstable material, removing log puncheons, constructing bridges, and restoring fish passage. These types of improvements have recently been completed on the reservoir perimeter roads as well as the 50, 70, and 57 roads.

Legal Requirements

In managing its road system in the SFTMW, SPU must comply with the following Washington State laws:

- The SFTMW is in the state forest zone, which falls under WDNR jurisdiction and must meet state forest practice regulations under WAC 222-24.
- Gravel pits are regulated by the Surface Mining Act administered by WDNR.
- The Washington Department of Fish and Wildlife has permitting authority for forest activities that have potential to impact aquatic habitat: WAC 220-110, WAC 222-24, WAC 232-14.
- King County implements state shoreline regulations, which apply to any work within 200 feet of the 100-year floodway of shorelines of state significance, including the Tolt River and Tolt Reservoir: RCW 90.58.
- The Washington Department of Labor and Industries regulates forest road conditions and geometry, and bridge structures from the perspective of safety: RCW 296-54-531.
- The Washington Department of Transportation (WDOT) Manual M 36-64, the *Washington State Bridge Inspection Manual*, has the guidelines for frequency and requirements of bridge inspections.
- Design and construction of bridges is regulated by WDFW, WDNR, and Ecology.

Issues

Roads within the SFTMW continue to have direct and indirect effects including the following:

- Changes in stream channel structure and geometry from increased sediment loads;
- Interruption of sediment and wood transport at stream crossings;
- Road encroachment into floodplains and riparian zones; and
- Barriers to fish passage and wildlife migration.

Road-Generated Fine Sediment

The 50, 50.3, 71 and 71.4 roads produce the most sediment because they are relatively long or have a high connection to water bodies. Overall, 50 percent of the active roads in the watershed deliver directly to streams. This is an unusually high percentage compared to other watersheds; it is attributable to the long lengths of road paralleling the reservoir that deliver directly to the reservoir (the 50 and 70 roads). The location of these roads makes it difficult to prevent delivery of sediment.

Road-Related Landslides

Isolated erosion features related to roads remain on the south side of the SFTMW.

Roads with Potential Fish Barriers

Roads fragment fish habitat by creating barriers to upstream fish movement. A fish survey in 1995 (Tappel and Tappel) identified two culverts as barriers to fish passage in the SFTMW. Additional barriers are likely along the 70, 73, and 50 roads; these have not been surveyed.

Decommissioning restores natural drainage and stream crossings.

Road Use Agreements

Improvement and maintenance of roads used by adjacent landowners, and the frequency and nature of their use needs to be addressed in the road use agreements with Hancock Forest Management, Inc. The following issues have been identified with the shared road use:

- Segments of the 71 Road receive frequent and heavy use by adjacent landowners for timber extraction. These roads have not been maintained or improved by the user groups and are in need of work.
- The 30 Road is seldom used by SPU, but is considered a core road that provides access for the adjacent landowner. Currently this road is in poor condition and in need of improvements.
- Maintenance for spur roads that start on City property and terminate on adjacent properties
- Adjacent property owners who use SFTMW roads for haul, resulting in increased maintenance, or are the primary users of remote roads (the 30 Road) have an impact on the economics and scheduling of maintenance work.

Consideration of Options

Because the purpose for roads is only to provide access for management and restoration activities, the need for each road segment in the SFTMW was evaluated based on access needs. The short and long-term need for each road was weighed against its possible impacts on water quality and habitat in addition to the financial cost required to improve, decommission, or maintain it.

Recommended Actions

Recommended actions focus on providing access for management projects and ongoing work while working to reduce impacts on water quality and habitat. Future road work falls into three categories:

- **Road improvements**—Road improvements address issues such as poor or improper drainage, structural concerns associated with the cut-slope, prism or fill-slope, and road shaping and surfacing. Roads are prioritized for improvements based on the capacity of the existing road to provide needed access, the extent to which current conditions are contributing to resource degradation, and the extent to which economically feasible solutions exist to address the critical concerns.

- **Maintenance**—Road maintenance represents annual work needed to prevent drainage problems from escalating into larger problems and maintaining road tread to achieve designed drainage characteristics.
- **Decommissioning**—When a road is no longer needed, it is classified as non-essential and placed on a list of roads to be decommissioned. Decommissioning commonly involves removal and relocation of over-steepened and unstable fill as well as restoration of natural drainage patterns and stream crossings.

Road Prioritization

A schedule was developed to prioritize road improvements and decommissioning (Tables 9-3 and 9-4).

Improvements are prioritized based on a road's ability to provide needed short-term access as well as the extent of adverse impacts for which cost-effective solutions have been identified (e.g., road-generated fine sediment delivery).

TABLE 9-3.
RECOMMENDED SCHEDULE FOR ROAD IMPROVEMENTS

Rec. #	Road	Justification
High Priority		
TR1	30.1	Needed to support protection, invasive species, and forestry work
TR2	52.2	Needed to support protection, invasive species, and forestry work
TR3	71	Needed to support protection, invasive species, and forestry work; Improvements have started and need to be completed in order to achieve intended operational and resource benefits
TR4	70	Core road with greatest use and greatest potential to adversely affect reservoir water quality
Moderate Priority		
TR5	50	Core road with greatest use and greatest potential to adversely affect reservoir water quality
TR6	71.4	Very high use; potential to deliver large quantities of sediment to Consultant Creek and reservoir
TR7	52	Needed to support protection, invasive species, and forestry work
TR8	70.4	Needed to support protection, invasive species, and forestry work
TR9	30.3	Needs evaluation and design work
TR10	30.4	
TR11	30	Access for restoration projects—Hancock owns

**TABLE 9-4.
RECOMMENDED SCHEDULE FOR ROAD DECOMMISSIONING**

Rec. #	Road	Justification
High Priority		
TR12	70.5	Nonessential road adversely affecting aquatic resources; encroaches into Consultant Creek riparian zone
Moderate Priority		
TR13	30.8	Nonessential road on potentially unstable slope; encroaching riparian zone or delivering fine sediment
TR14	50.7(1/2)	Nonessential road on potentially unstable slope; encroaching riparian zone or delivering fine sediment
TR15	52.2	Nonessential road on potentially unstable slope; encroaching riparian zone or delivering fine sediment
TR16	52.21	Nonessential road on potentially unstable slope; encroaching riparian zone or delivering fine sediment
TR17	70.8	Nonessential road on potentially unstable slope; encroaching riparian zone or delivering fine sediment
TR18	50.60	Nonessential road; moderate to little current adverse impact on aquatic or upland resources
TR19	50.61	Nonessential road; moderate to little current adverse impact on aquatic or upland resources
TR20	50.9	Nonessential road; moderate to little current adverse impact on aquatic or upland resources
Low Priority		
TR21	71.1	Nonessential road; little current adverse impact on aquatic or upland resources
TR22	71.42	Nonessential road; little current adverse impact on aquatic or upland resources
TR23	71.43	Nonessential road; little current adverse impact on aquatic or upland resources
After 2025, High Priority		
TR24	55	Nonessential road; encroaches on riparian zones; is a source of fine sediment to a fish-bearing stream
After 2030, High Priority		
TR25	52	Nonessential road contributing fine sediment to the South Fork Tolt Reservoir
TR26	30.6	Nonessential road contributing fine sediment to the South Fork Tolt Reservoir
After 2040, High Priority		
TR27	73	Nonessential road contributing fine sediment to fish-bearing streams
TR28	30.5	Nonessential road contributing fine sediment to fish-bearing streams
After 2060, High Priority		
TR29	30.3	Nonessential road on potentially unstable slopes
TR30	30.4	Nonessential road

Three road segments have been prioritized for improvement prior to 2014. Eight other roads have been given a moderate priority, reflecting those contributing adversely to water quality but which in their present condition are able to meet SPU's access needs.

Roads no longer needed by SPU and for which access does not need to be maintained per agreements with neighboring properties are designated as non-essential roads. Three roads have been identified for decommissioning prior to 2014 because of their adverse impacts to aquatic habitat and water quality as well as those that require expensive annual maintenance. Eleven additional roads have been given a moderate priority, are also classified as non-essential; given sufficient funds, these will be decommissioned between 2014 and 2025.

Standards

Road maintenance and improvements in the SFTMW are governed by three main principles: (1) provide safe access for permitted public and City staff activities; (2) ensure that high water quality standards are maintained; and (3) perform work with economic accountability. The unique terrain and the water supply and habitat resources in the SFTMW require road improvement activities to be conducted to high standards.

Steep terrain in the SFTMW means there are very few wetlands that could be impacted by roads. However, there are numerous vulnerable water crossings and a water-adjacent perimeter road around the reservoir that is an ongoing major sediment source.

Road management standards for maintenance and improvement in the SFTMW will be same as those used to manage the Cedar River watershed (*City of Seattle Cedar River Watershed Road Management Standards and Guidelines*, Draft, January 2004).

These standards address all aspects of road construction, maintenance and decommissioning, including work methods, drainage structures, materials, and environmental protection. They include methods to ensure that all road work is conducted to provide protection of water quality and habitat, reduce road failures, and provide appropriate safe access.

Each road class has a unique suite of structural features and dimensions and ongoing maintenance levels. When fully implemented, these standards provide sufficient detail to ensure that SFTMW road work meets WDNR Forest Practices Board Rules (WAC Chapter 222-2). See Appendix D for detail on road standards.

Seattle Public Utilities

South Fork Tolt Watershed Management Plan

PART 3.
IMPLEMENTATION

June 2011

CHAPTER 10
PLAN IMPLEMENTATION

CHAPTER 10.
PLAN IMPLEMENTATION

The management plan is intended to be implemented over a 20-year timeframe and will be reviewed and updated as needed during that time. A complete review and update of the Plan should commence at the end of the 20-year period. The vision, goals, objectives, and policies of the Plan are fixed, though the recommended actions are designed to be revised and updated as appropriate, thus providing some flexibility over the course of plan implementation.

This chapter provides a framework for implementing the recommended actions defined in the previous chapters. Table 10-1 summarizes the management actions, the timing of planned implementation, and the chapter of this plan in which the actions are described in detail. The information provided in the table can be used in conjunction with the more detailed management actions described in the previous chapters and associated appendices. Each recommended action will be included in one or more of the following phases:

- **5-Year Phase**—First five years of plan implementation. This phase includes many of the watershed protection actions as well as forest and aquatic resources restoration actions and transportation actions pertaining to watershed health and water quality.
- **10-Year Phase**—Years 5-10 of implementation. Many 10-Year Phase actions are follow-on tasks or monitoring related to actions initiated in the 5-Year Phase.
- **20-Year Phase**—Years 10-20 of implementation. These actions, although still important, are more integral to achieving other watershed management goals.
- **As-Needed Actions**—As-Needed actions are essential to meeting the primary goal and are required to occur prior to the design and construction of new structures, initiation of a new activity, or granting of a new permit.

The primary goal of this plan is to maintain and protect source water quality and quantity for the water supply and downstream ecosystems. Actions that are most critical to meeting this goal have been prioritized in the 5-Year Phase or As-Needed actions.

As-needed actions critical to meeting Plan goals must also ensure that proposed activities meet other goals and policies of SPU and follow best management practices. Unless also part of phased actions, they are generally to be conducted prior to any new construction activities within or adjacent to the watersheds. For example, adherence to cultural resource management protocols must precede all ground-disturbing activities.

This management plan identifies new actions not yet undertaken, as well as previously initiated and ongoing activities. Table 10-1 presents a proposed implementation schedule and work plan for the first six years of plan implementation.

A number of watershed protection actions are prioritized, including installation and replacement of gates, deployment of portable toilet facilities, implementation of access control and emergency response programs, and completion of analyses regarding mining claims and agreements with neighboring landowners. High priority ecosystem actions include planning and initiating forest treatment projects, implementing the invasive species control and cultural resources programs, and completing fish and wildlife surveys.

Table 10-1 identifies the status of each 5-Year Phase management action as: Ongoing, Initiated, or Needed.

TABLE 10-1.
IMPLEMENTATION OF THE SOUTH FORK TOLT WATERSHED MANAGEMENT PLAN

Action[a]	Description	Chapter	Date	Status
5-Year Phase				
WP1	Develop comprehensive Tolt Water Supply Security and Protection Plan	3	2011-2015	Ongoing
WP2	Install Industrial Fire Precaution Level warning signs at access gates on the 50 and 70 Road entrances to the municipal watershed	3	2011	Needed
WP3	Station a fire trailer at the Vista House	3	2011	Initiated
WP4	Install Cyber locks	3	2011	Initiated
WP5	Install new gates	3	2011-2013	Initiated
WP6	Post “No Trespass” signs every 100 feet around the perimeter of the City-owned portion of the watershed	3	2011-2015	Needed
WP7	Install portable toilets in appropriate locations throughout the watershed	3	2011-2012	Needed
WP9	Implement increased patrol schedule	3	2011-2015	Needed
WP11	Station 12-foot rescue cache trailer at the Vista House to expedite emergency response	3	2011-2012	Needed
WP12	Analyze USFS land ownership issues	3	2011-2013	Ongoing
WP13	Update Hancock agreement; request 30 road access for restoration projects	3	2012-2013	Needed
WP14	Analyze mining claims issues	3	2011-2013	Ongoing
FOR1	Prioritize restoration activities based on the decision model for restoration treatments	4	2011	Ongoing
FOR4	Commence ecological thinning treatments beginning at Northshore East and East Shore	4	2011-2012	Needed

a. Actions defined in Technical Module Chapters 3-9; numbers correspond to listed recommended actions. WP = Watershed Protection; FOR = Forest Resources; AQ = Aquatic Resources; FW = Fish and Wildlife; IS = Invasive Species; CR = Cultural Resources; TR = Transportation

TABLE 10-1 (continued).
IMPLEMENTATION OF THE SOUTH FORK TOLT WATERSHED MANAGEMENT PLAN

Action[a]	Description	Chapter	Date	Status
5-Year Phase (continued)				
FOR5	Plant less tolerant species (Douglas-fir, Western redcedar) in canopy gaps	4	2011-2015	Needed
FOR6/ AQ2	Commence riparian thinning treatments	4	2011	Needed
AQ1	Install large woody debris (LWD) in floodplain channels of the South Fork Tolt River between the 50 Road and the Tolt Reservoir	5	2011	—
AQ3	Assess and prioritize riparian restoration opportunities in small streams	5	2011-2013	Ongoing
FW1	Conduct special habitat survey and ground verification of the special habitats map	6	2011-2015	Needed
FW3	Complete or expand surveys for the following species: marbled murrelet, common loon, and amphibians	6	2013-2015	Needed
FW4	Continue efforts to monitor and provide common loon nesting platforms in the reservoir	6	2011	Ongoing
FW5	Complete assessment of northern goshawk habitat quality	6	2011-2015	Needed
IS1	Implement early detection/rapid response protocol; survey a portion of the watershed every year, with a complete survey every five years	7	2011	Ongoing
IS2	Encompass all invasive species surveys and control treatments in the South Fork Tolt Municipal Watershed within SPU's Invasive Species Program for major watersheds	7	2011	Ongoing
IS3	Complete invasive species surveys	7	2011-2012	Ongoing
IS4	Complete experimental invasive species control efforts	7	2011-2015	Ongoing
CR2	Update GIS database for known and potential resources	8	2011-2015	Needed
TR1	Improve 30.1 Road	9	2012-2015	Needed
TR2	Needed to support protection, invasive species, and forestry work	9	2012-2015	Needed
TR3	Improve 71 Road	9	2011-2012	Needed
TR12	Decommission 70.5 Road	9	2011	Needed

a. Actions defined in Technical Module Chapters 3-9; numbers correspond to listed recommended actions. WP = Watershed Protection; FOR = Forest Resources; AQ = Aquatic Resources; FW = Fish and Wildlife; IS = Invasive Species; CR = Cultural Resources; TR = Transportation

TABLE 10-1 (continued).
IMPLEMENTATION OF THE SOUTH FORK TOLT WATERSHED MANAGEMENT PLAN

Action[a]	Description	Chapter	Date	Status
10-Year Phase				
FOR3	Restoration thinning in Skookum and Siwash Creek subbasins	4	2011-2020	Needed
FOR4	Ecological thinning by Horseshoe Creek and convergence of the 70 and 70.7 roads	4	2016-2020	Needed
TR4	Improve 70 Road	9	2016-2020	Needed
TR5	Improve 50 Road	9	2016-2020	Needed
TR6	Improve 71.4 Road	9	2016-2020	Needed
TR7	Improve 52 Road	9	2016-2020	Needed
TR8	Improve 70.4 Road	9	2016-2020	Needed
TR13	Decommission 30.8 Road	9	2016-2020	Needed
TR14	Decommission 50.7(1/2) Road	9	2016-2020	Needed
TR15	Decommission 52.2 Road	9	2016-2020	Needed
TR16	Decommission 52.21 Road	9	2016-2020	Needed
TR17	Decommission 70.8 Road	9	2016-2020	Needed
20-Year Phase				
TR9	Improve 30.3 Road	9	2030	Needed
TR10	Improve 30.4 Road	9	2030	Needed
TR11	Improve 30 Road (access for restoration projects- Hancock road)	9	2030	Needed
TR18	Decommission 50.60 Road	9	2030	Needed
TR19	Decommission 50.61 Road	9	2030	Needed
TR20	Decommission 50.9 Road	9	2030	Needed
TR21	Decommission 71.1 Road	9	2030	Needed
TR22	Decommission 71.42 Road	9	2030	Needed
TR23	Decommission 71.43 Road	9	2030	Needed
TR24	Decommission 55 Road (after 2025)	9	2030	Needed
TR25	Decommission 52 Road (after 2030)	9	2030	Needed
TR26	Decommission 30.6 Road (after 2030)	9	2030	Needed
TR27	Decommission 73 Road (after 2040)	9	2040	Needed
TR28	Decommission 30.5 Road (after 2040)	9	2040	Needed
TR29	Decommission 30.3 Road (after 2060)	9	2060	Needed
TR30	Decommission 30.4 Road (after 2060)	9	2060	Needed

a. Actions defined in Technical Module Chapters 3-9; numbers correspond to listed recommended actions. WP = Watershed Protection; FOR = Forest Resources; AQ = Aquatic Resources; FW = Fish and Wildlife; IS = Invasive Species; CR = Cultural Resources; TR = Transportation

TABLE 10-1 (continued).
IMPLEMENTATION OF THE SOUTH FORK TOLT WATERSHED MANAGEMENT PLAN

Action[a]	Description	Chapter	Date	Status
As-Needed Actions				
WP8	Inform all individuals entering the watershed of watershed access and control regulations, which include the requirement for sanitary facilities to be installed at all work sites and prohibit sanitation activities that could contaminate the water supply	3	—	Ongoing
WP10	Provide adequate level of incident response, investigation, resolution, reporting, and follow-up staffing	3	—	Ongoing
FOR2	Coordinate forest restoration treatments in different ecosystems and among other management activities such as road decommissioning and aquatic restoration	4	—	Ongoing
AQ5	Prioritize riparian projects and coordinate with other technical areas to increase efficiency and expedite road decommissioning	5	—	Ongoing
FW2	Assess presence and quantity of snags and downed wood during project planning in all proposed treatment areas to protect these features and to potentially increase their abundance	6	—	Ongoing
FW6	If found, protect nest sites of spotted owl, marbled murrelet, and other listed or sensitive species (e.g., common loon, peregrine falcons, northern goshawk)	6	—	Ongoing
FW7	Leave naturally deposited large woody debris on the reservoir delta in place. Stockpile any large woody debris removed from the reservoir	6	—	Ongoing
FW8	Minimize or avoid all disturbance to the delta from heavy equipment	6	—	Ongoing
IS5	Utilize integrated pest management principles	7	—	Ongoing
CR1	Follow recommendations and management standards adapted from the U.S. Secretary of the Interior’s Standards and Guidelines for Archeology and Historic Preservation	8	—	Ongoing
CR3	Consider protection and management of cultural resources in planning for projects or maintenance work in the watershed. This includes consulting the SPU cultural resource database	8	—	Ongoing
CR4	Consult and follow the appropriate protocol in Appendix C in the event of unanticipated discovery of cultural materials, discovery of human remains, vandalism, or an emergency	8	—	Ongoing
CR5	Follow the HABS/HAER standards if mitigation is necessary	8	—	Ongoing

a. Actions defined in Technical Module Chapters 3-9; numbers correspond to listed recommended actions. WP = Watershed Protection; FOR = Forest Resources; AQ = Aquatic Resources; FW = Fish and Wildlife; IS = Invasive Species; CR = Cultural Resources; TR = Transportation

Seattle Public Utilities

South Fork Tolt Watershed Management Plan

SUPPLEMENTAL INFORMATION

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REFERENCES AND GLOSSARY

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GLOSSARY

Terms

Archaeological sensitivity zones— Areas designated through the use of an archaeological probability model to determine the potential for ground-disturbing activities to impact previously undiscovered cultural sites or resources. These zones help inform the appropriate level of investigation required prior to and during ground-disturbing activities.

Alluvial fan—A fan-shaped deposit formed where a fast flowing stream flattens, slows, and spreads, typically at the exit of a canyon onto a flatter plain.

Anadromous—Fish that live in the sea but breed in fresh water.

Armoring (bed and banks)—The hardening of streambanks to reduce erosion potential using hard (rocks or structures) or soft (biotechnical) engineering techniques.

Avulsion—A quick change in channel course that occurs when a stream suddenly breaks through its banks.

Basal area (of a tree)—The cross-sectional area of the trunk, 4.5 feet above the ground; (per acre) the sum of the basal areas of the trees on an acre; used as a measure of forest density.

Bed coarsening—Changes in average size of stream bed material from smaller to larger dimensions through time, typically in response to changes in stream or watershed characteristics which would contribute to either great average flows or greater local velocities within the channel.

Biodiversity—Biological diversity; the combination and interactions of genetic diversity, species composition, and ecological diversity in a given place and at a given time.

Board-foot volume—A unit for measuring wood volume in a tree, log, or board. A board foot is commonly 1 foot by 1 foot by 1 inch, but any shape containing 144 cubic inches of wood equals one board foot.

Braided (channel)—A stream or river characterized by flow within several channels, which successively meet & divide. Braiding often occurs when sediment loading is too great to be carried by a single channel

Buffer—A forested, or otherwise undisturbed, strip left or treated differently during Silvicultural activities to protect sensitive ecosystems (e.g., streams, wetlands, and old-growth forests) or fish or wildlife habitat. Management activities such as planting or thinning may be allowed in buffers if they are consistent with the conservation objectives for the buffer.

Cambium—A layer of living cells between the bark and hardwood of a tree that each year produces additional wood and bark cells. This layer is responsible for the diameter growth of a tree.

Canopy—The cover of branches and foliage formed collectively by the crowns of trees or other growth. Also used to describe layers of vegetation or foliage in a forest, as when referring to the multi-layered canopies or multi-storied conditions typical of ecological old-growth forests.

Canopy closure—The degree to which the boles, branches, and foliage (canopy) block penetration of sunlight to the forest floor or obscures the sky; determined from measurements of density (percent closure) taken directly under the canopy.

Carbon sequestration—An approach to mitigate carbon emissions by capturing carbon dioxide (CO_2) and storing it instead of releasing it into the atmosphere.

Channel complexity—A suite of characteristics, often applied to a reach of stream within a given channel type (see below), with significantly variability in time and space. Often complexity refers to variability in physical channel characteristics such as frequencies and dimensions of pools, woody debris, and substrate sizes.

Channel incision—A process of channel adjustment by which the stream bed cuts into and ultimately establishes a lower bed elevation.

Channel type—segments of stream which share a unique suite of physical attributes, commonly related to gradient, valley confinement, and adjacent landforms and helps predict the reference or stable condition of the reach.

Clearcut—Removal of nearly all standing trees within a given harvest area. This system focuses on promoting regeneration of species that thrive in full sunlight. It is also the most efficient and economical method of harvesting timber. As defined by Forest Practice Rules (1995), "…a harvest method in which the entire stand of trees is removed in one timber harvesting operation. Except as provided in WAC 222-30-110, an area remains clearcut until: It meets the minimum stocking requirements under WAC 222-34-010(2) or 222-34-020(2); and the largest trees qualifying for minimum stocking levels have survived on the area for five growing seasons or, if not, they have reached an average of four feet."

Coarse sediment—Soil particles carried by water that are greater than 2 mm in size; usually gravel, cobble, and boulders.

Connectivity—A measure of the extent to which conditions between different areas of similar or related habitat provide for successful movement of fish or wildlife species, supporting populations on a landscape level.

Convergent (topography)—Slopes which drain to or funnel water towards a common point upslope of a stream channel.

Core roads—These roads are needed for long term use and provide access to critical infrastructure, and support land management and protection activities. Core roads also include those used for access to adjacent properties. Activities on these roads will be governed by Road Use Agreements (see Neighboring Properties Chapter).There are 14.3 miles of core roads in the SFTMW

Critical assets—Any asset or infrastructure component that is necessary for the delivery of water for the SFTMW.

Cultural resources—Areas, places, buildings, structures, outdoor works of art, natural features, and other objects having a special historical, cultural, archaeological, architectural, community, or aesthetic value.

Cultural resource management plan— A comprehensive plan developed to protect and manage cultural resources in a given geographic area (e.g. Cedar River Municipal Watershed Cultural Resources Management Plan).

Culturally sterile deposits— Deposits that contain no identifiable cultural material.

Curation— The process and procedure for evaluating, storing, documenting and archiving culturally significant material, including artifacts, documents, maps and oral histories.

Cut-and-leave thinning— An active forest restoration strategy involving the deliberate selective felling of trees to achieve a particular ecological objective. This technique is planned for riparian forests where trees will be felled towards a stream channel in order to enhance current levels of in-stream wood and accelerate growth of remaining riparian trees.

Cut-banks (roads)—See Cut-Slope

Cut-slope (roads)—The part of the road cross-section where material was excavated from the hill slope to provide space for road driving surface and ditch. Cut-slopes are designed to be constructed at an angle appropriate for the material on site.

Cyber-lock/cyber-key—Programmable, key retention padlocks that have the versatility of a key card system when no power or communication is available at remote locations. The operation of a cyber-lock involves a corresponding cyber-key that electronically connects with the padlock upon insertion. This connection exchanges data and allows or denies the operator access via the padlock. All of this data is retained in the cyber-lock and downloaded at a later time by security personnel.

Decommissioning—Deconstruction; work on roads no longer to be used that leaves them in a condition suitable to control erosion and maintain water movement. Methods of decommissioning include removal of bridges, culverts, and fills in accordance with WAC 222-24-050.

Depressional wetland— Depressional wetlands occur in topographic depressions that exhibit closed contours on three sides. Elevations within the wetland are lower than in the surrounding landscape. The shape of depressional wetlands vary, but in all cases, the movement of surface water and shallow subsurface water is toward the lowest point in the depression. Depressional wetlands may be isolated with no surface water inflow or outflow through defined channels, or they may have intermittent surface water flows that connects them to other surface waters or other wetlands.

Diameter at breast height—The diameter of a tree, including bark, measured 4.5 feet above the ground on the uphill side of a tree and measured in inches.

Dispersal (lateral dispersal of high flows)—Refers to the capacity of a stream to spread water during greater than annual peak flow events across a broad area, thereby minimizing the disturbance to the stream bed by changes in the frequency or magnitude of peak flows.

Distribution (of a species)—The spatial arrangement of individuals of a species within its range.

Disturbance—Significant change in forest structure or composition through natural events (such as fire, flood, wind, earthquake, or disease) or human-caused events (forest management).

Downed wood— Wood found on the forest floor in various stages of decomposition. As the wood decays it plays an essential role in forests and streams, including: food, shelter, growing sites for plants and fungi, soil enrichment, and stream habitat.

Early detection/rapid response protocol— A prompt and coordinated containment and eradication response when new invasive species infestations are detected. This results in lower cost and less resource damage than implementing a long-term control program after the species is established.

Early-successional—Recently harvested or disturbed forest habitat dominated by young trees and shrubs.

Ecological thinning— The practice of cutting, damaging or otherwise killing some trees from some areas of dense, second-growth forest (typically over 30 years old). The intent of ecological thinning is to encourage development of the habitat structure and heterogeneity typical of late-successional and old-growth stands, characterized by a high level of vertical and horizontal forest structure, and to improve habitat quality for wildlife. Techniques may include variable-density thinning to create openings, develop a variety of tree diameter classes, develop understory vegetation, and recruit desired species; and creating snags and logs by uprooting trees, felling trees, topping trees, injecting trees with decay-producing fungus, and other methods. Ecological thinning does not have commercial objectives. However, in cases where excess woody material is generated by felling trees, trees may be removed from the thinning site and sold or used in restoration projects on other sites.

Ecosystem—A natural system composed of component organisms interacting with their environment.

Ecosystem services— Natural assets that provide a full suite of goods and services which are vital to human health and livelihood**.** Lacking a formal market, these natural assets are often overlooked. When our watersheds and forests are undervalued they are increasingly susceptible to development pressures and conversion. Recognizing these ecosystems as natural assets with economic and social value can help promote conservation and more responsible decision-making.

Endangered species, federal—A designation as defined in Section 3 of the federal Endangered Species Act for a species in danger of extinction throughout all or a significant portion of its range.

Endangered species, state—A wildlife species native to the State of Washington, that is seriously threatened with extinction throughout all or a significant part of its range within the State. State endangered species are legally designated in WAC 232-12-014 and defined in WAC 232-12-297 Section 2.4.

Epiphytic—Usually grows on another plant but is not parasitic.

Fill-slope—The part of the road cross-section where material is placed on the downslope side of the hill to provide space for the road driving surface. The angle of the material is designed to be appropriate for the material used.

Fine sediment—Soil particles carried by water that are less than 2 mm in size; usually clay and silt.

Forensic anthropologist—Forensic anthropology is the application of the science of physical anthropology and human osteology (the study of the human skeleton), most often in cases where the remains are more or less skeletonized. A forensic anthropologist can also assist in the identification of deceased individuals whose remains are decomposed, burned, mutilated or otherwise unrecognizable.

Forest management— A range of human interventions affecting forest ecosystems that vary depending on the management objectives.

Forest succession—The sequential change in composition, abundance, and patterns of species that occurs as a forest matures after an event in which most of the trees are removed. The sequence of biological communities in a succession is called a sere, and the communities are called seral stages.

Geographic Information System—A computer system for collecting, storing, retrieving, transforming, displaying, and analyzing spatial or geographic data, accomplished by linking areas or map features with associated attributes for a particular set of purposes, including the production of a variety of maps and analyses.

Gullying—The process that results in a gully: landforms created by running water eroding sharply into soil, typically on a hillside, that resemble large ditches or small valleys.

Habitat— The sum total of environmental conditions of a specific place occupied by plant or animal species or a population of such species. A species may require or use more than one type of habitat to complete its lifecycle.

Headwaters—The source of a stream or stream system.

Humic layer—The top, organic layer of soil, made up mostly of leaf litter and humus (decomposed organic matter).

Hydrology—The cycling, movement, distribution, and properties of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Integrated pest management—An approach to pest management that uses current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

Invasive species—Non-indigenous species (e.g. plants or animals) that adversely affect the habitats they invade economically, environmentally or ecologically.

Isolate—One to nine artifacts discovered in a location that appear to reflect a single event or activity.

Key habitat—Habitat that is utilized by and often required for a species for breeding or rearing or both.

Lacustrine fringe wetland—Wetlands that generally occur on river floodplains and along lakeshores and are influenced by seasonal variations in groundwater levels. These wetlands support an abundance of warm-water loving plant and animal species.

Lake—A body of open water greater than 20 acres in area and at least 6.6 feet deep at low water.

Large woody debris—Large pieces of wood in or partially in stream channels, including logs, pieces of logs, root wads of trees, and other large chunks of wood. Large woody debris provides streambed and bank stability and habitat complexity. Often called coarse woody debris within forests.

Late-successional forest—Forest in the later stages of forest succession; the sequential change in composition, abundance, and patterns of species that occurs as a forest matures. Characterized by increasing biodiversity and forest structure, such as a number of canopy layers, large amounts of coarse woody debris, light gaps (canopy openings), and developed understory vegetation.

Linkage—Connectivity between watershed processes and sensitive aquatic resources . Also used to describe connections between critical aquatic resources and those historic and current management activities most responsible for changes to these resources.

Listed wildlife species, federal—Under the federal Endangered Species Act, species, or sub-unit of a species, formally listed in the Federal Register as endangered or threatened by the Secretary of the Interior or the Secretary of Commerce. A listing refers to the species or sub-unit by scientific and common name and specifies over what portion of its range it is endangered or threatened.

Listed wildlife species, state—Wildlife species that are classified as endangered, threatened, or sensitive under Washington State law. Defined in WAC 232-12-297.

Main stem—The primary stream channel of a river into which tributaries flow, extending from the mouth of the river to its furthest headwater.

Management prescriptions—A set of procedures designed to accomplish a specific management objective.

Marbled murrelet—*Brachyramphus marmoratus.* A Pacific seabird that typically nests in mature or old-growth forests within 50 miles of the marine environment; listed as a federal and state threatened species.

Mass wasting—The downslope movement of earth caused by gravity. Includes but is not limited to landslides, rock falls, debris avalanches & creep. It does not include surface erosion by running water. It may be caused by natural erosional processes, by natural disturbances, or by human disturbances.

Mitigation—Methods of reducing adverse impacts of a project by (1) limiting the degree or magnitude of the action; (2) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (3) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; or, (4) compensating for the impact by replacing or providing substitute resources or environments.

Morphology (channel, wetland)—The form and structure (characteristic physical features) of streams and wetlands.

Municipal watershed—A portion of the watershed basin.

Native species—Any wildlife species naturally occurring in a specific area of Washington for purposes of breeding, resting, or foraging, excluding introduced species not found historically in this state; defined by WAC 232-12-297.

Non-essential road (current)—These roads have been identified as providing no current or future access needs. These roads will be scheduled for decommissioning to a standard that will eliminate potential adverse environmental impacts from the road. Roads with the highest potential to adversely affect water quality, because of steep slopes, high mass wasting potential or other conditions, will be decommissioned first. All roads must be maintained to a stable condition until they have been decommissioned.

Non-essential road (future)— These roads will be needed to provide access only for a limited time to implement projects described in this watershed management plan. These activities include stream restoration, forest habitat restoration projects, environmental studies, or invasive species removal. When the project has been completed and the road is no longer needed, it will be reclassified as non-essential (current) and scheduled for decommissioning. The roads may be needed for various lengths of time ranging from just 5 years until as late as 2060, and must be maintained in a stable condition until they are eventually decommissioned.

Non-native species—Those animal and plant species that were not originally in a specific geographic area, but have been introduced, either intentionally or unintentionally, by humans.

Northern spotted owl—*Strix occidentalis caurina.* A medium-sized, dark brown owl native to the Pacific coastal region that primarily nests and lives in old-growth forest; federally listed as a threatened species and listed as endangered by Washington State.

Old-growth forest—Conditions in older conifer forest stands, with vertical and horizontal structural attributes sufficient to maintain some or all of the ecological functions of a natural "ecological old-growth" forest, which is typically at least 200 years old and often much older. Old-growth forests typically contain large live trees, large dead trees ("snags") and large logs. Old growth forests usually have multiple vertical layers of vegetation representing a variety of tree species and age classes.

Osteologist—One who studies the morphology and pathology of bones.

Piezometer well—An instrument for measuring water pressure.

Pistol butting— A deformation of lower tree trunks resulting from physical forces associated with steep slopes, such as unstable soils or heavy snow loads, that put down-slope pressure on the tree trunks and cause a curved, rather than a straight, trunk at the base. Pistol butting is often a sign of unstable slopes.

Pool habitat— Distinct areas within a stream channel defined by very low water surface slopes and relatively deep water.

Prism—The road cross-section, including cut-slope angle, ditch width and depth, road crown, in-slope or out-slope, and fill-slope angle. The road prism or cross-section designed to have angles appropriate to the material on site.

Rain on snow zone—The area where several times during the winter the snowpack is partially or completely melted during warm periods and/or rainstorms.

Recruitment (of wood/trees)—The process of tree entry into a stream channel via natural processes or active restoration.

Recordation—A term used in archaeology to denote all archaeological evidence, including the physical remains of past human activities, which archaeologists seek out and record in an attempt to analyze and reconstruct the past. In the main it denotes buried remains unearthed during excavation.

Reservoir—The South Fork Tolt Reservoir, one of Seattle's primary water sources.

Residual advanced regeneration—Trees that became established under the canopy of preceding forests stands.

Response reach—Typically low gradient channels where extensive, long-term changes to key aquatic characteristics are predicted following large to modest changes in watershed processes due to natural causes & or anticipated human activity.

Restoration planting—Planting of native trees, shrubs, and other plants to encourage development of habitat structure and heterogeneity, to improve habitat conditions for fish and wildlife, and to accelerate development of old-growth conditions or riparian forest function in previously harvested second growth.

Restoration thinning—A silvicultural intervention strategy applied in areas of young (usually 10 to 40 years-old) over-stocked forest with the intent of increasing biological diversity and wildlife habitat potential, accelerating the development of mature forest characteristics, and minimizing the amount of time a stand remains in the stem exclusion stage (a stage characterized by minimal light penetration and low biological diversity). This strategy protects water quality by reducing the risk of large-scale catastrophic damage to the watershed (primarily through development of wind-firmness and increased resistance to insect attack, which is exacerbated by the stress on intense competition among trees). Techniques for restoration thinning include cutting, girdling, or otherwise killing some trees in variable density thinning patterns, retaining a mix of species that is characteristic of natural site conditions, and leaving small gaps or openings characteristic of naturally regenerated forests that result from small natural disturbances such as wind or disease.

Riparian habitat— Habitat along lakes, rivers, and streams where the vegetation and microclimate are influenced by year-round or seasonal water and associated high water tables or that influence the aquatic environment.

Riparian management zone—As defined in the Washington State Forest Practice Rules (WAC 222), it is "the area protected on each side of a [typed water body that is] measured horizontally from the outer edge of the bank-full width or the outer edge of the [channel migration zone], whichever is greater." Specific rules guide allowable forest management activities within these zones.

Riparian zone—The area adjacent to surface waters and areas of high groundwater levels where the terrestrial system both influences and is influenced by the aquatic system.

Riverine wetland—Wetlands that are found within river and stream channels and are strongly influenced by seasonal runoff patterns. When inundated, riverine wetlands provide habitat for water-tolerant plants such as willows, and aquatic animals such as tadpoles and immature fish.

Road shaping—Working on the shape of the road to achieve the designed road cross-section or prism, including cut-slope angle, ditch width and depth, road crown, in-slope or out-slope, and fill-slope angle.

Scarification—Scratching the hardened road bed with equipment teeth. This softens it to allow vegetative growth, usually grasses or trees, during road decommissioning.

Scour (bed scour, debris flow scour, gravel scour, lateral scour) — Mobilization and transport of streambed gravel during high flows; the erosion of streambed and/or banks caused by flood water in a river or stream.

Second-growth forest—Forest stands in the process of regrowth following a stand-replacing disturbance.

Sensitive Resource—A portion of the aquatic (stream or wetland) network which either has been significantly altered or has a high likelihood of being altered due to natural causes & or anticipated human activity.

Shovel test—A popular form of rapid archaeological survey in the U.S. and

Canada. It designates a series of test holes (0.50 m or less) in order to determine whether the soil contains any cultural remains that are not visible on the surface. The soil is sifted or screened through wire mesh to recover artifacts.

Side-cast berm—Material deposited adjacent to the road which is higher than the road surface and prevents surface water from flowing off the road. A berm can be a design feature in appropriate locations, but is often a problem-causing feature. Side-casting road material can result in over-steepened slopes that, in very steep terrain, can cause slope instability and failure under certain conditions. It is not always a problem-causing feature.

Silviculture—The theory and practice of controlling the establishment, composition, growth, and quality of forest stands in order to achieve management objectives. Includes such actions as thinning, planting, fertilizing, and pruning.

Site class—An index of forest productivity measured by the height of dominant trees at 50 years of age; Site Class I represents the highest productivity and Site Class V represents the lowest productivity.

Slash—Coarse and fine woody debris generated during logging operations or through wind, snow or other natural forest disturbances.

Snag—A standing dead tree.

SNOTEL station—An automated system of snowpack and related climate sensors operated by the Natural Resources Conservation Service of the U.S. Department of Agriculture in the Western United States. All SNOTEL sites measure snow water content, accumulated precipitation, and air temperature. Some sites also measure snow depth, wind speed, solar radiation, humidity, and atmospheric pressure. These data are used to forecast yearly water supplies, predict floods, and for general climate research.

Snow creep—A way that snow or ice can move by deforming its internal structure.

Species—A unit of the biological classification system (taxonomic system) below the level of genus; a group of individual plants or animals (including subspecies and populations) that have common attributes and are capable of interbreeding. The federal Endangered Species Act defines species to include subspecies and any “distinct population segment” or “evolutionary significant unit” of any species.

Species of concern—An unofficial status designation given a species which appears to be in jeopardy, but for which insufficient information exists to support listing.

Stand (forest stand)—A group of trees that possesses sufficient uniformity in composition, structure, age, spatial arrangement, or condition to distinguish then from adjacent groups of trees.

Stream reach—A segment of a stream that has beginning and end points selected for some specific characteristic.

Stratigraphy—A branch of geology that studies rock layers and layering (stratification).

Substrate (stream)—The composition of a stream bed including either mineral or organic materials.

Succession—The natural replacement of one plant (or animal) community by another over time in the absence of disturbance.

Talus slope—An accumulation of rock debris at the base of a cliff or rock formation, typically forming a slope that is often unstable.

Transient snow zone—An elevation band, often between 1,500 and 3,000 feet in the Pacific Northwest, where winter precipitation has a high probability of falling as snow then rapidly melting a few days or weeks later as a result of warm air temperatures or rain fall. . Rapid snow melt triggered by heavy rain storms and warm temperatures ("rain on snow") in this zone has historically contributed to extreme flooding in middle to low elevation streams during the fall and winter months.

Triple bottom line—An evaluation that captures an expanded spectrum of values and criteria for measuring organizational (and societal) success; economic, environmental and social.

Tributary—A stream that flows into a larger stream or body of water.

Triple bottom line—An evaluation approach that captures an expanded spectrum of values and criteria for measuring organizational (and societal) success: economic, environmental and social.

Turbidity—A measure of the content of suspended matter that interferes with the passage of light though the water or in which visual depth is restricted. The measurement of turbidity is a key test of water quality.

Understory—Vegetation that grows in the lowest forest strata, often in the shade of the forest canopy. Plants in the understory consist of a mixture of seedlings and saplings of canopy trees together with understory shrubs and herbs.

Washington Administrative Code—All current, permanent rules of each Washington state agency.

Watershed—A basin contributing water, organic matter, dissolved nutrients, and sediments to a stream, lake, or ocean.

Wetland—Land where the water table is usually at or near the surface or the land is covered by shallow water and has one or more of the following attributes: the land supports, at least periodically, predominately hydrophytic plants (plants adapted to water or waterlogged soil); substrate is predominately undrained hydric soils; and/or the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season each year.

Acronyms

AF (channel type)—Alluvial Fan

AFd (channel type)—Alluvial (debris) Fan

CAPS—Cedar Access Permitting System

CFR—Code of Federal Regulations

CRMP—Cultural resource management plan

CRP—Cultural resource professional

DAHP—Department of Archaeology and Historic Preservation

dbh—Diameter at breast height

DEM—Digital elevation model

ESA—Endangered Species Act

FERC—Federal Energy Regulatory Commission

FP (channel type)—Floodplain

FPd (channel type)—Floodplain Delta

FPN (channel type)—Narrow Floodplain

GIS—Geographic information system

HABS—Historic American Buildings Survey

HAER—Historic American Engineering Record

HPO—Historic preservation office

ICS—Incident Command System

IFPL—Industrial Fire Precaution Level

LWD—Large woody debris

MBSNF—Mount Baker Snoqualmie National Forest

MM (channel type)—Moderate Gradient and Width

MMN (channel type)—Moderate Gradient Narrow

NEPA—National Environmental Policy Act

NHPA—National Historic Preservation Act

NRHP—National Register of Historic Places

P&CP Mgr—Public and Cultural Programs Manager

RCW—Revised Code of Washington

RUA—Road Use Agreement

SC (channel type)—Steep Foot-Slope

SEPA—State Environmental Policy Act

SFTMW—South Fork Tolt Municipal Watershed

SHPO—State historic preservation officer

SPU—Seattle Public Utilities

TCP—Traditional cultural property

USFS—United States Forest Service

WAC—Washington Administrative Code

WARSEM—Washington Road Surface Erosion Model

WDFW—Washington Department of Fish and Wildlife

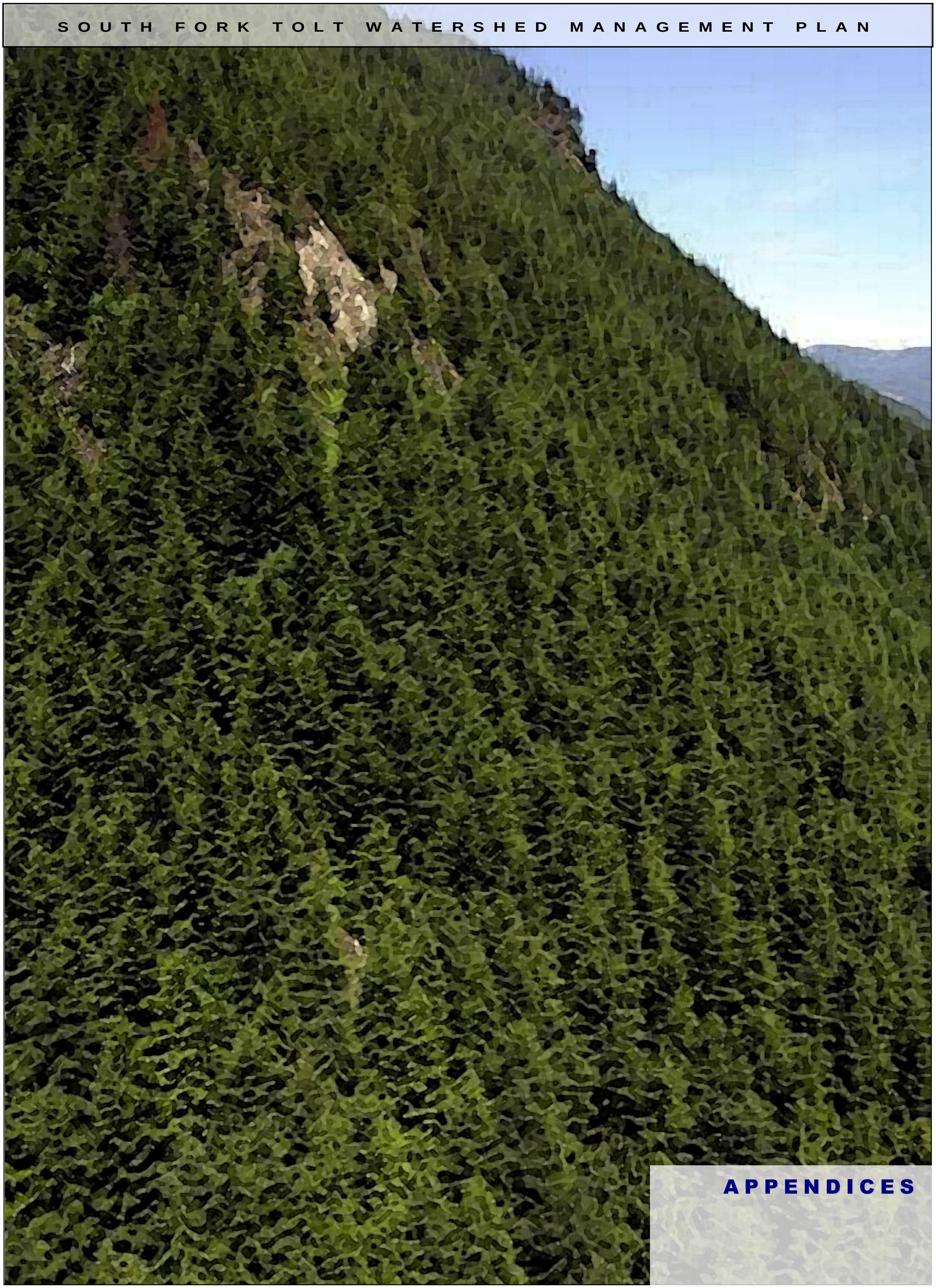
WDNR—Washington Department of Natural Resources

WDOT—Washington Department of Transportation

WFPB—Washington Forest Practices Board

WOA—Watershed Operation Agreement

MAPS



APPENDICES

APPENDIX A.
FOREST MANAGEMENT OPTIONS ANALYSIS

MODEL OF CARBON SEQUESTRATION FOR THE SOUTH FORK TOLT MANAGEMENT OPTIONS ANALYSIS

Information for timber inventory and harvest is imported by decade from OPTIONS growth model given in tons of carbon dioxide equivalents (CO2e, DR Systems, Inc.). Volume inventory is converted to total biomass (following Jenkins et al. 2003) and decadal increment is combined for the period of 2027 to 2066, 50 years. Dead wood is calculated as a fixed percentage of live biomass (following Smith et al. 2005) and increment of dead wood is summed over 50 years. Timber harvest output from OPTIONS model is divided into short (48%) and long term (52%) products, and detritus (102%). Emissions from products are calculated with individual decay rates (following Smith 2004). Annual sequestration is calculated as the sum of inventory increment, sum of dead wood increment, and sum of harvest volume divided by 50 years. Annual emissions are calculated as the sum of all emissions over 50 years. Net sequestration is annual sequestration minus annual emissions. Option 1, “Sustained Yield Timber Management,” is used as baseline and subtracted from other options to calculate additionality. Annual sequestration per acre is calculated by dividing annual sequestration by 7150 forested acres. Carbon sequestration and emissions from soil are not included.

SOUTH FORK TOLT MUNICIPAL WATERSHED ECOSYSTEMS SERVICES VALUATION EFFECTS OF FOREST RESTORATION

The proposed changes in forest management in the South Fork Tolt Municipal Watershed (SFTMW) are expected to affect the provisioning of ecosystem goods and services. Some ecosystem services are expected to be increased through active restoration (habitat development) while others are expected to be reduced through timber harvest (carbon sequestration). In order to inform policy decisions of whether or not to move forward with forest restoration in the watershed, we conducted an ecosystem service valuation comparing the effects of the proposed treatments with the no-action alternative. This valuation seemed necessary as the proposed restoration program would potentially reduce net carbon sequestration over the next 50 years compared to the no-action alternative. Average annual sequestration under forest restoration is projected to be 31,661 metric tons of carbon dioxide equivalents (t CO2e) compared to 38,954 CO2e under the no-action alternative. The City of Seattle has implemented a policy through its Climate Action Plan to reduce carbon emissions by the City's government operations as well as by the City's population and businesses in the interest of reducing climate change brought about by greenhouse gas emissions. Because carbon sequestration in the City’s watersheds can offset emissions taking place elsewhere in the City, it is important to quantify any reduction in sequestration (7,290 t CO2e) associated with active restoration management. However, carbon sequestration is only one element of the ecosystem services provided by the forests in the watersheds, so a change in carbon sequestration should be evaluated against benefits from other ecosystem services that are enhanced through active restoration.

Methods

Ecosystem service valuation (ESV) attempts to quantify those goods and services that have value to society and applies different techniques to attach monetary values to those goods and services. Estimating each service in monetary units provides a basis to compare benefits or costs for each category of ecosystem service and to quantify the natural capital of the SFTMW as an asset to the City of Seattle.

The Supplemental Ecosystem Services Study to the Tolt River Watershed Asset Management Plan (Batker 2005) served as a basis for this analysis. The study provided annual ecosystem service values in dollars for 23 identified categories of ecosystem services for the entire Tolt River watershed (63,800 acres). Batker estimated these values using the benefit transfer method, which entails the use of case studies from other regions and ecosystems (Gund Institute for Ecological Economics database) to extrapolate values and applying them to the Tolt watershed. The annual total value of ecosystem services provided by forested lands in the watershed was estimated by Batker to range from about $360M to $1.3B, depending on which sources were used in the benefit transfer method.

For the ecosystem services valuation of the South Fork Tolt watershed, we scaled these values down from the total forested area of the watershed to the forested area of the city-owned portion of the Municipal Watershed. We examined each of the 23 identified ecosystem service categories with respect to how they would be affected by the proposed forest restoration program and concluded that in 13 categories a difference in service value could be quantified. For each of the 13 categories, we estimated the change in ecosystem service level as best we could reasonably do so using the no-action alternative as a baseline for comparison. The remaining 10 categories were not included in the comparison. Two ecosystem service categories (disturbance prevention and refugium) were each split into quantifiable elements, and a proportion of the ecosystem service value was assigned to each of the elements. This allowed us to separate out elements that had greater importance in the original case study, used in Batker's analysis, but were less important in our analysis (e.g. non-forest habitat, flooding). We quantified change based on a rationale and information (Table 6) that resulted in what we believe are defensible metrics. In other cases, we used what we felt were conservative estimates based on professional judgment.

We then applied the estimate of percent change in ESV to the low and the high end of the range of values for each service, as scaled down from Batker's estimates, to arrive at a monetary value for the change in ecosystem service level due to restoration. We also made a mixed low/high valuation. We used the high range in value in cases where the ecosystem service was particularly important to the management goals in the SF Tolt watershed (e.g., disturbance prevention, water supply, refugium). In cases where ecosystem services in the original studies have less importance in the SFTMW (D. Batker pers. communication), we used the more conservative lower estimates. Values for climate regulation (i.e., carbon sequestration) were estimated using four different methods (Table 8). The estimate used in this ESV analysis followed Stern (2007), which was in the middle range among the four estimates. Values for timber inventory and harvest were derived from modeling conducted by DRSystems, Inc. (Options Model Run 6) for the South Fork Tolt Watershed Management Plan.

Results and Conclusion

The results of the valuation showed that implementing forest restoration in the SFTMW would provide a net benefit of ecosystem services ranging from \$108K to \$1.3M annually. Using the mix of low and high values we considered most appropriate for the watershed, the benefit was about \$563K. A detailed accounting of the values for each service is shown in Table 7. Costs included \$316K for lost carbon sequestration and \$4K to \$27K for increased fire hazard. All other services had a positive net economic benefit, with disturbance prevention (excluding fire hazard) value ranging from \$38K to \$250K and refugium value ranging from \$133K to \$405K.

The analysis of how forest restoration affects the individual and total ESV in the SFTMW shows that there will likely be a net benefit of restoration, despite the reduced carbon sequestration value. The wide range of estimates for the net benefit of restoration reflects the uncertainty in ecosystem service valuation methods. Given that most studies contributing to the original analysis are 5-10 years old and typically undervalue ecosystem services at today's estimates (D. Batker, pers. communication), we have greater confidence that the net benefit is positive, even if the magnitude of that benefit has a wide range. Despite uncertainty in estimating ecosystem services values, the overall positive value of restoration even under relatively conservative assumptions indicates that the economic cost of reduced carbon sequestration is more than offset by other net ecosystem benefits. Updating the case studies used for ecosystem service valuation and establishing local case studies would greatly reduce the uncertainty in this valuation and provide a powerful tool for sound ecological management of our natural capital.

VALUATION OF CARBON SEQUESTRATION UNDER HABITAT RESTORATION IN THE SOUTH FORK TOLT MUNICIPAL WATERSHED

The best economists can do is roughly estimate the optimal "carbon price," based on computer models that incorporate data on economic growth, rising greenhouse emissions, abatement costs and expected climatic damages. A recent iteration of a model developed by Nordhaus pegs the optimal carbon tax at \$29 per metric ton. The tax would rise at a rate of 2 percent to 3 percent annually to reflect increasing damages from global warming, reaching \$90 per metric ton by 2050 and \$200 per metric ton by the end of the century (in 2005 dollars). In other models, estimates of the optimal carbon price range from \$18 to over \$350 per metric ton—stark evidence of the broad scope of uncertainty. The Stern Review calculated the social cost of CO2 equivalent at \$85 per ton (in 2000 \$s) which is equivalent to \$312 per ton of carbon. More recently still, Harvard economist Marty Weisman concluded that the Stern estimate is the more reasonable given that most other economists haven't taken plausible worse-case scenarios into account when they estimate expected climatic damages. Therefore, the Stern Review value of $396 per metric ton of carbon (2008 dollars) was used to estimate the value of carbon sequestration.

An 80% "leakage factor" and 50% "general equilibrium effect" were also assumed. The leakage factor accounts for the fact that carbon sequestration is not as reliable as emissions reduction in keeping CO2 out of the atmosphere. For example, there's always some risk that a forecast fire could release sequestered carbon. The general equilibrium effect refers to the possibility that withholding timber from the market that would otherwise be economical to harvest might cause prices to rise enough to induce other producers to slightly increase their harvests, thus offsetting some of the carbon sequestration.

SOUTH FORK TOLT MUNICIPAL WATERSHED ADAPTIVE MANAGEMENT APPROACH

The forest restoration approach in the SFTMW will be guided by information developed through the implementation of the Cedar River Municipal Watershed (CRMW) Habitat Conservation Plan, which incorporates an adaptive management approach as detailed in the Upland Forest Habitat Restoration Strategic Plan. In the CRMW, we define explicit ecological objectives for restoration projects and monitor the effects of restoration prescriptions over time. This project effectiveness monitoring typically includes pre-treatment and post-treatment data for different treatment types including untreated areas. Several research trials to investigate key questions relative to restoration effectiveness have begun, some in collaboration with external scientists,. One example of this research is the Forest Restoration Experiment that was designed in collaboration with forest ecosystem scientists at the University of Washington. In order to continually broaden our knowledge and skills in the new field of forest restoration, watershed staff network with other forest restoration practitioners and scientists to share information and results. Finally, to track change over the watershed landscape over time, watershed ecologists have established a long-term forest monitoring program that combines a network of permanent sampling plots and remote sensing data.

Compared to the Cedar River Watershed, this plan does not propose a comprehensive adaptive management program. However, it does have very robust inventory data for the entire City ownership in the SFTMW, as well as a strong forest projection model. As described in the following paragraphs and illustrated in Figure 1, a passive adaptive management program in the SFTMW will build on these two components, in addition to capitalizing on lessons learned through the CRMW adaptive management program.

Given the uncertainty in long-term projections of forest development and limited experience with the proposed restoration prescriptions, we plan to implement passive adaptive management under the forest resource management plan. The elements of the proposed management may be adapted at three different time scales:

- Implementation contracts may be adapted on a yearly basis following contract compliance monitoring and as-built review.

- Silvicultural prescriptions and proposed treatment areas may be adapted following review of current inventory, effectiveness monitoring, and permanent inventory clusters on a multi-year basis during ordinance process.
- Silvicultural prescriptions and treatment schedule may be adapted to meet plan goals following long-term review of permanent inventory clusters on a 5 to 15 year basis.

The model projections of forest development will be updated through yearly data collected during project appraisal and compliance monitoring. Comparison of model projections with current inventory will enable us to update growth models and adjust projections of structural development and tree growth.

Compliance data will be used to assess the effectiveness of prescriptions and contracts in achieving management objectives. A yearly sub-sample of compliance plots will be re-measured during the ordinance cycle and long-term review interval to assess the response of forests to restoration treatments.

Additional permanent inventory plots will be installed in areas that are not scheduled for restoration management to assess forest development without any treatments and to capture long term trends in forest health and community response to global climate change. This monitoring and adaptive management program may be modified if changes in forest health and structural development require increased data collection or reduced sampling schedules. Inventory and monitoring will be conducted following protocols outlined in Table 9.

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FIGURES & TABLES

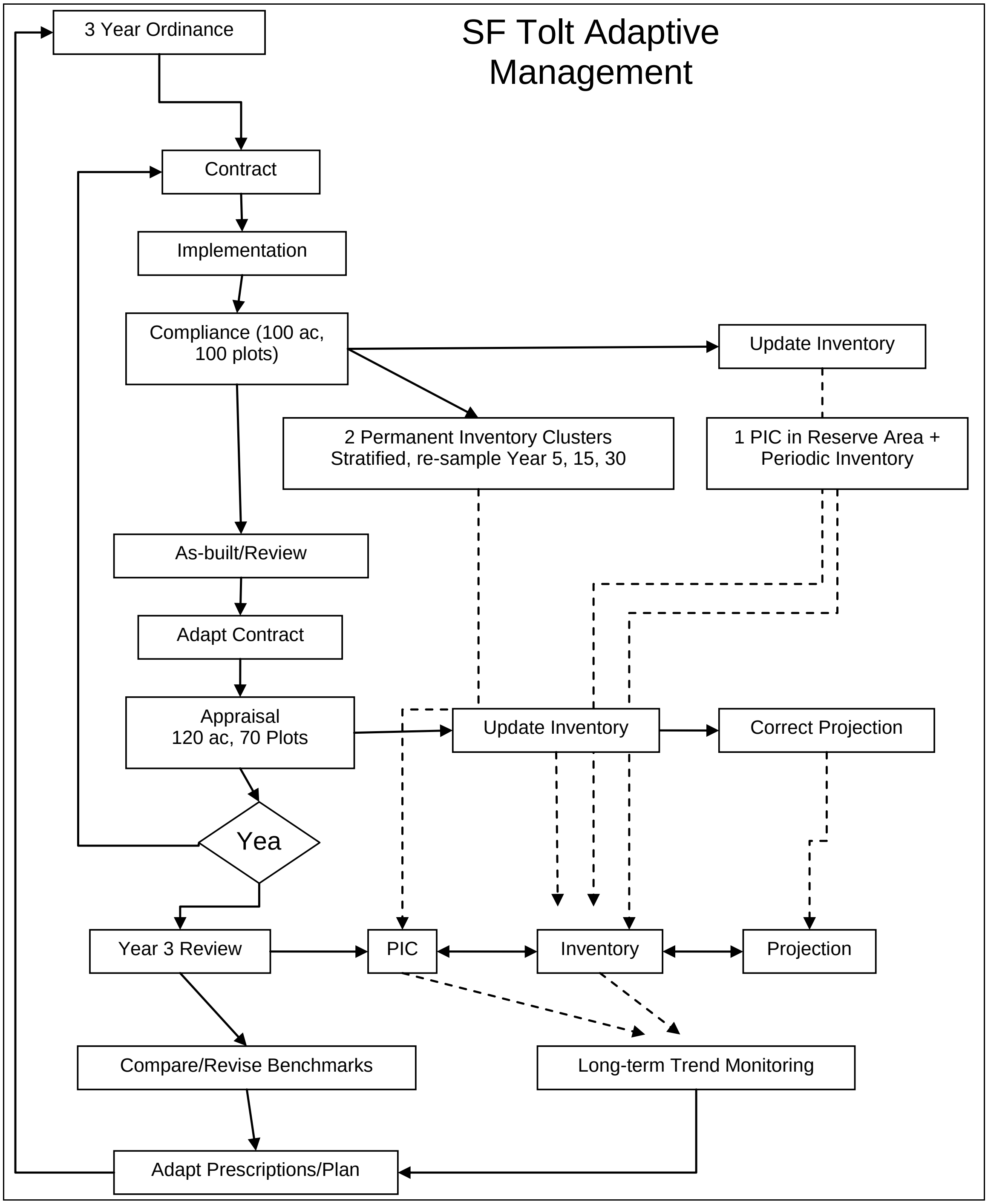

Figure 1. Graphic illustrating how newly acquired compliance and appraisal data will be leveraged to update the forest projections and feed the SFTMW adaptive management cycle.

TABLE 1.
DETAILED SILVICULTURE PRESCRIPTIONS TO BE USED AS GUIDELINES FOR FOREST RESTORATION ACTIVITIES.

Treatment/Type	Conditions for Treatment	Percent of Treatment Area	Site Index (dominant tree height in feet at age 50) >100	90	70
Planting	In canopy gaps following Ecological Thinning	20%	100 tpa WRC, 100 tpa BLM	100 tpa WRC, 100 tpa RA	100 tpa WRC, 100 tpa RA
Restoration Thinning	Tree height >15 ft or min. age 15 yrs, no thinning if height > 40 ft or age > 40 yrs	75%	150 tpa	200 tpa	250 tpa
		25%	Gaps		
Ecological Thinning 1	At 55% of max SDI or RD 60, BA >260 sq ft/ac, QMD>12”	20%	100 tpa; remove 45% CFVol; Thin from below	120 tpa; remove 45% CFVol; Thin from below	130 tpa; remove 45% CFVol; Thin from below
		40%	200 tpa; remove 35% CFVol; Thin proportional	200 tpa; remove 30% CFVol; Thin proportional	240 tpa; remove 30% CFVol; Thin proportional
		20%	gaps; remove 85% CFVol; Variable Retention Harvest		
		20%	Unthinned skips; no removal		
Ecological Thinning 2	Above 65% of max SDI or RD>75, BA > 260 sq ft/ac, QMD<10”	60%	200 tpa; remove 30% CFVol; Thin from below	240 tpa; remove 25% CFVol; Thin from below	
		10%	gaps; remove 85% CFVol; Variable Retention Harvest		
Understory Thinning	15 yrs after ET1 at >500 tpa understory	60%	250 tpa; if understory H/D<100		
Habitat Enhancement	During Ecological Thinning	80%	4 tpa for snags and CWD		

tpa - trees per acre; WRC - western red cedar; BLM - big leaf maple; RA - red alder; SDI - stand density index; RD - Curtis’ relative density; BA - basal area in square feet per acre (sq ft/ac); QMD - quadratic mean diameter; CFVol - cubic foot volume of stand; H/D - tree height to diameter ratio; CWD - coarse woody debris

Thinning from below: thin smallest trees first until density target is reached

Proportional thinning: thin trees relative to their abundance in diameter classes

Variable retention: retention of 15% of tree volume standing uniform or clumped

TABLE 2.
TIMBER HARVEST VOLUMES FROM ECOLOGICAL AND RIPARIAN THINNING FOR THE INITIAL 7 YEARS OF RESTORATION ACTIVITIES AND FOR DECADES 2017 TO 2077

	Timber harvest volume by species (1000 cubic feet)			
	Douglas Fir	Hemlock	Red Alder	True Firs[a]
2010	210		3	
2011	213			
2012	213			
2013	159	54		
2014	142	71		
2015	213			
2016	100	113		
2017-2026	490	1001		
2027-2036	155	846	41	377
2037-2046	229	245		947
2047-2056	2	349		1069
2057-2066	21	678		722
2067-2076	53	171		1105
2077-2086	57	5		

a. True firs include noble fir and Pacific silver fir

Table 3: OPTIONS Model projections of forest habitat types (acres) by decade reported for Option 3, Habitat Development Option; Habitat type definitions are given in Chapter 5.

Model Reporting Year	2007	2017	2027	2037	2047	2057	2067	2077	2087	2097	2107	2117	2127	2137	2147	2157	2167	2177	2187	2197	2207
Forest Habitat Type	Area in acres, total forested acres: 7163																				
(Opt_3_run5_1_final_structure.xls)																					
Giant tree, multi-story	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Large tree, multi-story, closed	68	68	68	68	68	206	206	206	288	335	379	101	68	68	68	219	219	219	219	219	219
Large tree, multi-story, moderate	387	437	437	437	461	461	461	461	461	461	461	751	958	958	958	958	958	958	958	958	958
Large tree, multi-story, open	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Large tree, single-story, closed	0	0	0	264	521	669	549	646	719	936	1298	1545	1704	1694	1753	1906	2169	2511	2746	2760	2802
Large tree, single-story, moderate	227	227	227	227	227	252	293	405	286	473	359	402	458	667	913	959	942	1003	1006	1004	1015
Large tree, single-story, open	0	0	0	0	0	0	25	25	42	53	160	170	206	71	21	24	45	58	81	81	81
Medium tree, multi-story, closed	0	136	179	352	631	369	376	409	424	381	152	152	152	152	152	0	0	0	0	0	0
Medium tree, multi-story, moderate	0	24	24	24	0	7	33	0	0	0	186	174	0	0	0	0	0	0	0	0	0
Medium tree, single-story, closed	0	136	958	940	1009	1280	1710	1834	1962	2100	2103	1947	1791	1788	1729	1689	1476	1109	874	862	820
Medium tree, single-story, moderate	0	0	57	26	75	147	235	129	216	48	305	564	653	732	590	545	523	552	553	552	541
Medium tree, single-story, open	0	0	0	0	74	86	87	245	254	215	126	146	98	98	98	95	63	50	27	27	27
Small tree, multi-story, closed	660	525	482	308	29	145	121	121	24	20	11	11	11	11	11	11	11	11	11	11	11
Small tree, multi-story, moderate	75	51	51	51	51	51	43	43	43	43	51	51	51	51	51	51	51	51	51	51	51
Small tree, single-story, closed	1543	2746	2257	2448	2535	2130	1926	1715	1374	1312	945	701	470	259	195	96	114	104	104	104	104
Small tree, single-story, moderate	538	67	334	99	136	196	185	251	431	254	166	114	234	289	379	383	387	334	330	330	330
Small tree, single-story, open	0	0	196	234	249	248	293	146	120	98	69	13	35	55	71	65	65	65	65	65	65
Sapling/pole, closed	3057	2432	1639	1471	909	766	505	409	384	307	307	245	198	194	98	84	61	61	61	61	61
Sapling/pole, moderate	323	86	69	56	88	83	54	56	75	52	24	16	16	16	16	16	16	16	16	16	16
Sapling/pole, open	81	74	100	112	91	66	60	60	60	73	60	60	60	60	60	60	60	60	60	60	60
Shrub/seedling, open	83	113	52	33	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Large Tree Habitat (>20" DBH)	731	731	731	996	1276	1588	1533	1743	1796	2259	2657	2970	3394	3458	3713	4066	4334	4748	5011	5022	5076
Medium Tree Habitat (15-19" DBH)	0	296	1218	1342	1789	1889	2442	2618	2656	2744	2871	2962	2693	2769	2569	2330	2063	1711	1463	1442	1388
Small Tree Habitat (10-14" DBH)	2817	3389	3320	3140	3000	2771	2568	2276	1992	1727	1243	890	802	665	707	606	629	566	561	561	561
Sapling/Pole Habitat (1-9" DBH)	3461	2593	1808	1639	1089	915	619	526	519	433	392	321	274	270	174	160	138	138	138	138	138
Shrub/Seedling Habitat	83	113	52	33	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Single Story Forest Habitat	5143	4430	4008	3447	2801	2105	1463	1270	1244	1272	1255	1224	1236	1371	1421	1421	1432	1432	1432	1432	1432
Multi-story Forest Habitat	1865	2579	3069	3670	4353	5058	5700	5893	5919	5890	5908	5938	5927	5792	5742	5742	5731	5731	5731	5731	5731

Table 4: OPTIONS Model output of restoration treatments, harvest volumes, and revenue for Option 3, Habitat Development Option.

Model Reporting Year	2007	2017	2027	2037	2047	2057	2067	2077	2087
Modeled Restoration Treatments									
Area in acres treated following the reporting year									
Natural Regeneration	70	80	74	3					
Ecological Thinning#1 – Closed	389	539	204	579	463	587	564	10	
Ecological Thinning#2 – Open	186	175	285	22	146	106	52	25	
Planting	113	124	134	67	105	101	77	11	
Restoration Thinning	451	292	11	54	0	165	67	71	2
Riparian Thinning	133	83	17	24	12	7	6		
(Opt_3_run6_6a_silvrx.xls)									
Harvest Volumes									
Cubic feet, harvested following reporting year									
Douglas-fir	1,127,599	459,793	145,626	217,920	1,745	20,221	51,790	56,844	
Douglas-fir (riparian)	122,977	30,532	9,493	10,893	219	404	1,155	379	
Western hemlock	182,448	931,495	834,715	230,975	347,296	673,578	162,538	3,724	
Western hemlock (riparian)	55,133	69,179	11,569	13,525	1,711	4,129	8,672	1,548	
Noble fir			168,027	14,223	159,054	14,672			
Noble fir (riparian)			12,488			188			
Pacific Silver fir (riparian)			196,404	932,420	894,087	703,933	1,104,825		
Pacific Silver fir (riparian)			309	44	15,888	2,875			
Red alder	2,028		41,370						
Red alder (riparian)	814								
(Opt_3_run6_6a_tmbrvol.xls)									
Additional Biomass Harvested									
Metric Tons per decade	1808.7	1534.1	1344.1	1370.9	1287.8	1294.8	1224.3	77.5	
$ Value (not included in revenue)	72,349	61,365	53,763	54,837	51,513	51,791	48,973	3,100	
(Opt_3_run6_6a_biomass.xls)									
Cost/Timber Revenue Projections									
Dollar amount per decade, including cost for planting, restoration thinning, administration, and compliance									
Costs	636,021	738,964	485,327	529,473	495,053	628,911	436,929	73,246	463
Revenue	1,311,352	859,741	770,767	697,448	648,605	561,837	538,566	63,944	0
Net Revenue	675,332	120,777	285,440	167,975	153,552	-67,074	101,637	-9,302	-463
(Opt_3_run6a_reports.xls)									

TABLE 5.
ELEMENTS OF CARBON SEQUESTRATION AND EMISSIONS CALCULATED BY DECADE FOR 7150 FORESTED ACRES IN THE SOUTH FORK TOLT MUNICIPAL WATERSHED

Model Reporting Year	2027	2037	2047	2057	2067
		(all data in tons CO2e)			
Option 1: Sustained Timber Yield Management (Baseline)					
Timber Inventory	951,142	1,114,425	1,280,145	1,450,595	1,612,501
Total Biomass	1,531,338	1,794,225	2,061,033	2,335,458	2,596,127
10yr Live Sequestration Total	238,862	262,887	266,808	274,425	260,669
CWD	137,820	161,480	185,493	210,191	233,651
10yr CWD Accumulation	21,498	23,660	24,013	24,698	23,460
10yr Timber Harvest	92,873	85,998	90,653	98,052	87,769
Long-term Products	44,579	41,279	43,513	47,065	42,129
Short-term Products	48,294	44,719	47,139	50,987	45,640
Detritus	94,730	87,718	92,466	100,013	89,524
10yr Emissions					
Long-term Products	16,750	12,162	9,122	5,759	1,611
Short-term Products	47,936	44,961	47,524	50,452	31,948
Detritus	93,765	87,243	89,396	83,729	36,746
Annual Net Sequestration (50 yrs)	24,344				
Option 3: Habitat Development					
Timber Inventory	1,055,806	1,266,813	1,460,160	1,637,159	1,785,289
Total Biomass	1,699,847	2,039,568	2,350,858	2,635,826	2,874,316
10yr Live Sequestration Total	340,380	339,721	311,289	284,968	238,490
CWD	152,986	183,561	211,577	237,224	258,688
10yr CWD Accumulation	30,634	30,575	28,016	25,647	21,464
10yr Timber Harvest	30,898	31,516	29,605	29,765	28,145
Long-term Products	14,831	15,127	14,211	14,287	13,510
Short-term Products	16,067	16,388	15,395	15,478	14,636
Detritus	31,516	32,146	30,197	30,360	28,708
10yr Emissions					
Long-term Products	5,620	4,413	2,961	1,754	517
Short-term Products	16,099	16,289	15,403	15,393	10,245
Detritus	31,490	31,609	28,980	25,530	11,784
Annual Net Sequestration (50 yrs)	31,661				
Option 4: No Action Alternative					
Timber Inventory	1,155,807	1,415,022	1,638,787	1,836,539	2,000,779
Total Biomass	1,860,850	2,278,185	2,638,447	2,956,829	3,221,255
10yr Live Sequestration Total	426,498	417,335	360,262	318,381	264,426
CWD	167,477	205,037	237,460	266,115	289,913
10yr CWD Accumulation	38,385	37,560	32,424	28,654	23,798
10yr Timber Harvest	0	0	0	0	0
10yr Emissions	0	0	0	0	0
Annual Net Sequestration (50 yrs)	38,954				

Option 2 Sustainable Harvest and Habitat Development is not included in the table because it did not contribute to the evaluation of the Habitat Development Option

Table 6.
Elements of ecosystem services used for quantification, including rationale for inclusion in SFTMW valuation

Ecosystem Service Category	Quantifiable ecosystem service elements	% of total ecosystem service	Rationale for quantifying and partitioning of ecosystem service	Quantification of change in ecosystem service
Gas regulation	Carbon uptake and oxygen release		Not quantified	
	Nitrogen fixation		Not quantified	
	Evapo-transpiration		Not quantified	
Climate regulation	Carbon sequestration		Based on market values for C02 equivalents, 50 year biomass accumulation less emissions from on-site and off-site decomposition.	Avg. annual sequestration difference between restoration and status quo options. Value of reduced carbon sequestration with restoration option calculated following Stern (2007).
Disturbance prevention	Headwater sediment storage	20	Disturbance prevention is divided into five ecosystem service elements. The proportional value of each element was subjectively assigned based on the relative importance and risk of each element in the SF Tolt watershed. Restoration actions are not anticipated to affect surface flow soil erosion or flooding, but will have varying effects on other elements. Headwater sediment storage estimated as shown in sheet "ESV-sediment storage." Fire hazard calculated as change in area of moderate fire hazard. Windthrow hazard calculated as increase in height/diameter ratio following thinning of young trees, with value at low end of range (Wilson and Oliver, 2000). Other values of disturbance prevention are calculated from high end of range due to importance to Utility.	Estimated 2.2 % decrease in sediment yield over watershed
	Windthrow hazard	5		Increased height/diameter ratio on RT acres, 15% of area.
	Fire hazard	5		Change in acres of moderate fire hazard, 3% increase over 50 years.
	Insect mortality	5		Reduced propagation of insect disturbance in deciduous-mixed stands, 10% of area (Watt 1992).
	Surface flow soil erosion and flooding	65		No change as a result of restoration.
Water regulation	Peak flows, base flows		Thinning reduces leaf area resulting in reduced evapotranspiration, higher baseflows in summer and overall more discharge from watershed. Rationale based on Pery (2007). For details, see file "Ecosystem Service Valuation. Sediment Retention.xls." High end of values selected due to importance to Utility's goals.	Value (0.5%) applies to base flows only
Water supply	Interception, storage, condensation			Value (0.5%) applies to base flows only
	Reservoir capacity		Not quantified	
Soil retention	Rooting strength-surface erosion		Not quantified	
	Vegetative cover		Not quantified	
Soil formation	Organic soil horizon		Decomposition rate increases under reduced canopy density.	Not quantified.
Nutrient regulation	Nitrogen cycling		Batker's valuation of nutrient regulation is based on bottom land forests, adjusted downward to 10%. Increase in deciduous species will increase amount of N, reducing C/N ratio of decaying veg and soil, and will increase cation exchange capacity (Binkley, 1992).	Deciduous species decrease C/N ratio (20%) and increase CEC where conifer stands are converted to deciduous-mixed stands.
	Cation exchange capacity			
	Decomposition rate		Decomposition rate increases under reduced canopy density.	Not quantified
Waste treatment	Air pollutant filtration (Ozone)			Not quantified
Pollination	Flowering vegetation		Increase of deciduous species in canopy and understory will increase pollinator populations. Low end estimate from case studies due to remote location.	Increase deciduous species on 9% of area,
	Endemic insect populations		Not quantified	
	Habitat fragmentation, isolation		Not quantified	
Biological control	Breadth of food web, endemic populations		Increase in plant species diversity should increase insect diversity, with positive effects on biological control. Low end estimate from case studies due to remote location.	Increase deciduous species on 9% of area
	Soil disturbance and invasives transport		Invasive plant species control under separate valuation.	

Table 6.
Elements of ecosystem services used for quantification, including rationale for inclusion in SFTMW valuation

Ecosystem Service Category	Quantifiable ecosystem service elements	% of total ecosystem service	Rationale for quantifying and partitioning of ecosystem service	Quantification of change in ecosystem service
Refugium function	LSF habitat, structure, decadence	50	Refugium function is primarily applied to terrestrial habitat and wildlife species. Direct metrics of value to species are not readily available, so indirect metrics based on forest attributes are used. Each of these has a proportional value to the "refugium" service, based on professional judgment of early successional habitat value: forest structure (50%) and covertype diversity (40%), non-forest habitat (5%) and habitat connectivity (5%). Structural complexity is major direct affect, new habitat available for some species, identified by vertical structure, tree size, and canopy closure. Mixed-deciduous forest provides wider range of habitat than conifer forest - increased species richness and resilience. Forest restoration increases habitat value of special habitats (shade, hydrology of wetlands). Restoration increases patch size of higher value habitat - scale effect. Changes in non-forest habitat and habitat connectivity value were not quantified but would be expected to be positive. High end of values from case studies was selected due to regional and institutional importance.	Forest structure metric is derived from amount of multistory vs single-story canopy, size class, and canopy closure. Scores: single story (1), multi story (3), small tree (1), medium tree (2), large tree (4), closed canopy (1), moderate closed (2), open canopy (3). See "Opt3_4 Structure Values.xls" for calculation of score sums.
	Covertype diversity (mixed dec-con forest)	40		Covertype diversity is determined as percentage of forest with mixed conifer-deciduous and used as index of increasing value (analysis in file "Species Composition Opt3 Opt4.xls."
	Non-forest habitat	5		Change in non-forest habitat was not quantified but would be expected to be positive.
	Habitat connectivity	5		Change in habitat connectivity value was not quantified but would be expected to be positive.
Nursery function	Benthic community		Not quantified	
	Non-forest habitat		Not quantified	
	Deciduous component, migratory birds		Deciduous-mixed stands provide better foraging habitat for bird species. Low end estimate from case studies due to remote location.	Increase of deciduous species on 10% of area.
Food	Alternative forest product values		Not quantified	
Raw materials	Gross timber value		Net value of timber after contractor costs/profit taken out of gross value harvested.	Calculated from inventory and harvest volumes, $91,000 per year, average of 50 years.
	Biomass value		Gross market value of biomass resulting from thinning slash.	Calculated from inventory and harvest volumes, 156,000 tons per year, $6250 per year, 50 year average
Genetic resources	Locally adapted seed sources		Not quantified	
	Viable population size		Not quantified	
Medical resources	Taxol		Not quantified	
Ornamental resources	Salal, bear grass, boughs		Non-timber forest products that are harvested for use in flower arrangements, basketry, Christmas wreaths, and other products. By increasing understory growth, restoration will enhance productivity of watershed for these materials.	Thinning will increase abundance of these species by 5% where low stand density persists.
Aesthetic information	Existence value		Not quantified	
Recreation	Visitor preference, access		Not quantified	
Cultural & artistic information	Tribal gathering and hunting		Restoration thinning treatments should increase amount of huckleberry growth and other species gathered by Native Americans, such as bear grass. Low end estimate from case studies due to remote location.	Increased huckleberry, bear grass productivity at least 2%
Spiritual & historic information			Not quantified	
Science & education	Scientific studies		Monitoring and documentation of forestry treatments will provide information about the effectiveness of forest restoration methods. Low end estimate from case studies due to remote location.	Estimate contribution to forest science as 25% of this ecological service estimate
	Educational case studies		Not quantified	
	Public information		Not quantified	
Navigational services			Not quantified	

Table 7. Summary of changes in ecosystem service values resulting from forest restoration in the SF Tolt Municipal Watershed.

Ecosystem Service	Quantifiable Elements	% Contribution to Ecosystem Service	Change in Service Level[2]	Value before Restoration (low)[1]	Value before Restoration (selected)[1]	Value before Restoration (high)[1]	Change in Value ($): Low Value Range	Change in Value ($): Selected Values (low, high)	Change in Value ($): High Value Range
Climate regulation	Carbon sequestration			NA	NA	NA	-$316,000	-$316,000	-$316,000
Disturbance prevention	Headwater sediment storage	20%	2.2%	$497,493	$3,601,846	$3,601,846	$10,945	$79,241	$79,241
	Windthrow hazard	5%	15.0%	$124,373	$124,373	$900,461	$18,656	$18,656	$135,069
	Fire hazard	5%	-3.0%	$124,373	$900,461	$900,461	-$3,731	-$27,014	-$27,014
	Insect mortality	5%	10.0%	$124,373	$124,373	$900,461	$12,437	$12,437	$90,046
	Surface flow soil erosion, flooding	65%	NA	NA	NA	NA	NA	NA	NA
Water regulation	Peak flows, base flows		0.5%	$2,487,463	$13,544,234	$13,544,234	$12,437	$67,721	$67,721
Water supply	Interception, storage, condenstion		0.5%	$2,487,463	$18,904,715	$18,904,715	$12,437	$94,524	$94,524
Nutrient regulation	Nitrogen cycling		1.8%	$2,487,463	$2,487,463	$16,988,095	$44,774	$44,774	$305,786
Pollination	Flowering vegetation		9.0%	$34,824	$34,824	$62,187	$3,134	$3,134	$5,597
Biological control	Breadth of food web, endemic populations		9.0%	$4,975	$4,975	$194,022	$448	$448	$17,462
Refugium function[3]	LSF habitat, structure, decadence	50%	14.2%	$621,866	$1,894,203	$1,894,203	$88,305	$268,977	$268,977
	Cover type diversity	40%	9.0%	$497,493	$1,515,362	$1,515,362	$44,774	$136,383	$136,383
	Non-forest habitat	5%	0.0%	$62,187	$189,420	$189,420	$0	$0	$0
	Habitat connectivity	5%	0.0%	$62,187	$189,420	$189,420	$0	$0	$0
Nursery function	Deciduous component, migratory birds		9.0%	$353,220	$353,220	$485,055	$31,790	$31,790	$43,655
Raw materials	Gross timber value			NA	NA	NA	$91,000	$91,000	$91,000
	Biomass value			NA	NA	NA	$6,250	$6,250	$6,250
Ornamental resources	Salal, bear grass, boughs		5.0%	$7,462	$7,462	$49,749	$373	$373	$2,487
Cultural & artistic information	Tribal gathering and hunting		2.0%	$2,487,463	$2,487,463	$14,924,775	$49,749	$49,749	$298,496
Science & education	Scientific studies		25.0%	$2,488	$2,488	$4,975	$622	$622	$1,244
Total value change with forest restoration							$108,401	$563,064	$1,300,922

1 Current ecosystem value either from low or high end of range provided by Batker 2005. In "selected values" column,
high values were used for those ecosystem services considered of high importance in SF Tolt watershed and low values for all others.
2 Change in service level considered as average change over 50 year period.
3 Non-forest habitat and connectivity likely to be positively affected but not quantified.

TABLE 8

Valuing CO2 Sequestration in the Tolt Watershed Under Various Assumptions

	Scenarios			
	Nordhaus 1	Nordhaus Adj 2	Stern Adj 3	"Prius Policy" 4
Assumptions				
CO2 Sequestration in mTons/yr	7,290	7,290	7,290	7,290
Sequestration vs. Emission Reduction Factor	100%	**80%**	80%	80%
General Equilibrium Effect	100%	**50%**	50%	50%
Rate of CO2 Cost Escalation:	**3%**	3%	**0%**	0%
Discount Rate	5%	5%	5%	5%
Years	50	50	50	50
Real Cost of Carbon per Metric Ton in 2008	**$42**	$42	$396	$1,247
Real Cost of Carbon per Metric Ton in 2058	$190	$190	$396	$1,247
Real Cost of CO2 per Metric Ton in 2008	$11.80	$11.80	**$108**	**$340**
Equivalent Gas Tax per Gallon	$0.10	$0.10	$0.95	$2.98
Value of CO2 Sequestration from Status Quo				
50 year Present Value	$2,687,725	$1,075,090	$5,775,457	$18,186,856
Levelized (annual) Value	$147,225	$58,890	$316,361	$996,217

TABLE 9.
INVENTORY AND MONITORING PROTOCOLS FOR THE SFTMW ADAPTIVE FOREST MANAGEMENT PROGRAM

Protocol	Use	Stand Type	Data	Number of plots	Schedule	Cost
Appraisal	Contract development, projection update	Pre-treatment stand	Inventory, timber cruise	ET 40, RT 30	yearly, not re-sampled	$10k/year
Compliance Monitoring	Compliance, inventory update	Post-treatment stand	Inventory	ET 80, RT 20	yearly, not re-sampled	$25k/year
Permanent Inventory Cluster	Effectiveness monitoring	Post-treatment stand	Overstory, understory	2 clusters/ year	resample year 5, 15, 30	$5k/year
Periodic Inventory	Trend monitoring, inventory update	Reserve	Overstory, understory	1 cluster/year + 30 Inv. Plots	resample cluster	$5k/year

APPENDIX B.
POTENTIAL WILDLIFE SPECIES IN THE MUNICIPAL WATERSHED

TABLE B-1.
POTENTIAL AND CONFORMED FISH AND WILDLIFE SPECIES IN THE SFTMW

Potential Species (Common Name)	Confirmed	Potential Species (Name)	Confirmed
American Marten		Bushy-tailed Woodrat	
American Coot		California Myotis	
American Crow		California Quail	
American Dipper	Yes	Canada Goose	Yes
American Goldfinch		Canada Lynx	
American Kestrel		Canvasback	
American Robin		Cascade Golden-mantled Ground Squirrel	
American Wigeon		Cascades Frog	Yes
Bald Eagle	Yes	Cedar Waxwing	
Band-tailed Pigeon		Chestnut-backed Chickadee	
Bank Swallow		Chipping Sparrow	
Barn Swallow		Cinnamon Teal	
Barred Owl		Clark's Nutcracker	
Barrows Goldeneye	Yes	Cliff Swallow	
Beaver		Coast Mole	
Belted Kingfisher		Coastal Cutthroat Trout	Yes
Bewick's Wren		Coastrange Sculpin	
Big Brown Bat		Common Bushtit	
Black Bear	Yes	Common Garter Snake	
Black Rat		Common Goldeneye	Yes
Black Swift		Common Loon	Yes
Black-capped Chickadee		Common Merganser	Yes
Black-headed Grosbeak		Common Nighthawk	
Black-tail (Mule) Deer	Yes	Common Raven	
Black-throated Gray Warbler		Common Snipe	
Blue Grouse		Common Yellowthroat	
Bobcat	Yes	Cooper's Hawk	
Brewer's Blackbird		Cougar	Yes
Brown Creeper		Coyote	
Brown-headed Cowbird		Creeping Vole	
Bufflehead	Yes	Dark-eyed Junco	
Bull Trout		Deer Mouse	
Bullfrog		Double-crested Cormorant	

TABLE B-1.
POTENTIAL AND CONFORMED FISH AND WILDLIFE SPECIES IN THE SFTMW

Potential Species (Common Name)	Confirmed	Potential Species (Name)	Confirmed
Douglas' Squirrel	Yes	Hutton's Vireo	Yes
Downy Woodpecker		Keen's Deer Mouse	
Dusky Flycatcher		Keen's Myotis	
Eared Grebe		Killdeer	
Eastern Gray Squirrel		Large-mouth Bass	
Eastern kingbird		Largescale Sucker	
Elk		Lark Sparrow	
Ensatina		Lesser Scaup	Yes
Eurasian wigeon		Lincoln's Sparrow	
Evening Grosbeak		Little Brown Myotis	
Fisher		Loggerhead Shrike	
Fox Sparrow		Long-eared Myotis	
Fringed Myotis		Long-legged Myotis	
Gadwall		Longnose Dace	
Golden Eagle		Longnose Sucker	
Golden-crowned Kinglet		Long-tailed Vole	
Golden-crowned Sparrow		Long-tailed Weasel	
Gray Jay		Long-toed Salamander	Yes
Gray Wolf		MacGillivray's Warbler	
Great Blue Heron		Mallard	Yes
Great Horned Owl		Marbled Murrelet	
Greater Scaup	Yes	Marsh Shrew	
Green Heron		Marsh Wren	
Green-winged Teal		Masked Shrew	
Grizzly Bear		Merlin	
Hairy Woodpecker		Mink	
Hammond's Flycatcher	Yes	Montane Shrew	
Harlequin Duck	Yes	Mountain Beaver	
Heather Vole		Mountain Bluebird	
Hermit Thrush		Mountain Chickadee	
Hoary Bat		Mountain Goat	
Hoary Marmot		Mountain Quail	
Hooded Merganser		Mountain Whitefish	
Horned Grebe	Yes	Muskrat	
House Finch		Northern Alligator Lizard	
House Wren		Northern Flicker	

TABLE B-1.
POTENTIAL AND CONFORMED FISH AND WILDLIFE SPECIES IN THE SFTMW

Potential Species (Common Name)	Confirmed	Potential Species (Name)	Confirmed
Northern Flying Squirrel		Red-breasted Nuthatch	
Northern Goshawk		Red-breasted Sapsucker	
Northern Oriole		Red-eyed Vireo	
Northern Pintail		Red-necked Grebe	Yes
Northern Pygmy Owl		Redside Shiner	
Northern Red-legged Frog		Red-tailed Hawk	
Northern River Otter		Red-winged Blackbird	
Northern Rough-winged Swallow	Yes	Riffle Sculpin	
Northern Saw-whet Owl		Ring-necked Duck	
Northern Shoveler	Yes	Roughskin Newt	Yes
Northern Shrike		Rubber Boa	
Northern Spotted Owl		Ruby-crowned Kinglet	
Northern Water Shrew		Ruddy Duck	Yes
Northwestern Garter Snake		Ruffed Grouse	
Northwestern Salamander	Yes	Rufous Hummingbird	
Olive-sided Flycatcher		Savannah Sparrow	
Opossum		Sharp-shinned Hawk	
Orange-crowned Warbler		Shorthead Sculpin	
Osprey		Short-tailed Weasel (Ermine)	
Pacific Giant Salamander		Shrew-mole	
Pacific Jumping Mouse		Silver-haired Bat	
Pacific Treefrog	Yes	Snow Bunting	
Pacific-slope Flycatcher		Snowshoe Hare	
Peregrine Falcon		Song Sparrow	
Pied-bill Grebe		Southern Red-backed Vole	
Pika		Speckled Dace	
Pileated Woodpecker		Spotted Sandpiper	Yes
Pine Siskin		Spotted Towhee	
Porcupine		Steller's Jay	
Prickly Sculpin		Striped Skunk	
Purple Finch		Swainson's Thrush	
Purple Martin		Tailed Frog	
Raccoon		Threespine Stickleback	
Rainbow Trout	Yes	Three-toed Woodpecker	
Red Crossbill		Torrent Sculpin	Yes
Red Fox		Townsend's Big-eared Bat	

TABLE B-1.
POTENTIAL AND CONFORMED FISH AND WILDLIFE SPECIES IN THE SFTMW

Potential Species (Common Name)	Confirmed	Potential Species (Name)	Confirmed
Townsend's Chipmunk		Western Redback Salamander	
Townsend's Mole		Western Screech Owl	
Townsend's Solitaire		Western Spotted Skunk	
Townsend's Vole		Western Tanager	
Townsend's Warbler		Western Terrestrial Garter Snake	
Tree Swallow		Western Toad	
Trowbridge's Shrew		Western Wood Pewee	
Trumpeter Swan		White-breasted Nuthatch	
Turkey Vulture		White-crowned Sparrow	
Vagrant Shrew		Wild Turkey	
Van Dyke's Salamander		Willow Flycatcher	
Varied Thrush		Wilson's phalarope	
Vaux's Swift		Wilson's Warbler	
Violet-green Swallow	Yes	Winter Wren	
Warbling Vireo		Wolverine	
Water Vole		Wood Duck	
Western Bluebird		Yellow Perch	
Western Brook Lamprey		Yellow Warbler	
Western Fence Lizard		Yellow-bellied Marmot	
Western Grebe	Yes	Yellow-rumped Warbler	
Western Meadowlark		Yuma Myotis	

APPENDIX C.
SUPPLEMENTAL INFORMATION ON CULTURAL RESOURCES

INTRODUCTION

This appendix provides detailed information on the required level of effort and the standards for conducting Cultural Resources surveys. Also listed is the proper protocol for the following circumstances: unanticipated discovery of cultural materials, treatment of human remains, vandalism, and emergency response.

MANAGEMENT STANDARDS FOR CULTURAL RESOURCES

The following recommended management standards for the municipal watershed are adapted from the U.S. Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation*:

- General Standards:
  - Recognize that the municipal watershed's cultural resources are important to affected Indian tribes, oversight agencies, and members of the public. Consult with these stakeholders about cultural resource management during planning for projects and activities and when considering research or public programs based on archaeological sites.
  - Preserve and protect National Register-listed or eligible resources, as well as collected artifacts and documentation about the municipal watershed's cultural resources.
  - If preservation and protection of National Register-listed or eligible resources is impossible because of laws or operating conditions, mitigate adverse effects on such resources.
  - Provide for public interpretation and education regarding the cultural resources of the watershed.
  - Assist in the development of research-oriented use of in situ and curated cultural materials.
- Archaeological Standards:
  - Protection must be consistent with environmental regulations.
  - Strive to avoid disturbance of archaeological sites resulting from project activities.

  - Work to safeguard archaeological sites from vandalism.
  - Consider providing engineered protection to archaeological sites threatened by erosion.
  - Conduct data recovery of archaeological sites if avoidance or protection is not practical.
- Historical Building and Structure Standards:
  - Take actions to reasonably maintain and preserve the integrity of historical buildings and structures.
  - Maintain the original use of historical buildings and structures to the extent feasible. If it is necessary to change the use, take into consideration the character-defining features, site, and environment of the resource.
  - Retain and preserve the historical character of a resource by reasonable means and methods. Avoid removing historical materials or altering characteristic features and spaces.
  - Recognize historical resources as physical records of their time, place, and use. Avoid changes that create an earlier appearance, but have no historical basis.
  - Retain and preserve changes that occurred over a period of time, if they have become significant in their own right.
  - Repair rather than replace deteriorated architectural features. When replacement is necessary, match the new material to the old in design, color, texture, and other visual qualities. Use documented, physical, or pictorial evidence to substantiate missing features.
  - Replace outmoded, deteriorated, or defective equipment and machinery without unnecessary alteration or removal of character-defining features.
  - Avoid chemical or physical treatments that cause damage to historical materials; use appropriate means for the surface cleaning of structures.
  - Make new additions, exterior alterations, and related new construction compatible with characteristic historical materials as well as size, scale, and the environment. Differentiate new work from the old.
- Traditional Cultural Property Standards:
  - Consult with the Snoqualmie Tribe and the Tulalip Tribes, as well as tribes that historically visited or were invited to the area, about the identification and treatment of traditional cultural properties (TCPs). Treatment may include identification of time periods when audible or visible impact should be restricted.
  - Recognize that the natural setting of most TCPs contributes to their significance and integrity. Avoid altering natural features located within their boundaries or that are visible or audible from within the boundaries, except as needed for safety, the management of the municipal water supply, or for compliance with other laws, regulations, and agreements.

- When ground-disturbing activities are needed in or near identified TCPs, conduct these activities with sensitivity to avoid erosion and other types of disturbance to the natural environment.
- Avoid, to the extent practicable, construction of structures visible from identified TCPs. If such construction occurs, make it compatible, to the extent practicable, with the natural environment.
- Recognize that the permanence of TCPs is important to their cultural significance. Conduct actions affecting them in a manner that maintains and preserves their overall integrity.

The Secretary's Standards are not regulatory. They are intended to provide technical advice about archaeological and historic preservation practices and methods. They are widely used by regional, state, and local governmental agencies throughout the United States and provide a readily acceptable and widely recognized set of management standards. SPU endeavors to apply the standards in a reasonable manner, considering the economic and technical feasibility of implementing the standards within the context of its responsibility for the overall management of the watershed and its other resources. The standards recognize that change is inherent. Through application of the standards, SPU seeks to preserve and protect the watershed's National Register-eligible cultural resources without losing the flexibility needed to manage the watershed as required by law, agreements and operating conditions.

Consultation

SPU consults with federally recognized Indian tribes in compliance with applicable laws and regulations, seeking and taking into consideration the concerns of tribal representatives in making decisions or taking actions that may affect the natural and cultural resources of the watershed. The Snoqualmie Tribe, the Tulalip Tribes and the Confederated Tribes and Bands of the Yakama Indian Nation have an historical connection to the watershed. SPU also consults with other members of the public, such as local historical groups, that may be interested parties regarding potential effects on cultural resources.

Information and Collections Standards

Archaeological site and resource information is exempt from public disclosure. However, information from the SFTMW GIS cultural layers may be shared with the state DAHP, King County HPO, and Indian tribes for inclusion in their cultural resource databases.

Information relating to the nature and location of TCPs is considered confidential and is shared only with appropriate Indian tribes. SPU permits no public disclosure of information on TCPs (RCW 42.17.310 (1)(k)). Location information for TCPs is available only at a general level, for management use. The no-public-disclosure policy includes specific information related to Indian burials or remains.

In October 2001, SPU completed and opened to the public the Cedar River Watershed Education Center at Rattlesnake Lake. The Cedar River Watershed Education Center includes the Heritage Library and Gale Archives. The purpose of the Heritage Library and Gale Archives is to acquire, record and preserve records and artifacts relating to the unique cultural and natural heritage of the Cedar and Tolt River Watersheds. These materials are to be utilized for the following purposes:

- For understanding the past, present, and future use of the watersheds by people.
- To aid in the appreciation and preservation of the cultural and natural history of the watersheds.
- To serve as a resource for the education of the public and Seattle Public Utilities’ employees.
- To provide research material for scholars.

PUBLIC EDUCATION AND INTERPRETATION

Public education and interpretation at the SFTMW is limited to a few special interest groups annually (e.g. Snoqualmie Tribe, retired Seattle Water Department employees, City of Carnation, etc.). SPU staff actively seek input from interested parties (Tolt Historical Society, Snoqualmie Tribe) with a heritage link to the SFTMW in order to add to the body of knowledge available. SPU may partner with these groups in the future to plan and implement educational programs related to the watershed’s cultural history.

CULTURAL RESOURCE PERSONNEL RESPONSIBILITY

Responsibility for management of the SFTMW’s cultural resources is assigned to the Public and Cultural Programs Manager (P&CP Mgr.) of Seattle Public Utilities’ Watershed Services Division. The P&CP Mgr. works with a cultural resource professional (CRP), an archaeologist with cultural resource management experience, to perform the following duties:

- Oversight of implementation of the management measures described in this SFTMW Management Plan.
- Curation of collected historic and archaeological materials at the Cedar River Watershed Education Center’s Heritage Library and Gale Archives.
- Maintenance of the municipal watersheds’ cultural resource database and geographic information system.
- Appropriate incorporation of cultural resource information in public education programs and staff training.

- Coordination and consultation with oversight agencies and Indian tribes, as called for by the CRMP.

The CRP will meet the professional qualification standards outlined in Appendix A of 36 CFR Part 61. The P&CP Mgr. need not be a cultural resource professional, but will attend basic and periodic training on topics such as the Section 106 compliance process and others, to acquire and maintain familiarity with the needs for cultural resource management.

SPU requires all watershed staff to be informed about preserving and protecting cultural resources. All staff members who supervise, inspect, or perform ground-disturbing activities will receive training in cultural resource identification. Training will cover compliance with applicable regulations and the concerns of Indian tribes associated with cultural resources and human remains, with special emphasis on practical skills. Topics will also include procedures for addressing emergency situations that could affect cultural resources.

Contractor crew members doing work in the SFTMW that may impact cultural resources will also be required to have training on cultural resource sensitivity for the project area. The P&CP Mgr. will arrange for an on-site orientation for the contractor on cultural resource sensitivity for the project area, including artifact identification. The contractor will be required to train any crew members not present at the orientation.

Coordination with Project and Maintenance Work Planning

All SPU staff are required to consider protection and management of cultural resources in planning for projects or maintenance work in the SFTMW, especially for projects such as ecological thinning of second-growth forest, road maintenance, road decommissioning and habitat restoration that may involve ground disturbance or vegetation modification. Routine operations such as road maintenance and culvert replacement have the potential to adversely affect cultural resources.

Staff members will review the SFTMW GIS database during the planning stages of any proposed activities to determine if the proposed project area includes identified cultural resources and to determine the area’s potential for unrecorded cultural resources. The results of this review will determine the level of required survey and protective measures.

Level of Effort for Previously Identified Cultural Resources

When a proposed project or maintenance activity has the potential to impact a previously identified cultural resource that has not been evaluated for NRHP eligibility, that resource must be investigated and evaluated to determine its eligibility. The survey standards to be employed to evaluate the NRHP eligibility of a given site will be determined by evaluating the anticipated level of disturbance associated with the proposed activity and the likelihood that a resource of the kind identified in the GIS would meet NRHP eligibility criteria. The likelihood that a particular kind of resource may meet NRHP eligibility criteria depends upon a variety of factors, including the age of the resource and its presumed rarity or commonness. For example, a twentieth century logging site would likely be categorized as having a lower potential for meeting eligibility criteria, because of its relatively recent age and because such sites may be common in the SFTMW. On the other hand, prehistoric archaeological sites may be relatively more likely to meet eligibility criteria.

Within a project area, there may be varying levels of potential for eligible resources, as well as different levels of disturbance. Survey procedures will vary accordingly within the project area. The level of effort for various kinds of resources and various levels of disturbance are presented in Figure 1 (see 'Archaeological Survey Standards' below for explanation of survey standards.)

		Level of Disturbance		
		Low	Medium	High
Potential for NRHP-Eligible Cultural Resources	Low	Monitoring	Monitoring	Monitoring
	Medium	Pedestrian Survey	Level B Testing	Level B Testing
	High	Level B Testing	Level A Testing	Level A Testing

Figure 1. Level of Effort for Previously Identified Cultural Resources

Low disturbance is considered to be activity that will disturb no more than 10 percent of a project area's soil. Disturbance of the humic layer is acceptable, as is soil compaction. Hand planting of seedlings may be one example of a low disturbance project. Medium disturbance includes activity that will disturb between 10 percent and 30 percent of the project area's soil. Again, disturbance of the humic layer is acceptable, as is soil compaction. Some aspects of an ecological thinning project may fall into the medium disturbance category. High disturbance is associated with activities that affect more than 30 percent of a project area's soil, including preparation of landings and grading, and any activity that completely alters the ground surface. Gravel pit expansion would be an example of a high disturbance project.

Level of Effort for Areas with No Previously Identified Cultural Resources

The absence of recorded resources in the GIS does not mean that no cultural resources are located within a specific project area. The P&CP Mgr. will review proposed activities to determine whether they will occur in areas of high, medium, or low potential for archaeological resources and whether the proposed activity has a high, medium, or low potential for affecting archaeological resources (as discussed above). This evaluation will determine whether cultural resources investigations will be required for the activity, and the scope and extent of the investigations. The levels of effort for varying levels of disturbance in areas of undocumented archaeological resources are presented in Figure 2.

		Level of Disturbance		
		Low	Medium	High
Archaeological Potential	Low	Monitoring	Monitoring or Pedestrian Survey	Pedestrian Survey
	Medium	Monitoring	Pedestrian Survey or Level B Testing	Level B Testing
	High	Level B Testing or Pedestrian Survey	Level A Testing	Level A Testing

Figure 2. Level of Effort for Areas with No Previously Identified Cultural Resources

SPU has developed a model of cultural resource potential, using data already contained within the SFTMW GIS, to categorize areas of the municipal watershed as to their potential for containing archaeological resources. This model uses environmental factors, such as slope, distance to water or meadows, and distance to trails, to evaluate the likelihood of past human activity in a given area. In general, areas that are level and located near streams, lakes, marshes or trails are more likely to contain archaeological resources than steeply sloped areas distant from water or trails.

Survey Standards

All archaeological survey and testing activities conducted within the SFTMW will incorporate the following procedures:

- For each previously unrecorded site, a State of Washington Archaeological Site Inventory Form will be completed and filed with DAHP.
- Data collected during survey and testing will be added to the GIS cultural layers.
- Artifacts will be recovered if an unstable situation threatens the loss of archaeological data. This includes situations where erosion is ongoing (e.g., a beach) or where damage or vandalism of an artifact is possible (e.g., in an area of public access or use). A permit is

required for collection of artifacts from a site that is listed or eligible for listing in the Washington State Register of Historic Places.

Monitoring Standards

For actions that require monitoring based on Figure 1 or 2, the following standards apply:

- A qualified archaeologist or trained staff person will monitor ground-disturbing activity in the project area.
- The monitor is responsible for observing the ground-disturbing activity to ensure that the significance of any unanticipated archaeological resources is evaluated.
- If the monitor observes cultural material, he/she has the authority to halt the ground-disturbing activity.
- The monitor will evaluate the cultural material and make an initial assessment as to its potential significance. If the monitor is not a qualified archaeologist, he/she will consult with the CRP or other qualified archaeologist to make the assessment.
- If the monitor determines that the material is not potentially significant, a survey form will be prepared to document the location and nature of the material, and work may proceed.
- If the monitor determines that the material is potentially significant he/she will notify the P&CP Mgr. and the CRP, who will make a determination as to what level of investigation is appropriate.

Pedestrian Survey Standards

For actions that require a pedestrian survey based on Figure 1 or 2, the following standards apply:

- A qualified archaeologist will conduct a pedestrian survey for ground-disturbance activities in the project area.
- All pedestrian surveys conducted in the SFTMW will employ a maximum interval of 20 meters (66 feet). This requirement applies to areas of dense ground cover, wet soils, or no surface exposure. Even areas of slope, as long as the slope is not a hazard to traverse, will be subject to pedestrian survey when required. Pedestrian survey in areas of high probability will employ a maximum interval of 10 meters (33 feet).
- Pedestrian surveys will be conducted in order to identify cultural resources visible on or above the ground surface, and to identify discreet landscape features with higher archaeological potential than identified in the GIS model. If higher potential landscape features are identified during pedestrian survey, these areas may be subject to Level A or B testing, in accordance with Figures 1 and 2.

Subsurface Testing

Survey protocols that include subsurface testing will be required in areas of the SFTMW with a medium or high potential for archaeological resources if proposed actions will result in a medium or high level of disturbance. The requirements of these survey protocols will be made a condition of all contracts with cultural resource management firms. Minimum standards for all archaeological testing in the watershed are outlined below. These standards apply to work by SPU, cultural resource contractors, and all other contractors working in the SFTMW.

- The intensity of subsurface testing will be determined by the potential for archaeological resources and the nature of the proposed ground-disturbing activity. The GIS database will be used to provide SFTMW managers, reviewers, and consultants with an evaluation of unsurveyed areas as high, medium, or low potential for containing extant subsurface resources (see Figures 1 and 2).
- Level A or Level B shovel testing will be conducted in accordance with the matrix of conditions and expectations included in Figures 1 and 2:
  - Level A testing will be conducted at maximum intervals of 15 meters (50 feet).
  - Level B testing will be conducted at maximum intervals of 20 meters (66 feet).
  - Areas where the ground slope exceeds 25 percent grade may be investigated less intensively, but at least one shovel test will be excavated per acre surveyed.
- All material removed from shovel tests will be screened using a maximum mesh size of 1/4-inch hardware cloth.
- Profile diagrams of the strata in each shovel test will be drawn with texture, composition, and color descriptions.
- Each shovel test will be identified by a unique number and its location plotted on a map of appropriate scale.
- If necessary, the number and placement of test units will be decided upon in consultation with the SPU staff or contracted archaeologist. Test units will be excavated when shovel testing identifies a concentration of artifacts or subsurface features. Depending on context, a test unit may measure 1-meter square or 1 meter by 2 meters in plan. The size of test units provides a better view of stratigraphy and provides information on the deposits that contain artifacts. Test units are excavated down to culturally sterile deposits. Levels within each unit should not exceed 10 centimeters in thickness. If naturally occurring levels are used that exceed 10 centimeters in thickness, these should be sub-divided into arbitrary levels no thicker than 10 centimeters. A sketch map must be prepared for the base of each level and a detailed profile drawn of at least one wall, including detailed descriptions of sediment texture, composition, and color. All excavated materials are sieved through a screen with maximum mesh size of 1/4-inch hardware cloth. Artifacts are bagged by level and at least 1-meter excavation unit.
- A sketch map will be produced for all areas surveyed. This map will depict the approximate location of all pedestrian transects and shovel test excavations, with areas that yielded cultural material highlighted. All sketch maps will contain at least one recoverable reference point, a north arrow, the dates of survey, and the full name of the mapmaker. The location and information about the archaeological survey will be entered in the SFTMW GIS.

CULTURAL RESOURCE PROTOCOLS

Protocol for the Unanticipated Discovery of Cultural Materials

Despite review of existing databases and other materials, and sometimes archaeological survey, it is possible for archaeological deposits to be uncovered or located during routine maintenance or project activities. If cultural materials that appear to be older than 50 years are encountered by watershed staff or contractors, the following protocol will be implemented:

- If any member of a construction, maintenance or other field crew believes that he or she has made a cultural resource discovery, all work adjacent to the discovery will stop, and the work supervisor, P&CP Mgr. and CRP will be immediately notified.
- The work supervisor will take appropriate steps to protect the discovery site. At a minimum, the immediate area of the discovery site will be secured. Vehicles, equipment, and unauthorized personnel will not be permitted to traverse the site.
- An area of work restriction will be determined in consultation with the CRP and will be sufficient to provide for the security and protection of the cultural materials. SPU will enforce appropriate security measures.
- The CRP will determine whether the discovery meets NRHP eligibility criteria.
- If the discovery meets NRHP eligibility criteria based on its information value, the CRP will immediately contact the SHPO and the King County HPO to seek consultation regarding appropriate treatment. If SHPO and King County HPO representatives determine that the discovery is an NRHP-eligible prehistoric or historic Native American deposit, then SPU will consult with the affected Indian tribes to determine potential cultural heritage significance and appropriate treatment of the find. Treatment measures may include mapping, photography, limited probing, sample collection, alteration of the project to avoid further impact, or other activity. Any resulting subsurface excavation will require an archaeological excavation permit, as stipulated in RCW 27.44 and RCW 27.53, and implementing WAC's 25-48.
- The CRP will prepare a report on the methods and results of the treatment measures within four months of completion of the measures. The report will be addressed to the SHPO. SPU will provide a review copy of the draft report to the SHPO, affected Indian tribes, and the King County HPO. After a 30-day review period, SPU will make revisions that take into account review comments and provide a copy of the final report to each of these parties.

Protocol for Treatment of Human Remains

The acidic soils of the region do not facilitate the preservation of bone. However, the possibility of preserved human skeletal material, or conclusive material evidence of burial sites, cannot be disregarded. In the event that human remains are discovered on SFTMW property, whether during planned maintenance and project activities, authorized archaeological excavations, or as a result of natural processes, the following protocol will be strictly followed:

- All ground-disturbing activity within 30 feet of the remains will be halted immediately.
- The P&CP Mgr. will be immediately contacted and will assume responsibility for assuring that this protocol is followed.
- In cases when it is not clear whether the skeletal remains are human, a qualified osteologist will be contacted to make a determination.
- The King County Medical Examiner’s Office will be contacted immediately and asked to determine whether the remains are part of a potential crime scene. A forensic anthropologist may be required to determine whether the remains are of Native American ancestry.
- All skeletal material will be left in place until a designated professional archaeologist or medical examiner directs its removal.
- The SHPO will be contacted by telephone and informed of the discovery. The SHPO will be kept informed of all discussions regarding the remains until their final status is resolved.
- The listed federally recognized Indian tribes will be contacted. Representatives of these groups will be invited to be present during the Medical Examiner’s inspection of the remains.
- If the Medical Examiner determines the remains to be historical and Indian, the interests of the tribes become paramount, in accordance with Washington State law (RCW 27.44.040).
- If the remains are determined to be Indian, no analyses—beyond inventory—will be performed without written consent of the tribes.
- If the remains are to be removed, an archaeological excavation permit will be required.
- The remains will not be transported off-site, except to protect them from imminent damage.
- The remains will not be transported beyond the borders of the State of Washington without written consent from the SHPO and the tribes.
- SPU will allow reburial on utility property if the tribes desire that action. Selection of an SPU-managed reburial location will take into account foreseeable future uses of the location.
- If the Medical Examiner determines the remains to be historical and non-Indian, SPU will use historic documentation in an attempt to locate familial descendants. If descendants are located, SPU will allow reburial on utility property, if requested.
- The location of reburials will be noted on planning maps to prevent future disturbance. These maps will not be available to the public.
- SPU will treat areas of known burials—both in situ and reburials, with the respect accorded any cemetery.
- The cost of exhumation, transportation, and reburial are the responsibility of SPU. SPU is not responsible for maintenance of reburial locations.

Protocol for Response to Vandalism

Vandalism consists of disturbance to cultural resources, resulting from unauthorized digging into archaeological sites, collection of artifacts, or damage to structural remains. Because the SFTMW is closed to public access, the probability for vandalism within the municipal watershed is low. However, if at any time, SPU employees or contractors encounter unauthorized visitors who appear to be digging or collecting materials from the ground surface, or are in possession of excavation equipment; or if an SPU representative encounters evidence of recent unauthorized excavations or abandoned digging equipment (such as screens or shovels), the following protocol will be implemented:

- If a possible vandal or looter is present, the SPU representative will note information about the person, their equipment and their vehicle and immediately relay the information to a SPU watershed inspector, who will confirm the information and notify the King County Sheriff's Office.
- SPU representatives who note abandoned excavations or digging equipment will notify within 24 hours the P&CP Mgr., who will notify the King County Sheriff's Office and the DAHP. The SPU staff archaeologist, or a contracted professional archaeologist, will visit the site to assess any damage.
- If a hunter-fisher-gatherer site has been vandalized, the P&CP Mgr. will notify representatives of the federally recognized Indian tribes and the DAHP and invite them to attend the site inspection.
- The assessment of impact will be described in a formal letter report from SPU to the tribes and the DAHP.
- In consultation with the tribes and the DAHP, SPU will determine what actions, if any, should be taken to mitigate damage and prevent further damage.
- Any act of vandalism or looting that involves human remains will also trigger the protocol for the treatment of human remains outlined above.
- All acts of vandalism or looting will be referred to the King County Sheriff's Office for investigation and possible prosecution.

Protocol for Emergency Response

A number of events can occur in the SFTMW that require a rapid response to safeguard the municipal water supply, provide for protection of wildlife habitat, protect public and private property, and prevent serious injury or loss of human life. These include, but are not limited to, forest fire, wind and electrical storms, mass wasting events (erosion), culvert blockage, earthquake, and dam failure. This emergency response protocol is designed to be implemented after such events have occurred:

- The supervisor of response will notify the P&CP Mgr. of the location and nature of the emergency activities.

- The P&CP Mgr. will check the relevant databases for information on cultural resources in the vicinity of the emergency response.
- If cultural resources are located in the area of the emergency event or the response (for example, both the area of a forest fire and the location of a fire line), then the CRP will be asked to assess the condition of those resources.
- The P&CP Mgr. will notify the SHPO, King County HPO, the U.S. Army Corps of Engineers or other federal agencies (when in an area of their jurisdiction) and any affected Indian tribes of the emergency situation as soon as time permits.
- The CRP will compare existing documentation to the results of a field visit to determine if cultural resources have been destroyed, damaged, or endangered by the emergency event or the response. If any of these conditions exist, the CRP will document them in the field by means of mapping, photographs, and, in the case of imminent loss, collection of artifacts. The CRP will prepare a report documenting the nature and location of the emergency event, the nature of the response, the effects upon cultural resources, and recommendations to prevent further damage to the resources or to mitigate their loss. This report will be prepared for the DAHP within four months of the event, with draft copies sent to the DAHP, King County HPO, and any affected Indian tribes for review and comment. After a 30-day comment period, the comments of all consulting parties will be incorporated into a final report and copies sent to all participating parties.
- If no alteration to the condition of the resources has occurred, a letter to that effect noting the dates of the field visits will be placed on file in lieu of a formal report.

APPENDIX D. SUPPLEMENTAL INFORMATION ON ROADS

INTRODUCTION

This appendix provides detailed information on current road conditions in the SFTMW, including the following: 2006 Comprehensive Road Inventory, Washington Roads Surface Erosion Model (WARSEM), and SPU staff access needs. Also listed are SPU road standards for road improvements, maintenance, decommissioning, and construction.

CURRENT SITUATION

The following summary of current road conditions was extracted directly from the Road Erosion Assessment which was completed by Dube in 2007 (Aquatic Conditions for the South Fork Tolt River Watershed Management Plan: Road Erosion Assessment) as part of a broader assessment of aquatic and watershed conditions conducted by Malcolm Pirnie, Inc. for SPU.

Road Conditions/Issues

The detailed road inventory collected information on road conditions and included 32.3 of the 38 miles of active road in the watershed; 5.8 miles of primarily ridge-top roads were not inventoried due to weather-related access problems. In addition, 1.1 miles of related roads outside the watershed were inventoried. The inventory included information on the road tread, ditch, cutslope, and fillslope. The entire database of approximately 565 road segments has been provided electronically to SPU for their use in road maintenance and planning.

The South Fork Tolt Reservoir watershed is gated and closed to public use, so the majority of roads in the watershed have very little traffic use. The roads around the reservoir (50, 57, and 70 roads) and the roads in the vicinity of the dam (spurs 70.1,70.2, 50.2) receive the most use with daily trips by SPU personnel to check on the reservoir and water supply system. These roads are gravel surfaced and maintained in generally good condition. Midslope roads (73, 52, 52.2, 55, portions of the 71 road) receive lighter use and are surfaced with borrow or unsurfaced with a native blocky coarse tread. These roads are in fair condition. Culverts are functioning, but in several locations road grading has resulted in a grading berm that directs all road surface drainage into streams (even on crowned and outsloped road segments) and an over-steepened fillslope. Ridgetop roads include the 30 road on the southern ridge and the 71 road on the northern ridge. These roads are native surfaced or surfaced with borrow. The drainage structures are functioning, but there are many steep and narrow sections that are a rough drive. The 30.1 road is also very steep and rough in spots.

Several key road issues were noted on the road system. These are included in the road inventory database and summarized below:

- Sidecast berms – Several segments of road were graded with sidecast berms. These berms direct all road runoff to streams since there was a break in the berm at each stream crossing that allowed water to run over the outside shoulder and into the stream. These features increase the delivery of sediment and water to streams by altering the drainage patterns on crowned and outsloped road sections to act as insloped roads. Primary roads with sidecast berm segments include: 52, 52.2, 55, 70, and 70.4.
- Water across road – Evidence of water running across the road tread was seen on a few segments of the 52.2 and 71.4 road. This is caused by either an undersized or plugged culvert or a full ditchline.
- Oversteepened fill/soft fill on shoulder – Oversteepened fillslopes and often soft fill on the road shoulder was observed on segments of the 30.1, 52, 52.5, and 55 roads. These conditions are the result of construction on very steep sideslopes and/or the accumulation of many years of material from road grading that has been sidecast. In most cases these areas were stable, but a few segments had minor cracking or the potential to delivery material to streams.
- Culvert fill failing – The fill around culverts was noted as failing at a few locations on the 50 and 70 road systems. These roads parallel the lake shore and have a high potential for delivery of any failed sediment.
- Cutslope seepage – Seepage from the cutslopes was noted on several segments of the 50, 50.3, 52, 52.2, and 55 road. The south side of the reservoir appeared to have more drainage issues and to have water closer to the surface (perhaps due to thinner soils or differences in bedrock exposure). Interception of cutslope seepage can increase the delivery of water and sediment to streams.
- Slumping/raveling – Slumping and/or raveling cutslopes were noted primarily on the 71.4 road. Slumping and raveling can introduce more sediment into the ditchline that can be delivered to streams.
- Deeply eroded ditch on 30 road, station 5100 – A stream or large source of near-surface drainage appears to have been intercepted by the cutslope between station 5100-6100 on the 30 road. Water has eroded the ditchline, resulting in gullying and the potential for delivery of sediment and water to the upper end of Crystal Creek.
- Mass wasting on 55 road, Station 6292 – The 55 road past the 55.2 road junction was very steep, with numerous large drivable dips, waterbars, and high, unstable cutslopes. A fresh slide blocked the road at station 6292 as noted during the November 7, 2006 inventory (this was during the very large storm event that caused extensive flooding). SPU road personnel indicated that this location was an area of frequent mass wasting events; sediment often comes down the chutes and blocks the road in this area.

Estimated Road Surface Erosion

The average annual amount of sediment produced from road surface erosion was estimated for the South Fork Tolt Reservoir watershed using WARSEM. All active roads were included in the estimate. Decommissioned roads were not included in the estimate since these were observed to be well vegetated and had no traffic to disrupt the road prism. Two traffic scenarios were run. The higher traffic assumed a moderate/light traffic level on main roads and a light/occasional level on all other roads. The lower traffic scenario assumed the light/occasional use level on all roads. Abandoned/non-drivable roads were modeled using the no traffic rate under both scenarios.

An estimated 240 to 330 tons/year of sediment is delivered to streams in the watershed from road surface erosion (Table 1) based on low and high traffic scenarios. An additional 80 to 140 tons/year is delivered to streams from inventoried roads below the dam (area designated as in the Outside sub-basin in Table 1).

TABLE 1.
ESTIMATED ROAD SURFACE EROSION (TONS/YR)

Sub-basin	High Traffic	Low Traffic
Chuck Judd Creek	1	0
Consultant Creek	33	27
Dorothy Creek	1	1
East Shore	17	13
Horseshoe Creek	5	3
North of Dam	10	9
North Shore Central	7	4
North Shore East	59	35
North Shore West	4	2
Phelps Creek	9	5
Rainbow Creek	47	40
Single East Shore Tributary	0	0
Siwash Creek	2	2
Skookum Creek	36	35
South Fork Tolt River	10	5
South Shore Central	2	1
South Shore East	5	2
South Shore Southeast	3	2
South Shore Southwest	13	7
South Shore Tributary 1	28	23
South Shore West	38	25
Total SF Tolt Reservoir watershed	328	241
Outside	139	81

The primary factors influencing the road surface erosion estimates are delivery (does the road segment drain to a stream?), road width, surfacing, and traffic. The length of road by delivery class in each sub-basin are shown in Table 2. Overall, 50% of the active roads in the watershed deliver directly to streams. This is an unusually high percentage compared to other watersheds, but is caused by the long lengths of road paralleling the reservoir (50 and 70 roads) that deliver directly to the reservoir. The location of these roads makes it difficult to prevent delivery of sediment. The relatively low traffic levels, low gradients, and gravel surfacing on these roads helps to reduce erosion.

TABLE 2.
LENGTH OF ROAD BY DELIVERY CLASS (FT)

Sub-basin	Direct Delivery	1-100 Feet From Stream	100-200 Feet from Stream	No Delivery
Chuck Judd Creek	603	0	0	0
Consultant Creek	5070	1969	2040	3682
Dorothy Creek	227	1051	706	1922
East Shore	6786	1950	0	9095
Horseshoe Creek	96	1431	2370	4389
North of Dam	5121	1389	907	0
North Shore Central	4115	0	792	2581
North Shore East	11743	4097	2725	16528
North Shore West	3112	0	0	0
Phelps Creek	3367	286	0	0
Rainbow Creek	5413	0	0	1302
Single East Shore Tributary	133	0	0	1333
Siwash Creek	1152	0	0	3364
Skookum Creek	6051	0	644	798
South Fork Tolt River	3758	0	0	1076
South Shore Central	1408	272	0	0
South Shore East	3226	0	0	123
South Shore Southeast	1219	0	0	0
South Shore Southwest	4782	77	0	0
South Shore Tributary 1	6788	288	1406	6793
South Shore West	11851	860	1402	4877
Total SF Tolt Reservoir watershed	86019	13671	12992	57861
Total Length in Miles	16.29	2.59	2.46	10.96
Percent of Total Road Length	50%	8%	8%	34%
Outside	20198	1134	357	35962

ROAD STANDARDS

Because of the variability in the long-term uses of core road segments, specific road standards should be tailored to the needs and use requirements for each road segment. Roads may be reclassified as use requirements change. To ensure uniformity of standards, core roads will be divided into the following use classes based on the type and density of traffic use:

- High Density Heavy Use—Roads required for heavy loads (i.e., log haul from eco-thinning) and roads that carry a high-volume of all traffic throughout the year (i.e., mainline roads and primary connectors to adjacent properties).
- Moderate Use—Roads needed primarily for watershed management activities and protection, a high volume of light traffic. Some roads may carry a limited number of heavy loads for a short duration (i.e., log haul from eco-thinning). These roads may have seasonal restrictions for heavy hauling to avoid expensive improvements, depending on a cost-benefit analysis.
- Low Density Light Use—Roads needed for administrative and security activities (e.g., fire and security). These roads would normally be used only by light-duty vehicle, although occasional use by fire equipment may be required.

All road work will be designed to provide the appropriate level of access while addressing three basic elements of road condition: material stability, proper drainage and surface erosion.

Road Improvement Standards

Road improvement activities may include the following:

- Reshaping the road prism, including cut bank, side slope, ditch and road surface shaping
- Specialized road stabilization projects, which may include, but not be limited to, removal of over-steepened fill or construction of keyed fills, gabions or welded wire walls
- Road realignment—adverse grades, a too-small radius, or clearance issues may require realignment for specific projects or ongoing access
- Drainage improvements, including ditch construction and replacement and addition of cross-drain culverts
- Stream crossing replacements, including peak flow stream passage and fish passage; this could be large culverts, box culverts or bridges
- Rebuilding catch basins or outfalls
- Applications of crushed surfacing and or ballast rock, and compaction of surfacing
- Road widening or narrowing and addition of pullouts and turnarounds.

Road improvement projects will be scheduled to bring roads up to required standards and to provide access for special projects. Roads used for specific projects will be brought up to standards so they will provide appropriate access while protecting water quality and habitat in adjacent wetlands and waterways. Improvements will ensure road stability throughout the duration of the project. Future road improvement projects will depend on the results of a detailed road use analysis. If specific road segments will be required to support heavy haul, road conditions will be evaluated and improvement prescriptions specified. Detailed road improvement specifications will address issues regarding safe access, employ strategies to reduce environmental impacts, and be fiscally responsible.

Road Decommissioning Standards

Road decommissioning projects return roads to a condition of long-term stability by reducing the risks of mass wasting and surface erosion. Protection of surface water is the primary goal, along with habitat improvement. Once a road has been constructed in a location, it has altered the conditions at that location and the site cannot be completely restored to its pre-road condition. However, following standards developed in the Pacific Northwest for road decommissioning, the road bed can be stabilized to allow for the restoration of natural drainage and vegetation. The three basic elements of road deconstruction are the following:

- Stabilizing all material
- Establishing or restoring natural drainage
- Protecting freshly exposed mineral soil from surface erosion.

When all three conditions have been accomplished, the site should no longer be at risk of mass wasting and surface erosion that could result in sediment delivery to streams.

Road decommissioning projects will be designed to meet WDNR forest practice rules for forest road abandonment. Decommissioned roads may be inspected periodically for continuing stability, proper drainage patterns and resistance to erosion.

Road decommissioning projects are field-designed by a watershed engineer with designs for stream crossings and other technical consultations provided by watershed hydrologists. Prescriptions for decommissioning work are identified by location along the road, measured in stations (100 feet). Detailed plans will include but not be limited to the following work elements:

- Culvert removal and fill material removal
- Culverts to be removed at stream crossings; the watershed hydrologist will design each stream crossing restoration project and direct stream bypass work that may be required while working in the stream bed
- Stream cross section slopes and armoring to provide stable, permanent crossings; some fill material may be retained and stabilized where total removal would cause greater erosion or environmental damage
- In locations that could provide connectivity between significant amounts of fish habitat, stream channels will be reconstructed to provide fish passage
- The watershed hydrologist will delineate the extent of fill removal from wetlands

- Frequency and location of water bars
- Extent of over-steepened side cast or fill removal and removal of grading berms
- Scarification prescriptions, including depth and extent
- Erosion control required during decommissioning operations and after decommissioning is complete
- Salvaging of materials, either riprap, ballast or crushed rock
- Designated waste site, or on-site location of removed fill
- Treatment of ditches
- Treatment of landings.

The following minimum physical road specifications and guidelines should be incorporated into the design of any new proposed roads, or into the reconstruction, improvement and maintenance of existing roads in order to provide maximum traffic safety and management access while reducing or eliminating adverse environmental impacts.

Road Construction Standards

Tables 3 through 5 list recommended road construction standards. These standards apply to road improvement projects the same as they would apply to new road construction.

TABLE 3.
HIGH DENSITY/HEAVY USE ROAD STANDARDS

Road Width	• Minimum 16-foot running surface • Maximum 20-foot running surface (mainline roads)
Ballast/Base	• 12 inches (or as needed for support) of compacted pit-run type material.
Surfacing	• Minimum 6 inches of compacted surfacing with material resistant to decomposition and breakdown that may contribute to road surface erosion. • Crown at 6%. • Surface rock specifications may be adapted on a site-specific basis at the discretion of the engineer.
Ditches	• Depth: minimum 1 foot below road surface • Width: minimum 1 foot
Cut-slopes	• 1:1 —Common material, cut-slope less than 10 feet high • ¾:1—Common material, cut-slope more than 10 feet high • ½:1—Side slope > 70%, or fractured rock cut-bank • ¼:1—Hardpan or solid rock cut-bank
Fill-slopes	• 1½:1 Typical • 1¼:1 angular rock (as approved by engineer)
Fill Widening	• Minimum extra widening (in feet) added to fill-slope side of subgrade to be: • 1 foot for fills less than 6 feet, or • 2 feet for fills 6 feet or more
Alignment	• Horizontal: minimum 100-foot radius • Vertical: minimum 200-foot curve
Curve Widening	• Minimum extra widening (in feet) added to inside of curves to be: • 400'÷ radius of curve (typical), or • 200'÷ radius of curve (mainline)
Turnouts	• Turnouts shall be inter-visible but not exceed 750 feet spacing on typical roads. • Turnouts will have 50-foot lead-ins and lead-outs with 100-foot long pull-out zone. • Turnouts are not required for roads with at least 20-foot wide running surfaces (mainlines).

TABLE 4.
MODERATE USE ROAD STANDARDS

Road Width	• 12- to 18-foot running surface • (16-foot preferred)
Ballast/Base	• Ballast for anticipated seasonal use.: • 12 inches (or as needed for support) of compacted pit-run type material may be require for winter use with heavy equipment. • No ballast may be required in conjunction with seasonal haul restrictions.
Surfacing	• Minimum 6 inches of compacted surfacing with material resistant to decomposition and breakdown that may contribute to road surface erosion. • Crown at 6%. In-sloping or out-sloping at 6% may be acceptable on site specific basis (per engineer). • Surface rock specifications may be adapted on a site-specific basis at the discretion of the engineer.
Ditches	• Depth: minimum 1 foot below road surface • Width: minimum 1 foot • Note: No ditch required for in-slope or out-slope roads.
Cut-slopes	• 1:1 —Common material, cut-slope less than 10 feet high • ¾:1—Common material, cut-slope more than 10 feet high • ½:1—Side slope > 70%, or fractured rock cut-bank • ¼:1—Hardpan or solid rock cut-bank
Fill-slopes	• 1½:1 Typical • 1¼:1 angular rock (as approved by engineer)
Fill Widening	• Minimum extra widening (in feet) added to fill-slope side of subgrade to be: • 1 foot for fills less than 6 feet, or • 2 feet for fills 6 feet or more
Alignment	• Horizontal: minimum 50-foot radius • Vertical: minimum 100-foot curve
Curve Widening	• Minimum extra widening (in feet) added to inside of curves to be 400'÷ radius of curve.
Turnouts	• Turnouts shall be inter-visible but not exceed 750 feet spacing on typical roads. • Turnouts will have 25-foot lead-ins and lead-outs with 50-foot long pull-out zone.

TABLE 5.
LOW DENSITY/LIGHT USE ROAD STANDARDS

Road Width	• Minimum 12-foot running surface
Ballast/Base	• No heavy loads expected on these roads, ballast required only as needed for traction or support of light vehicle traffic.
Surfacing	• Seasonal use is expected on these roads, surfacing is required only if needed for surface erosion protection. • Crown at 6%. In-sloping or out-sloping at 6% are acceptable. • Surface rock specifications may be adapted on a site-specific basis at the discretion of the engineer.
Ditches	• Depth: minimum 1 foot below road surface • Width: minimum 1 foot • Note: No ditch required for in-slope/out-slope roads.
Cut-slopes	• 1:1 —Common material, cut-slope less than 10 feet high • ¾:1—Common material, cut-slope more than 10 feet high • ½:1—Side slope > 70%, or fractured rock cut-bank • ¼:1—Hardpan or solid rock cut-bank
Fill-slopes	• 1½:1 Typical • 1¼:1 angular rock (as approved by engineer)
Fill Widening	• Minimum extra widening (in feet) added to fill-slope side of subgrade to be: • 1 foot for fills less than 6 feet, or • 2 feet for fills 6 feet or more
Alignment	• Horizontal: minimum 35-foot radius (or as needed) • Vertical: minimum 100-foot curve (or as needed)
Curve Widening	• Minimum extra widening (in feet) added to inside of curves to be 200’÷ radius of curve.
Turnouts	• Turnouts shall be inter-visible but not exceed 750 feet spacing on typical roads. • Turnouts will have 25-foot lead-ins and lead-outs with 50-foot long pull-out zone.

Road Drainage

Roads are arguably the single most dramatic management impact to be made on the landscape and can severely disturb natural drainage patterns. Not only can roads redirect surface waters into an adjacent drainage basin (drainage piracy), but cut-slopes may also intercept sub-surface flows, transferring that additional drainage into the ditch line and creating an increase in surface waters that ultimately enter the stream network. The primary function of the road drainage system is to intercept, collect and safely disperse surface and sub-surface runoff from roads.

Proper road drainage is considered to be one of the most critical factors affecting long-term road stability and potential environmental degradation (i.e., sedimentation). A properly designed road system will manage surface runoff in a manner that mimics natural drainage patterns as much as possible through the use of various structures, including road surface, ditches, culverts, bridges, water bars and fords. Appropriate design, placement and maintenance of these structures will vastly improve the lifespan of the road and significantly decrease the potential for adverse impacts to water quality (mass wasting and/or sedimentation). The following chapter is intended to assist Watershed staff in determining the suitable design, placement and maintenance procedures for these important drainage structures.

Road Surface

The road surface template is the first structure critical in controlling road drainage. Typically the road surface is an impermeable layer that can accelerate surface drainage on steeper-gradient roads.

Besides creating a safe running base for traffic, the road surface should also direct drainage to the appropriate location. In most cases, the road surface should be crowned approximately 6% to each side, this will allow the outer portion of the surface drainage to be directed over the shoulder as sheet flow and the inside portion directed into the ditch line. In the upper elevations of the SFTMW, out-sloping the road (at least 6%) to direct surface drainage over the shoulder can provide a low-maintenance drainage option. Out-sloping however, may create a dangerous situation for traffic in areas of potential snow accumulation and should be considered only as an option for seasonal use roads. Alternatively, the road may be in-sloped (at least 6%) so that drainage is directed towards the bank. In this case, the entire roadway acts as a wide ditch, which is a practical solution in instances where cut-banks may be unstable and ditch lines are difficult to maintain. Both crowned and in-sloped roadways will require the use of relief culverts as discussed later in this chapter.

In any event, no matter which type of road prism is selected (crown, in-slope or out-slope), the surface should be maintained such that significant wheel ruts are not allowed to develop. Wheel ruts can allow surface runoff to be directed down the roadway, bypassing ditch lines and relief culverts as designed, where the sediment-laden water can then directly enter a stream channel. This is especially critical on steeper gradient roadways (more than 6%). Shoulder berms should be avoided unless otherwise directed by the Watershed engineer on a site-specific basis. Petroleum products will not be used within the SFTMW for dust control.

Ditches

Ditches are an integral part of the road drainage system and perform a basic purpose—channeling runoff along a safe route until it can be safely discharged onto the forest floor. Ditch lines (and culvert headwalls) should be constructed as part of the subgrade instead of being gouged out of the cut-slope.

To properly facilitate drainage, ditch lines should be steep enough to keep water moving (at least 3%) in order to prevent puddling and subgrade saturation. When the existing road is relatively flat (i.e., 200 Road), the ditch line may be artificially steepened through the placement of additional relief culverts in a deeper location so that ditch water must drain toward the pipe. Additionally, sediment traps or grass-lined ditches and swales may be incorporated into the ditch line (prior to a culvert crossing) to reduce the potential for road sediments from entering the stream network (sediment traps shall be designed by the Watershed engineer).

As noted above, selected low-use roads or those located in the upper reaches of the SFTMW may be in-sloped or out-sloped to reduce maintenance costs and direct surface drainage as desired. Obviously roads constructed to either these templates do not need defined ditches, however the crowned road template is the most common in the Watershed and requires well-constructed and maintained ditch lines. A rigid maintenance and repair program as discussed later is an important factor in continued functionality of the ditch lines.

Culverts

Culverts are an extremely important component of the road drainage system. There are two basic culvert types—1) relief culverts (cross-drains, used for sending ditch water across the road and onto the forest floor, and 2) culverts which will pass a live waterway or stream under the road (these may require additional consideration for fish passage).

Relief Culverts (Cross-Drains)

Relief culverts are intended to safely discharge ditch water onto the forest floor. Excessive flows may be caused by long, continuous stretches of ditch line uninterrupted by culverts (or by obstructed culverts). Such heavy flow can create a severe erosion condition at the eventual outlet when all of this water is discharged at a single point.

The following considerations should be taken in the spacing and placement of relief culverts to reduce potential for soil erosion at the outlet:

- Relief culverts should be a minimum diameter of 18 inches and have at least 12 inches of cover below the drivable traffic surface.
- Culverts may be galvanized or aluminized per AASHTO specifications or double-walled corrugated polyethylene tubing AASHTO specification number M196.
- Annular corrugated bands and culvert ends shall be used on metal culverts. On culverts 24-inches and smaller, bands shall have a minimum width of 12 inches. On culverts over 24 inches, bands shall have a minimum width of 24 inches. Manufacturer's approved connectors shall be used for corrugated polyethylene tubing.
- Culverts will be bedded on a firm, well-compacted footing. Areas of poor soil conditions may require sub-excavation and backfill with competent material prior to bedding culvert. In excessively poor conditions, the Watershed engineer may allow a 4- to 6-inch crown in the culvert bed to allow for settlement/compaction.
- Relief culverts should be sloped 2% greater than the ditch line. As road (and ditch line) gradients increase beyond 10%, the culvert should also be skewed approximately 2° from perpendicular per each 1% percent of road gradient (i.e., 15% road = 30° skew).
- With the exception of extreme soil erosion conditions, horizontal spacing of culverts in the SFTMW should be based on a maximum vertical distance between culverts of 35 feet (i.e.,

35’□15% road grade = 235± foot spacing). In situation where the road is located in a section of extremely erosive soils, the Watershed engineer may modify this spacing requirement.

- Additional relief culverts shall be required in locations where the cut-slope intercepts sub-surface flows.
- Relief culverts should not discharge into convergent topography (swales, hollows) or other sensitive areas. Discharging onto natural ground in areas of divergent topography (noses, ridges) is preferred.
- Ditch relief culverts should discharge onto a well-vegetated forest floor at least 100 feet above a live waterway. When this is not possible (steep slopes, stream adjacent roads, etc.), an outlet control structure or sediment traps and/or grass-lined ditches and swales may be utilized (sediment traps shall be designed by the Watershed engineer).
- Downspouts or flumes will be incorporated when needed to facilitate discharge onto natural ground. Downspouts and flumes will be staked or otherwise securely fastened to remain in place.
- An energy dissipater shall be placed at the outlet of each relief culvert to reduce velocity and disperse flow over a broad area in order to decrease potential for soil erosion.
- Headwalls and catch-basins shall be constructed at the culvert inlet to direct water into the pipe and reduce potential of erosion around the inlet and cut-slope. Minimum dimensions are 2 feet wide and 4 feet long unless otherwise specified by the Watershed engineer or hydrologist.
- Any damaged galvanized coating or cut end shall be retreated with a minimum of two coats of zinc-rich paint (per manufacturer’s specifications).
- Turnouts should not be located above culverts.
- A routine inspection, maintenance and inventory program will be developed for all culverts within the SFTMW.

Stream Crossing Culverts

Stream culverts are intended to allow existing surface waters to pass unencumbered through the road prism. In cases where potential fish habitat or migration is a concern, a bridge or bottomless structural pipe-arch should be considered (see additional details in the Bridge section of the report).

Proper sizing of these structures is critical to the long-term stability of the crossing. Stream crossing culverts should be sized to pass a 100-year storm event without overtopping the pipe (i.e., maximum headwater depth = pipe diameter). However due to the higher elevation of most of the SFTMW, it is recommended that culvert sizes be based on 120% of the expected 100-year flows within and immediately below (□300’ vertical) the “rain-on-snow” zone (elevation 1400±’ to 3200±’). The Watershed engineer and hydrologist will approve final culvert sizing and placement decisions.

The following considerations should be taken in the placement and maintenance of stream crossing culverts (excluding bridges and structural pipe-arches):

- All stream crossings are designed by a Watershed Hydrologist and Watershed Engineer.
- A Hydraulic Project Approval (HPA) must be obtained from the Washington State Department of Fish and Wildlife as well as an FPA from the Washington State Department of Natural Resources for any stream crossing culvert placement or replacement within ¼-mile of fish bearing waters. The HPA may contain additional restrictions or requirements. King County Shoreline Division may also require a permit for work within 200 feet of a designated “Shoreline of the State” (Chester Morse Lake or Cedar River).
- Stream crossing culverts must be structurally designed to carry the load intended. In most cases, a pipe with a U-80 capacity (typical 80-ton truck) will handle any potential load required. Where deeper fills are required (□10 feet), the culvert gauge may need to be increased to accommodate the increased load. Culvert vendors should be able to supply staff with load tables to assist in ordering culverts of appropriate gauge.
- Culverts may be galvanized or aluminized per AASHTO specifications or double-walled corrugated polyethylene tubing AASHTO specification number M196.
- Annular corrugated bands and culvert ends shall be used on metal culverts. On culverts 24-inches and smaller, bands shall have a minimum width of 12 inches. On culverts over 24 inches, bands shall have a minimum width of 24 inches. Manufacturer’s approved connectors shall be used for corrugated polyethylene tubing.
- Prior to disturbance of the channel (new installation or replacement), all stream flow will be isolated and bypassed around the work zone to eliminate sediment input into the waterway. This may be accomplished with diversion culverts or by pumping around the work zone until installation of the new water crossing has been completed. Flow may be restored through the culvert only after all structural components of the installation have been completed. At no time will flowing water be allowed come into contact with erodible construction material.
- Turbidity levels associated with culvert installation operations shall not be allowed to exceed 5 NTUs (visible plume 20 feet below input source). When required, temporary settling basins shall be provided with sufficient capacity to detain runoff long enough to permit water quality to improve before discharge in the stream network.
- Stream crossing culverts should maintain the original stream alignment and grade as much as possible.
- As a general guideline, culverts should have a minimum cover of at least 50% of the pipe diameter (structural pipe-arches will have published minimum/maximum cover requirements).
- Backfill and compaction—the culvert will be backfilled and compacted in 12-inch lifts on each side, with one side never more than one lift higher than the other. Compaction will be accomplished with rollers or other heavy equipment capable of achieving at least of 95% standard soil density.

- An armored headwall will be constructed at the inlet to each culvert. The headwall will extend at least 24 inches beyond each side of the stream channel and at least 12 inches above the top of pipe.
- Exposed fill-slopes will be grass seeded and mulched with 2 inches of straw to reduce short-term erosion potential. Seed mixes are to be determined by a watershed biologist to avoid introducing exotic species or causing other problems.
- Waste material shall not be placed within 100 feet of a live stream or in such a manner that will allow sediment to enter the waterway.
- The working zone within the riparian area will be limited to the minimum necessary for safe operations.
- Turnouts should not be located above culverts.
- A routine inspection/maintenance/inventory program should be developed for all culverts within the SFTMW.

Bridges and Fish Passage Culverts

In many cases, streams (particularly in the lower stream reaches) may contain potential fish habitat and thus any proposed road crossing will require additional design considerations to allow for unimpeded fish migration in all life stages. Sizing and installation methodologies are similar to those identified above for stream-crossing culverts but should also include additional clearance of at least 6 feet to allow for debris passage. There are several however additional considerations associated with fish-bearing streams worth noting:

- Bridges shall be inspected at least annually by a qualified engineer to identify potential safety concerns and to determine if any maintenance is required. Findings of such inspections will be documented in a bridge inventory by staff and use to establish an annual bridge maintenance program.
- A team consisting of an engineer, a hydrologist and fish biologist shall design fish passage crossings.
- Bridge decks should be sealed over the entire length to keep sediment-laden surface drainage from entering the stream network.
- Road gradients of the approaches on both side of a bridge (or fish passage culvert) should slope upward towards the bridge to allow surface water to drain away from the crossing and discharge directly onto the forest floor through relief culverts.
- Debris and waste material (rust, paint, dirt, etc) shall be kept from dropping into the water. All work shall be carried out over a shield designed to catch such material for disposal at acceptable site.
- The road approaches should be paved (up road gradient) at least 100 feet on each side of the bridge (or fish passage culvert) to reduce sediment from being transported onto the deck and reduce maintenance requirements at the bridge ends.

- Ditch lines should not enter directly into the stream. Sediment traps or outlet control structures (as described above) may be used within the ditch line above the stream where standard methods are not feasible.
- Earth disturbing operations around these structures should be limited between July 1 and September 30 (HPA conditions may alter this operating window).

Road Deconstruction Standards

Road deconstruction will increase the frequency of cross-road drainage. This will involve constructing frequent deep water bars across the road bed. Drainage will be directed away from unstable areas and erodible soils. The frequency of drainage structures will be designed to approximate the surface and groundwater flows prior to road construction. Water bars will be tied into the original ditch line, and will be cut into the original road subgrade. The water bars will be constructed at an angle to intercept water that could flow down the original ditch line or roadbed and direct that water across the road onto stable locations. Where possible ditches will be filled in with road fill or fill slope material and sloped to a stable condition.

Over steepened road fill will be removed and either placed in the ditch line, on the road bed or hauled to a designated waste site. The retrieved side-cast material can not be compacted to the same density as the underlying road bed, however scarification of the original road bed will improve drainage through relocated road fill material and improve regeneration of forest vegetation. Since road fill cannot be sloped to be as stable as original soil, recon touring the entire road prism will not typically be done.

Roads constructed through wetlands will be evaluated with the purpose of restoring the wetland by either totally removing the road fill or in the case of extensive wetlands, of restoring the connectivity through the wetland. Often full road prism removal is required.

Minimal decommissioning will include scarification of the road bed. Exposed erodible soils will be protected by applying brush or straw and seed. Straw and seed mixes will be designed by a watershed biologist to avoid introducing exotic species or causing other problems. Bio-technical types of products such as coir mats may be used to protect exposed soils from erosion.

Roads not maintained after a number of years that are overgrown, have no drainage structures, and are evaluated to be stable through time will be considered “decommissioned as is”.

Perched landings pose particular stability issues and receive more engineering review. All known perched landings in the SFTMW have been removed and stabilized, but these standards are include to illustrate how the work has been done, and how we would treat the discovery of a perched landing, should one occur in the future. To decommission a landing the following must be addressed:

- Direct water flow away from the landing.
- Stabilize organic and mineral material to prevent downslope movement especially into streams, and waterways.
- Minimize surface erosion.

Each landing will be completely walked around and evaluated from all aspects.

Most landings are constructed on a side-slope ridge where the road would have entered a draw if it had continued. (This placement maximizes the area available for yarding.)

After reconnaissance detailed plans will be drafted that show direction and extent of drainage, extent of removal of side cast fill and woody debris. The landing area will be flagged consistent with the plans. If there is adequate room excavated mineral soils and woody debris will be placed on the road bench, against the cut bank if possible, or away from the cut bank if there is a need will need to establish a ditch against the cut bank to direct water around woody debris piles. Mineral soils will be placed first with the organic debris on top or against the sides, so the mineral soils will not become destabilized as the organics decompose. If the perched material needs to be removed from way below the landing, the plans will need to detail benching down to reach unstable material. This will also depend on deliverability—the risk of material entering a stream. If space is limited, end haul may be required. Pull back will not remove more material than necessary to recover the original slope. Some of the side-cast material may be left place if it is stable.

Road Maintenance Standards

Once they have been improved, roads require ongoing maintenance to remain stable and protect water quality and habitat from sediment delivery generated by surface erosion or mass wasting. At a minimum, roads require culvert inspection and cleaning, surface grading, ditch cleaning and brush cutting. Roads deteriorate with time and with use, but proper improvements will reduce maintenance needs and costs. The amount and nature of traffic is a significant factor in road maintenance activities and cost.

The unique terrain and the water supply and habitat resources in the SFTMW require road improvement and maintenance activities to be conducted to high standards. The steep terrain and highly erodible soils are prone to mass wasting, and road failure is likely if roads are not maintained to high standards. Maintenance activities include the following:

- Inspection and cleaning of culverts and ditches
- Repair to culverts, catch basins and out falls
- Checking drainage structures after storm events
- Road grading and sweeping
- Stabilization of cut banks and fill slopes
- Clearing roads after storm events and winter closure
- Vegetation management, eradication of invasive species, and clearing road side brush from sight lines.

The frequency of road maintenance will depend on road use class, and access needs for special projects. Eventually all roads will be assigned a maintenance class, and maintenance will be scheduled at the appropriate frequency.

Road maintenance operations should focus on sustaining a stable, functional road system that minimizes adverse impacts to water quality and stream or riparian habitat. Protection of water quality is the most important concern during road maintenance planning and activities. Road maintenance operations fall into two basic categories: work to rectify defects (repairs) or routine maintenance. Repair work is usually needed to mitigate for either poor construction or design practices (i.e., unstable banks or fills, poor drainage, etc.), uses that exceed design limits or for unforeseen environmental events (storms) whereas routine maintenance is required to sustain the current road standards due to degradation from traffic use. Unusual or unanticipated situations shall be referred to the Watershed engineer for specific direction.

Road segments that require extraordinary maintenance, deliver sediment to streams or are chronically wet and tend to deteriorate should be evaluated and scheduled for relocation, abandonment or reconstruction.

Some of the major elements of road maintenance are grading (shaping the road surface); maintaining drainage structures (ditches, water bars and cleaning and repair of culverts and catch-basins); vegetation control; application and replacement of rock ballast or surfacing; and removal of material such as rock fall from cut banks.

The Watershed engineers will continue research into new road construction and maintenance methods, techniques, and materials and apply that knowledge where it seems appropriate to protect water quality and to be cost-effective.

Grading

Routine grading is done to provide a good driving surface and maintain a road prism shape (crown, in-slope, out-slope) that allows adequate surface drainage. Additional considerations for grading include:

- Grading shall be done with an attempt to keep road material on the road, instead of pushing material off the road. This can be difficult where large quantities of over-sized material exist in the road surfacing and may require the use of replacement surfacing material on certain segments.
- Avoid grading when surface materials are excessively wet. When saturated, road surface material becomes easily rutted by traffic and can result in an increase in sediment input to streams that adversely impacts water quality.
- Avoid grading when surface materials are too dry unless water is applied to the surface in conjunction with grading. Dry material cannot be adequately compacted, resulting in loss of fines as dust and segregation of larger aggregates. Petroleum products will not be used within the SFTMW for dust control or for the retention of fines.
- Rock that has fallen on the roads will be prevented from entering streams or draws that deliver to streams. This material should be end-hauled to a stable location. Where there will be no impact to the stream network, oversized material can be pushed over the fill-slope.

- Excess surfacing or ditch material will not be pushed over the fill-slope but will be end-hauled to a stable location. Excess material that is pushed over the fill-slope can form over-steepened fills that may become unstable.
- Berms are not to be formed adjacent to the road except where designated by the Watershed engineer. Where berms only serve to keep surface water on the road, they will be eliminated, or reworked to allow proper drainage.
- Determine cause of chuckholes in road surface (standing water, too little surfacing, etc.) and select appropriate method to alleviate problem.
- Road segments where grading has potential to deliver sediment to streams will require special attention and alternate maintenance methods. Reduction of sediment delivery may be accomplished by changing grading techniques or timing of grading activities.

Maintaining Drainage Structures

Ditches, culverts, catch basins, water bars, and any other road drainage structure must be maintained to the standards discussed previously to ensure proper function. This plan will implement an inventory and inspection program that evaluates these structures at least annually and contains a provision for additional inspections following a major storm event. This inventory system includes methodologies to make measurable comparisons between maintenance options (i.e., WARSEM, etc.) and to help determine relative success for the alternative selected.

Right-of-Way Vegetation Management

Roadside vegetation needs to be controlled for safety (i.e., visibility) and to maintain a road system that has good air circulation and exposure to sunlight. Roads that are encroached by brush and trees can remain saturated and the surface rock may be invaded by the root system, thus loosing effectiveness. Sediment delivery potential increases and drainage control is more difficult to maintain as the structure of the road breaks down.

- The City of Seattle has adopted a policy of using no herbicides for roadside vegetation control in the Municipal Watersheds. Roadside vegetation control must be accomplished by mechanical methods, such as using a mechanized brush-cutter, chainsaws or other hand tools.
- Consultation with the Watershed biologist is recommended before brushing around fish-bearing streams. Potential mitigation for loss of riparian canopy due to brushing may include additional placement of LWD in the affected stream.
- Current information indicates that most of the roads within the municipal watershed require brushing every 1 to 3 years. In some locations there are other management priorities that result in postponing vegetation control.

Surfacing and Rock Replacement

To accommodate proper grading and maintain the function the road surface, additional ballast and/or surfacing material may be required in specific situations and should consider the following guidelines:

- Potential sources for surface rock will be evaluated for quality, clean (no fines) rock should be used in sensitive places to reduce sediment impact to water. Paved surfaces may be appropriate it areas of potentially high sediment delivery to the stream network.
- Ballast or surfacing rock will be hauled and placed and compacted with care to ensure proper drainage and avoid adverse impact to water quality.
- Petroleum products will not be used within the SFTMW for dust control.

Snowplowing

Snowplowing will likely be required on certain road segments to maintain management access into critical portions of the watershed. Care should be taken not to disturb the surfacing material using the following guidelines:

- Snowplowing with a grader is preferred over a bulldozer. Leave some snow cover on the road to protect the surface (less than 6-inches is easily accomplished with a grader, whereas 12-inches is most practical with a dozer).
- The use of “shoes” on bulldozers or rubber blade edges on graders will also help to protect the road surface.