Contents

List of Tables

Chapter 6
Water Resources

6.1 Introduction

This chapter addresses the affected environment, impacts to the environment, mitigation measures, and significant unavoidable adverse impacts related to groundwater and surface water resources, both freshwater and marine, for the Brightwater Regional Wastewater Treatment System (Brightwater System). Wetlands are discussed in Chapter 7. References and figures cited in this text can be found at the end of the chapter.

6.1.1 Overview of the Chapter

This chapter has been updated to respond to comments on the Draft EIS and to include information from technical studies that were conducted after publication of the Draft EIS. This chapter differs from Chapter 6 of the Draft EIS in the following respects:

- It combines the discussions of groundwater and surface water resources to allow for a more comprehensive review of water resource issues
- It is now organized by system (Route 9–195th Street System, Route 9–228th Street System, and Unocal System). For each system, the discussion is organized by system component (treatment plant, conveyance corridor, and outfall)
- The characterization of watercourses at the Route 9 site was revised as a result of additional evaluation
- An evaluation of flow impacts to streams along the conveyance routes was added
- Potential impacts of construction dewatering on project area aquifers, including potential drawdown of water supply wells, springs, and streams, are evaluated quantitatively
- A summary of applicable federal, state, and local regulations pertaining to groundwater and surface water resources was added

Comments on the Draft EIS were received from federal, state, and local agencies, public interest groups, and individuals. The majority of the comments fell into the following categories:

- Provide an evaluation of the interconnection between groundwater and surface water.
- Provide a more detailed evaluation of groundwater dewatering impacts.
- Discuss water quality and quantity impacts on Little Bear Creek, Willow Creek, and Edmonds Marsh.
- Discuss construction impacts at the portal sites.
- Provide more detail regarding the stormwater treatment system.
- Discuss effluent dilution and mixing in Puget Sound, and potential impacts of effluent discharge on aquatic life and human health.

Since publication of the Draft EIS, 10 technical studies relating to surface water and groundwater resources were conducted. They are contained in Appendices 6-A through 6-J. These studies were prepared to provide additional information to further refine the project design and to address comments on the Draft EIS. The contents of these studies are summarized in this chapter. The studies are briefly described below:

- Appendix 6-A, Affected Environment: Surface Water, provides additional information on surface water resources that could potentially be affected by construction and operation of the treatment plant and conveyance systems, including portal sites.
- Appendix 6-B, Geology and Groundwater, provides additional information on the interrelationship between groundwater and surface water in the project area. It also provides a more detailed analysis of construction and operation dewatering, including groundwater drawdown modeling to assess dewatering impacts on stream flows and on local and regional wells. The geology information is summarized in Chapter 4 of this Final EIS; the groundwater information is summarized in this Chapter 6.
- Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites, provides additional detail on erosion and sediment control and monitoring, runoff control facilities, and dewatering methods, volumes, and disposal for the treatment plant sites. Several comments on the Draft EIS requested additional information on surface water control during project construction and operation.
- Appendix 6-D, Permanent Stormwater Management at the Treatment Plant Sites, provides information on treatment plant sites, stormwater design standards, treatment and detention volumes, and stormwater facility design.
- Appendix 6-E, Route 9 Site Runoff Effects on the Geomorphology of Little Bear Creek, details a hydrologic modeling study conducted for Little Bear Creek to quantify the flow effects of stormwater runoff on the geomorphologic characteristics of Little Bear Creek and the potential for stream erosion and

habitat degradation. The study also evaluates the effects of stream diversions around the Route 9 site.

- Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites, provides construction and operation information for the conveyance systems, similar to the information for treatment plants presented in Appendix 6-D.
- Appendix 6-G, Assessment of Buoyant Materials and the Microlayer, provides an assessment of the potential effects of floatable particulate matter from the wastewater plant discharge on Puget Sound marine waters and shorelines.
- Appendix 6-H, Predesign Initial Dilution Assessment, provides more detailed analysis of effluent dilution in Puget Sound using refined outfall alignment and diffuser design information for the Route 9 and Unocal outfall locations.
- Appendix 6-I, Effluent Quality Evaluation for the Membrane Bioreactor and Advanced Primary System, provides an updated analysis of treatment plant effluent quality. It evaluates the effects of proposed changes to the treatment plant process on water quality, including the effects of effluent discharge on dissolved oxygen levels and shellfish in Puget Sound.
- Appendix 6-J, Summer Season Temperature Effects of Stormwater Ponds on Receiving Streams, was prepared to discuss the effects of stormwater discharge on the temperature of streams.

6.2 Affected Environment

This section describes the groundwater and surface water environments in the Brightwater project area. The project area is shown in Figure 6-1. Conditions that are common to both systems are presented first, followed by information specific to each system. Information for each system is organized by project component—treatment plant, conveyance corridors, and outfall zones.

6.2.1 Affected Environment Common to All Systems

This section describes water resources in the vicinity of both the Route 9 and Unocal Systems. The regulatory environment is described first, followed by groundwater conditions and surface water conditions. More detailed information is provided in Appendix 6-A, Affected Environment: Surface Water, and Appendix 6-B, Geology and Groundwater.

6.2.1.1 Regulatory Environment Common to All Systems

Activities involving groundwater or surface water are subject to regulatory authority at the federal, state, and local levels. These regulations are summarized below; more detail is included in Appendix 6-A, Affected Environment: Surface Water, and Appendix 6-B, Geology and Groundwater.

Federal Regulations

The Brightwater project is subject to a number of federal laws related to groundwater and surface water. These laws include Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA). Section 10 applies to all work in navigable waters of the United States, which in this case would be construction of the marine outfall in Puget Sound. Section 404 applies to the discharge of dredged or fill material into navigable waters of the United States, including Corps' jurisdictional wetlands. Section 404 would apply to any filling activities associated with the outfall structure; clearing and grading activities in Section 404-regulated wetlands and/or crossing of streams associated with the wastewater treatment plant construction, portal construction, and conveyance pipelines; and filling of stream beds relocated on the treatment plant site. Section 10 and Section 404 are administered by the U.S. Army Corps of Engineers (COE). Other Sections of the CWA that apply to surface waters associated with the Brightwater System include Section 401 (water quality certification) and Section 402 (NPDES permit), which are both administered by Ecology.

The CWA also regulates storage of petroleum products under the Spill Prevention, Control, and Countermeasures (SPCC) regulations (40 CFR 112) if a facility stores or uses more than 1,320 gallons of petroleum products. The quantity includes all drums, tanks, and operating equipment containing 55 gallons or more of petroleum products. The SPCC regulations require that an SPCC plan be developed and that secondary containment be provided for containers and tanks. No secondary containment is required for operating equipment such as transformers.

The Coastal Zone Management Act (CZMA) of 1972, amended in 1990, applies to projects where federal permits are required for work within the 15 coastal counties of Washington State, including King and Snohomish Counties. Ecology administers the CZMA, and reviews programs and projects for consistency with coastal zone management and protection criteria. As amended, the statute requires "any federal activity within or outside of the coastal zone that affects any land or water use of the coastal zone" shall be "consistent to the maximum extent practicable with the enforceable polices" of a state's coastal zone management plan.

The Safe Drinking Water Act authorizes the U.S. Environmental Protection Agency (EPA) to protect aquifers that supply at least half of the drinking water for an area and whose contamination would pose a significant hazard to public health. Such a formation is designated a sole-source aquifer. EPA's authority applies when federal funding is used for a proposed project that might contaminate the aquifer in recharge zones (areas where the aquifer is replenished by rainfall). An aquifer near the Route 9 treatment plant site—the Cross Valley Aquifer—has been granted a sole-source designation. This aquifer is discussed in more detail under Affected Environment: Route 9 System. Although the Brightwater System is not expected to use federal funds, evaluation procedures similar to those of EPA are used by other agencies to ensure aquifer protection.

Federal authority to regulate groundwater and surface water within the project area is also derived from three other major laws (including amendments and reauthorizations):

- National Environmental Policy Act (NEPA)
- Endangered Species Act (ESA)
- "Superfund," known more formally as Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Washington State Regulations

State authority to regulate groundwater and surface water in the project area derives from several sources, including groundwater policies, the federal CWA, the Model Toxics Control Act (MTCA, WAC 173-340), the Water Well Construction Act, water quality standards for surface water (WAC 173-201A), and water quality standards for groundwater (WAC 173-200). The Unocal site in Edmonds is a MTCA site under an Agreed Order with the site owner (Unocal Corporation) for investigation and cleanup. The property occupied by Woody's Auto Wrecking on the southern portion of the Route 9 site is listed on Ecology's Confirmed and Suspected Contaminated Sites List, indicating that investigation under MTCA may be required.

Sediment Standards

Ecology also administers the Washington State Sediment Management Standards (WAC 173-204), which govern the cleanup and disposal of contaminated sediments in the aquatic environment. The Washington State Department of Natural Resources (WA DNR) is involved in characterization and cleanup of contaminated soil and sediments on state-managed aquatic lands. Disposal of excavated sediments, whether contaminated or uncontaminated, is regulated by the Puget Sound Dredged Disposal Analysis program and administered jointly by Ecology, WA DNR, and COE.

Groundwater Rights

The appropriation and beneficial use of groundwater are regulated under the Revised Code of Washington (RCW 90.44, Regulation of Public Ground Waters). In addition, Ecology's Water Resources Program policy (POL-1037) allows Ecology to require formal application for a short-term water use permit in emergencies or for short-term nonrecurring projects of no more than 4 months duration.

Washington requires water rights for all significant groundwater withdrawals (more than 5,000 gallons per day) where water is put to beneficial use. Water rights are not typically required for construction dewatering where water is discharged to an appropriate receiving source. However, in such cases, Ecology can be expected to enforce all regulations related to compensation for measured impairment of neighboring wells or surface water discharge.

Groundwater Quality

Ecology regulates groundwater quality under the Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200). WAC 173-200 lists maximum contaminant concentrations for a wide range of groundwater quality parameters and also provides for an anti-degradation policy that prohibits groundwater contamination.

Water Well Construction

The Water Well Construction Act (chapter 18.104 RCW) is applicable to the Brightwater System as dewatering and monitoring wells are planned during both the construction and operations phases of the project. The Act establishes minimum standards for the construction and decommissioning for all wells in the state of Washington. Wells included under this regulation include all drinking water wells, dewatering wells, resource protection wells (monitoring wells), and abandonment or decommissioning of these wells. Specific regulations in this Act include the Minimum Functional Standards for Construction and Maintenance of Wells (chapter 173-160 WAC) and the Rules and Regulations Governing the Regulation and Licensing of Well Contractors and Operations (chapter 173-162 WAC).

Stormwater

Discharge of stormwater is regulated under the Federal Clean Water Act; regulatory authority for some of the CWA has been delegated to Ecology. The National Pollutant Discharge Elimination System (NPDES) program requires a plan to prevent stormwater pollution and to control erosion, as described in the following subsection. Under Section 402 of the CWA, federal regulations for controlling stormwater from construction sites larger than 1 acre are in place. Guidelines for temporary and permanent stormwater management can be found in Ecology's *Stormwater Management Manual for Western Washington* (Ecology, 2001), referred to in this chapter as the Ecology Manual. If groundwater must be discharged to surface water to allow construction, its surface water discharge is regulated under the NPDES program.

Surface Water Quality

Ecology adopted new water quality standards as of July 1, 2003. These standards are subject to EPA approval. If EPA objects to any portion of the new regulations, revisions could be made by Ecology at a later date. According to Ecology's rulemaking webpage, "The adopted changes to the 2003 rule cannot be used for Federal Clean Water Act actions until the Environmental Protection Agency approves the standards. The estimated time for approval is February 2004. The 1997 standards and criteria should be used as a basis for discussion-making until approval is received." (http://www.ecy.wa.gov/biblu/wac/17321a.hmtl.) The new standards reflect a use-based system for designating beneficial uses of fresh water. The old standards were class based, by which water bodies were assigned to classes with a prescribed set of beneficial uses. Under the new system for designating beneficial uses, all freshwater bodies in the Brightwater project area are designated for salmon and trout spawning, core rearing,[1] and migration; extraordinary primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values. Marine water bodies (Puget Sound) are designated for extraordinary aquatic life uses, shellfish harvest, primary contact recreation, wildlife habitat, harvesting, commerce and navigation, boating, and aesthetic values. See Appendix 6-A, Affected Environment: Surface Water, for a more detailed comparison of the current and proposed water quality standards.

Ecology is also responsible for identifying waters that do not meet applicable standards and for developing a plan to limit pollutant loads by adopting total maximum daily loads (TMDLs); this responsibility arises from Section 303(d) of the CWA. The list of such impaired waters is known as the "303(d) list" (Ecology, 2003). A list of water bodies in the Brightwater project area that are included on the 303(d) list is provided in Table 6-1.

Table 6-1. Water Bodies in the Brightwater Project Area That Are Included on the 303(d) List

Water Body	Parameter
Lake Washington	Fecal coliform bacteria
Little Bear Creek	Fecal coliform bacteria
Lyon Creek	Fecal coliform bacteria
McAleer Creek	Fecal coliform bacteria
North Creek	Fecal coliform bacteria, dissolved oxygen
Sammamish River	Fecal coliform bacteria, temperature, dissolved oxygen, pH
Swamp Creek	Fecal coliform bacteria, Dissolved oxygen

[1] The new standards distinguish core rearing from noncore rearing for freshwaters having different densities of salmon and trout under current and predevelopment conditions. Core rearing is associated with high densities of a population that are using waters that are within their optimal thermal range, usually in the middle to upper reaches of a water body. Noncore rearing is associated with low densities of a population that are using waters that are higher than their optimal thermal range, usually in the middle to lower reaches of a water body.

Ecology was delegated authority by EPA under Section 402 of the CWA to administer NPDES permits for wastewater discharge to surface waters during operation. Such permits may include limits on quantity and quality of discharge, as well as requirements for monitoring the effluent and its receiving water. Refer to Appendix 3-A, Project Description: Treatment Plant, for a discussion of wastewater discharge requirements.

Dewatering Activities

During project construction and operation, water can collect at low points onsite. This water can be either runoff from other portions of the site or groundwater. It often must be removed to continue with the activity being carried out at the site. This removal process is called dewatering. Dewatering flows that are directly or indirectly discharged to waters of the state are subject to State Water Quality Standards and discharge guidelines established by Ecology through NPDES permits, and outlined in the Ecology Manual. Dewatering groundwater discharged to surface waters must meet applicable water quality standards in the receiving water body. In addition, Ecology generally requires a hydrologic study when the dewatering groundwater discharge rate has the potential to exceed 10 percent of the flow rate of the receiving water body at the time of discharge. This hydrologic study must demonstrate that the creek and its water quality, channel morphology, or aquatic biota would not be harmed by a higher discharge rate.

Aquatic Lands

Washington Department of Natural Resources (WA DNR) is responsible for managing publicly owned aquatic lands, and grants use authorizations (easements or leases) for uses such as wastewater outfalls and stream crossings that affect public use of state-owned aquatic lands. As part of its easement authorization process, WA DNR evaluates impacts to aquatic lands. Aquatic lands are defined in 79.90.10 RCW as "all state owned tidelands, shorelands, harbor areas, and the beds of navigable waters." WA DNR-managed aquatic lands potentially impacted by this project include the Sammamish River and Puget Sound.

State Hydraulic Code

Under the State Hydraulic Code (RCW 75.20.100-160), any person, organization, or government agency wishing to conduct any construction activity in or near state waters must do so under the terms of a Hydraulic Project Approval (HPA) issued by the Washington State Department of Fish and Wildlife. State waters include all marine waters and fresh waters of the state.

The major types of activities in fresh water requiring an HPA include, but are not limited to, streambank protection; construction of bridges, piers, and docks; pile driving; channel change or realignment; conduit (pipeline) crossing; culvert installation; dredging; gravel removal; pond construction; placement of outfall structures; log, log jam, or debris removal; installation or maintenance (with equipment) of water diversions; and mineral prospecting.

Major saltwater activities requiring an HPA include construction of bulkheads, fills, boat launches, piers, dry docks, artificial reefs, dock floats, and marinas; placement of utility lines; pile driving; and dredging.

Local Regulations

Local jurisdictions, including King and Snohomish Counties, require review for work in or near identified sensitive or critical areas, such as streams and wetlands, prior to granting project permits. The resource must be evaluated, its value classified, and the project impacts assessed. Generally, development activities are restricted from occurring within streams and their locally designated buffers, although minor modifications may be allowed if compensated for by approved mitigation measures. Every city in the Brightwater project area requires such review (see Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites). Local jurisdictions in the project area also require management of stormwater during and after construction. Refer to Appendices 6-A, Affected Environment: Surface Water, and 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites, for more information on critical areas and stormwater requirements.

6.2.1.2 Regional Groundwater Conditions Common to All Systems

Aquifers and Aquitards

The geologic deposits in the region, as described in Chapter 4 and Appendix 6-B, Geology and Groundwater, form a sequence of aquifers and aquitards that vary in thickness and lateral continuity. Aquifers are generally granular water-bearing sediments through which groundwater flows, whereas aquitards are finer-grained sediments that inhibit water flow. The generalized occurrence of aquifers is shown in regional-scale cross-sections in Appendix 6-B. The following deposits constitute the primary aquifers and aquitards in the project area:

- **Recent Alluvium and Vashon Recessional Outwash Aquifers (Qal and Qvr Aquifers).** Recent Alluvium and Vashon Recessional Outwash deposits, where saturated, form the uppermost aquifers in the project area. Recessional outwash deposits are present as a thin mantle in upland areas and locally as thicker units in stream valleys. Groundwater generally occurs in both the Recent Alluvium and Vashon Recessional Outwash under unconfined (water table) conditions and is in hydraulic continuity with adjacent surface water features.
- **Vashon Till Aquitard (Qvt Aquitard).** Variable thicknesses of Vashon Till commonly cap uplands in the project area. The till typically has a very low

permeability and acts as a regional aquitard. Locally perched groundwater conditions develop seasonally on top of and within the till in areas of low topographic relief.

- **Vashon Advance Outwash Aquifer (Qva Aquifer).** The Qva Aquifer is the first regional aquifer occurring stratigraphically beneath the till. The Advance Outwash deposits form an extensive and laterally continuous aquifer in the project area. It is only absent within some of the major drainages, as shown in Appendix 6-B, Geology and Groundwater. Groundwater within the Qva Aquifer generally occurs under unconfined conditions, except along the edges of uplands where it may be confined beneath Vashon Till. Spring seepage commonly emerges from the base of the outwash where it is in contact with underlying Lawton Clay or other aquitards.
- **Vashon Lawton Clay Aquitard (Qvlc Aquitard).** Beneath the Advance Outwash, fine-grained lacustrine deposits occur locally and act as a confining layer separating the Qva Aquifer from deeper water-bearing zones in the undifferentiated pre-Fraser deposits.
- **Pre-Fraser Undifferentiated Aquifers and Aquitards (Qu Aquifers and Aquitards).** Multiple water-bearing zones occur within the pre-Fraser deposits in granular fluvial deposits of both glacial and nonglacial origin. These water-bearing zones, termed Qu Aquifers for purposes of this EIS, generally occur under confined conditions. Other units within the undifferentiated pre-Fraser deposits include till, lacustrine, and marine deposits that are typically fine grained in texture. These units act as confining beds and are termed Qu Aquitards.

Groundwater Recharge and Flow

Groundwater flow through the area is initiated by recharge infiltrating the ground in upland areas and moving downward until reaching the uppermost regional aquifer, typically the Qva Aquifer. Groundwater in this aquifer moves horizontally and discharges through spring flow or seepage on exposed slopes (for example, near Puget Sound) or into the alluvium and Recessional Outwash deposits in stream channels (such as North Creek and Swamp Creek). A portion of groundwater in the Qva Aquifer also flows downward through the underlying Lawton Clay aquitard and other intervening confining beds into the Qu Aquifers. Groundwater in the Qu Aquifer eventually discharges into Puget Sound or Lake Washington.

A regional-scale groundwater elevation contour and flow map for the Brightwater System project area was developed for the Qva Aquifer (see Appendix 6-B, Geology and Groundwater). The map shows groundwater recharge mounds in a broad band north and east of the conveyance alignments across the center of the plateau bounded by Puget Sound, Lake Washington, and the Snohomish River. Groundwater flow radiates outward from the central upland toward each of the regional discharge features. This regional pattern generally produces southerly groundwater flow (toward the Lake Washington basin) in the eastern two-thirds of the area and westerly flow (toward Puget Sound) in the area west of Lake Ballinger. Flow patterns are expected to be similar in the Qu Aquifers, as indicated by a general decline in groundwater elevations in this zone toward Puget Sound and Lake Washington.

The cross-sections in Appendix 6-B, Geology and Groundwater, also show the potential for downward flow, as indicated by typically higher groundwater elevations in the Qva Aquifer than in the Qu Aquifers. Some reversal of these gradients is present near and within primary drainages in the project area, indicating the potential for upward flow in the stream valleys and the potential for artesian flow from wells installed in these areas.

The data also indicate that the Brightwater System project area acts somewhat like a freshwater island in that most of the groundwater movement through the area down to near sea level comes from direct precipitation. There is no significant surface water run-on from other basins, nor does deep flow from other groundwater basins or from higher areas to the east appear to contribute significantly.

Groundwater Interaction with Surface Water

Groundwater and surface water interact locally in response to area-specific hydrogeologic conditions. The highest degree of connection is present in valleys where perennial streams flow through areas of permeable alluvium and/or Recessional Outwash deposits (Qal/Qvr Aquifer). Groundwater in these aquifers discharges to streams throughout the year, as indicated both by stream base flow that occurs during dry summer months and by groundwater elevations that are typically higher than stream-stage elevations. In most areas, the subterranean groundwater discharge to streams is not visible. However, in others, streams originate at springs or emerge from a creek bed where the bed intersects the water table surface. Examples include Deer Creek and Shelleberger Creek, both situated along the western bluff abutting Puget Sound and both of which represent intersection of the land surface with the Qva Aquifer water table. Another example is North Creek, which during the summer emerges from the stream bed approximately 6 miles north of its confluence with the Sammamish River.

Groundwater Quality

Groundwater quality in the greater Brightwater System project area is generally good and has no widespread contamination issues, as reported in the United States Geological Survey (USGS) study on groundwater systems and quality in western Snohomish County (Thomas et al., 1997). The USGS study also notes the potential for chemicals released from various human activities to locally impact groundwater quality, but does not draw regional-scale conclusions regarding this issue. According to a Draft Hazardous Waste Technical Memorandum (HWTM) prepared for the Brightwater System project in 2002 (King County, 2002d), no major sources of contamination (for example, Superfund sites or landfills) were identified along the conveyance corridors or at portal siting areas. However, the HWTM noted that there was a potential for groundwater contamination at various locations based on Washington State Department of Ecology (Ecology) records of sites undergoing cleanup. Contaminated sites are most likely to be present in areas with commercial or industrial development. The Route 9 site, the Unocal site, and the Chevron Richmond Beach Asphalt Terminal property are the largest individual industrial properties on or adjacent to the alternative conveyance corridors. Each property has documented or suspected soil and groundwater contamination as described later in this chapter.

Groundwater Use

Although individual domestic wells are present in the vicinity of the conveyance corridors, most of the population in the project area is served by public water systems. In particular, three relatively large public water supply systems depend on groundwater for all or a portion of their drinking water supply: the Cross Valley Water District (CVWD), Olympic View Water and Sewer District, and Lake Forest Park Water District. Commercial users are also present. For example, the Holyrood Cemetery draws its irrigation water from wells just south of the Unocal and Route 9–195th Street conveyance corridors.

6.2.1.3 Regional Surface Water Conditions Common to All Systems

The Brightwater project area is situated within the 692-square-mile Cedar River-Sammamish watershed. This watershed is designated as Water Resource Inventory Area (WRIA) 8 (WDF, 1975), which includes all land draining to Lake Washington. A small portion of the project area drains directly into Puget Sound. Land in WRIA 8 is largely forested (45 percent), but also includes urban (31 percent), water (15 percent), rangeland (5 percent), agricultural (1 percent), and other uses (3 percent) (Ecology, 2000).

The project area falls within several basins of WRIA 8:

- All creeks in the Brightwater project area drain to the Sammamish River, Lake Washington, or Puget Sound.
- The Little Bear Creek, North Creek, and Swamp Creek basins drain into the Sammamish River, which in turn drains into Lake Washington.
- The Lyon Creek and McAleer Creek basins drain directly into Lake Washington.
- Hall Creek drains to Lake Ballinger (which is the headwaters of McAleer Creek in Mountlake Terrace).
- The Willow Creek (in Edmonds), Barnacle Creek (in Shoreline), and Storm Creek (in Shoreline) basins drain directly into Puget Sound.

Descriptions of the Sammamish River, Lake Washington, and Puget Sound can be found below. Detailed water quality and discharge information for freshwater bodies is provided in Appendix 6-A, Affected Environment: Surface Water.

Sammamish River

The Sammamish River is approximately 13.8 miles long and flows north and west from Lake Sammamish before it enters the northeast end of Lake Washington at the City of Kenmore. The river is the outlet of Lake Sammamish. Water quality data were collected upriver at Bothell by Ecology (1959 to 1999) and at Kenmore, near the mouth of the river, by King County (1979 to 1999). From 1959 through 1999, the average wet-season flow of the Sammamish River at Bothell was 594 cubic feet per second (cfs); the corresponding average dry-season flow was 165 cfs (Ecology, 2002).

Water quality near the river's mouth at Lake Washington is degraded by warm temperatures, high fecal coliform bacteria concentrations, high turbidity, suspended solids, and low dissolved oxygen concentrations. The Sammamish River is on the 1998 CWA 303(d) list for fecal coliform bacteria, dissolved oxygen, and temperature. In samples collected from 1979 through 1999 by King County, water temperature, fecal coliform bacteria, and dissolved oxygen did not meet applicable water quality standards. At Kenmore, the high water temperatures can be attributed to the wide channel, sluggish current, and lack of riparian vegetation. These are the primary causes of substandard dissolved oxygen concentrations (King County, 2002d). King County water quality data and other data collected for the Sammamish River are summarized in Appendix 6-A, Affected Environment: Surface Water.

Lake Washington

Lake Washington is the largest lake in King County. It has a drainage area of 472 square miles and a surface area of 21,500 acres. The overall water quality of Lake Washington is good, and the lake is characterized as mesotrophic (having moderate transparency and moderate levels of nutrients and algae) (King County, 2002b).

King County collects data at several Lake Washington water quality stations, including one located near Kenmore and the mouth of the Sammamish River. Recent data (King County, 2002d) indicate good water quality in that vicinity (moderate levels of nutrients that are similar to levels in other areas of the lake). Although parts of Lake Washington are on the CWA 303(d) list (1998) for fecal coliform bacteria, the Kenmore station meets water quality standards for fecal coliform bacteria.

6.2.1.4 Puget Sound Conditions

Puget Sound is a deep, glacially carved, fjord-like estuary that connects to the Strait of Juan de Fuca through Admiralty Inlet and Deception Pass. It extends approximately 140 miles in a north-south direction, reaches a maximum depth of greater than 850 feet, and is characterized by a series of relatively deep basins separated by shallower sills. The Strait of Juan de Fuca opens into the north Pacific Ocean between Washington State and Vancouver Island in Canada. The tidal pattern of Puget Sound is dominated by a mixed semidiurnal tidal cycle, characterized by two unequal high tides and two unequal low tides each day, with a large tidal exchange averaging between 12 and 14 feet. The two alternative outfall zones (Zones 6 and 7S) are located between Richmond Beach and Edwards Point in Edmonds in the northern portion of Puget Sound's Central Basin (Figure 6-2). This area of Puget Sound is called the Triple Junction region. In the Triple junction region, Admiralty Inlet and Possession Sound join the Central Basin at the southern end of Whidbey Island. Water circulation within both outfall zones is generally similar.

Water Circulation in Puget Sound

King County conducted extensive oceanographic investigations to add to the understanding of water movement in Puget Sound (Ebbesmeyer et al., 2002). Currents in the Triple Junction region are complex and are affected by a number of factors: tidal exchange two times each day, winds, freshwater input from river flow, and bathymetry. The mean spring tidal range at Edmonds is 10.91 feet (NOAA, 2000). During incoming tides, water flows over shallow sills through Admiralty Inlet south into the Central Basin and also north through Possession Sound into the Whidbey Basin. During outgoing tides, currents from the Central Basin and Possession Sound converge as they enter Admiralty Inlet. Relative to the rest of the Central Basin, the complex and irregular bathymetry of the seafloor in this area creates more intense flood (inflowing) currents along the western shore between Kingston and Point No Point and more intense ebb (outflowing) currents between Richmond Beach and Edmonds. Typical tidal current speeds offshore of Edmonds and Point Wells are 1 foot per second (0.6 knot).

Tidal currents, combined with inflowing water, form a mean southward current along the western shore of the Central Basin (Kitsap County); this current extends from near the surface to the bottom. Along the eastern shore of the Central Basin (King and Snohomish Counties), the mean current flows north between the surface and a depth of approximately 360 feet, but flows south below 360 feet.

Puget Sound exhibits typical estuarine behavior, with the inflow of denser saline oceanic water at depth and outflow of less-dense brackish water at the surface. The depth at which this transition of flow occurs depends on numerous factors, including the amount of freshwater runoff. Brackish water is formed at the surface as rivers discharge fresh water to Puget Sound.

In the Triple Junction region, winds create complex current patterns because they reinforce surface flow in some locations and oppose it in others. The wind-induced surface currents create an opposing current at depth; for example, a wind blowing from the south induces a northward flow at the surface and a southward flow at depth.

The complex and irregular shape of the seafloor in this region creates significant variations in tidal currents. Above Whidbey Shoal (at the southern tip of Whidbey Island), flood currents generally flow into Puget Sound from Admiralty Inlet and diverge along the eastern shoreline offshore of Browns Bay. North of this divergence, currents flow into Possession Sound and south into the Central Basin. Ebb currents act similarly in the reverse direction. At depths below about 100 feet, flood and ebb currents flow around Whidbey Shoal; the location of their divergence or convergence is further south, offshore of Edmonds.

The complex pattern of currents in the Triple Junction region is anticipated to provide dispersion and mixing for effluent discharged into either Zone 6 or Zone 7S. In either outfall zone, the effluent plume is likely to be trapped in the lower portion of the water column and would follow the ambient currents and estuarine circulation at these depths. Thus, the discharged effluent would be carried further into Puget Sound or Possession Sound before it is mixed into shallower water depths and carried out of Puget Sound with the estuarine flow.

Water and Sediment Quality in Puget Sound

King County (2001) studied physical, chemical, and microbiological aspects of water quality in offshore waters and intertidal or beach areas of Puget Sound. Temperature, salinity, and density measurements indicated a well-mixed water column through most of the year, with some thermal stratification evident during the summer. Annually, water temperatures peaked between July and August at beach stations and between August and September at offshore stations. Peak summer temperatures ranged between 15 and 16 degrees Celsius in the offshore water column and between 16 and 19 degrees Celsius in intertidal waters. Salinities near the surface of Possession Sound were lower than in other areas due to the freshwater input of the Snohomish River.

At all stations in the vicinity of the alternative outfall zones, dissolved oxygen concentrations were above the minimum standard of 5.0 milligrams per liter (mg/L) (King County, 2001a). This is Ecology's (1998) level of potential concern for aquatic organisms. Concentrations as low as 4.5 mg/L were measured at depth in Possession Sound and mid-channel in the Central Basin (King County, 2001a). Although the previously applicable Class AA standard and the new extraordinary aquatic life and shellfish harvest uses prescribed for dissolved oxygen in the marine environment is 7.0 mg/L, Ecology acknowledges that natural conditions (such as upwelled oceanic water) can cause dissolved oxygen levels to fall below the standard, especially at depth. Therefore, the areas of low dissolved oxygen in the Central Basin are not listed on the State 303(d) list as impaired. However, Possession Sound is considered impaired and is listed on the 1998 303(d) list for dissolved oxygen.

Although varying seasonally, all ammonia concentrations for intertidal water stations and offshore water column stations, including those near the outfall zones, were well below the EPA acute and chronic ammonia criteria for marine waters (EPA, 1989). These criteria are based on total ammonia and are dependent on temperature, salinity, and pH. The acute ammonia criterion ranges from 1.3 to 200 mg/L based on corresponding temperature, salinity, and pH ranges; the chronic criterion ranges from 0.2 to 30 mg/L. Chlorophyll-a (a measure of phytoplankton concentration) and nutrient concentrations showed classic patterns of seasonal nutrient uptake and primary production. Nutrient concentrations in the water column are high during the winter months and decrease as the spring plankton bloom intensifies. As the spring bloom dies out, nutrient concentrations again increase until the summer plankton bloom begins. After the summer bloom terminates, the nutrient levels return to the winter levels and the cycle begins again.

Concentrations of metals detected in both offshore water column samples and intertidal water samples were below applicable acute and chronic state water quality criteria. A summary of metal concentrations for all Puget Sound sampling stations, including those near the two alternative outfall zones, is provided in Table 6-2. Neither Washington State nor federal water quality criteria have been set for antimony, chromium, cobalt, silver (chronic), thallium, and vanadium.

A total of 23 out of 108 organic compounds measured were detected one or more times in both the offshore water column and intertidal water samples. These organic compounds include several phthalates (which are plasticizers that are ubiquitous in the environment), polynuclear aromatic hydrocarbons (PAHs), and other semivolatile compounds. Neither Washington State nor federal agencies have promulgated marine water quality criteria for any of the organic compounds detected in this study (King County, 2001a; Parametrix and Intertox, 2002). Pesticides, herbicides, and polychlorinated biphenyls (PCBs) were not detected in any offshore water column or intertidal water samples (King County, 2001a).

All offshore water column stations in the Central Basin of Puget Sound met the previous Washington State Class AA marine surface water standard and the proposed Ecology standards for fecal coliform bacteria. Fecal coliform bacteria were seldom detected in offshore waters and, when detected, were generally at very low concentrations, rarely greater than 3 colony forming units (CFU) per 100 mL. At intertidal stations, however, the influence of freshwater runoff from the surrounding watersheds was evident. The number of stations that did not meet the Class AA marine standard (14 CFU per 100 mL) increased during the high rainfall months and at stations closer to freshwater sources (King County, 2001a). A summary of recent fecal coliform monitoring data for intertidal areas in the vicinity of the two alternative outfall zones is provided in Table 6-3. For monitoring years 2000 through 2002, the sampling stations at both Edwards Point and

Point Wells met both parts of the standard: a geometric mean of 14 CFU per 100 mL and not more than 10 percent of samples used to calculate the geometric mean having a value greater than 43 CFU per 100 mL.

Table 6-2. Puget Sound Offshore Water Column and Intertidal Metals Concentrations Compared to Washington State Water Quality Criteria

	Concentration (µg/L)			Marine Water Quality Criterion[b]	
Metal[a]	Minimum	Maximum	Mean	Acute (µg/L)	Chronic (µg/L)
Offshore Water					
Antimony	0.027	0.134	0.083	*	*
Arsenic	0.86	1.37	1.12	69.0	36.0
Cadmium	0.0346	0.0773	0.0634	42.0	9.3
Chromium	< 0.04 (MDL)	0.36	0.13	*	*
Cobalt	0.007	0.050	0.020	*	*
Copper	0.255	0.573	0.348	4.8	3.1
Lead	< 0.005 (MDL)	0.031	0.007	210.0	8.1
Mercury[c]	0.00014	0.00199	0.00034	1.8	0.025[d]
Nickel	0.357	0.660	0.414	74.0	8.2
Selenium	< 0.15 (MDL)	< 0.15 (MDL)	< 0.15 (MDL)	290	71.0
Silver	< 0.06 (MDL)	< 0.06 (MDL)	< 0.06 (MDL)	1.9	*
Thallium	0.008	0.013	0.010	*	*
Vanadium	1.07	1.55	1.37	*	*
Zinc[e]	0.25	1.21	0.51	95[d]	86[d]
Intertidal Water					
Antimony	0.042	0.112	0.075	*	*
Arsenic	0.70	1.28	1.04	69.0	36.0
Cadmium	0.0359	0.0732	0.0622	42.0	9.3
Chromium	0.09	0.16	0.12	*	*
Cobalt	0.0140	0.0768	0.0218	*	*
Copper	0.291	2.730	0.375	4.8	3.1
Lead	< 0.005 (MDL)	0.042	0.009	210.0	8.1
Mercury[c]	< 0.00010 (MDL)	0.00508	0.00070	1.8	0.025[d]
Nickel	0.330	0.774	0.400	74.0	8.2
Selenium	< 0.15 (MDL)	< 0.15 (MDL)	< 0.15 (MDL)	290	71.0
Silver	< 0.06 (MDL)	< 0.06 (MDL)	< 0.06 (MDL)	1.9	*
Thallium	0.007	0.011	0.010	*	*
Vanadium	0.91	1.85	1.34	*	*
Zinc[e]	0.51	8.09	1.10	95[d]	86[d]

[a] Dissolved concentrations are reported for all metals except mercury and zinc.
[b] Water quality criteria from WAC 173-201A (Ecology, 1997). Criteria are for dissolved metals except as noted.
[c] Total mercury concentrations reported for comparison to marine chronic criterion.
[d] Criterion is for total metals.
[e] Total zinc concentrations are reported because of repeated quality control failures in dissolved zinc analysis.
µg/L = Micrograms per liter.
<#(MDL) = Metal was not detected at or above the associated numeric method detection limit.
* = No state (or federal) criterion.

Table 6-3. Fecal Coliform Geometric Means and Peak Concentrations at Edwards Point (Zone 6) and Point Wells (Zone 7S) – 2000 through 2002

	Edwards Point	Point Wells
No. of samples	34	35
Geometric mean	6.8 CFU/100 mL	4.1 CFU/100 mL
Peak value	1,600 CFU/100 mL	36 CFU/100 mL
No. of samples > 43 CFU/100 mL	2 (5.9% of samples)	0 (0% of samples)

Sediment quality and benthic/epibenthic community structure in the two alternative outfall zones were evaluated to establish baseline conditions prior to operation of the outfall and to identify any contamination issues that would need to be addressed prior to and during construction activities (King County, 2001b). The analysis indicated that sediment quality is similar between the two alternative outfall zones. Small variations in physical properties, such as grain size distribution and organic carbon content, appeared to be associated with the depth of the sampling location. Sediment concentrations of trace metals and organic compounds met all applicable sediment regulatory and guidance criteria at every sampling location. Slightly elevated concentrations of some trace metals and organic compounds, relative to other locations, were detected at two nearshore sampling locations north of Zone 7S and may be associated with a stormwater outfall on the north side of Point Wells.

The benthic/epibenthic community structure was also very similar between the potential diffuser locations in the two zones. Both zones are almost completely dominated by *Macoma carlottensis*, a small clam. This community structure is similar to other locations in Puget Sound with deep muddy, clayey sediments such as those found in outfall Zones 6 and 7S (Lie, 1974; Llanso et al., 1998; Nichols, 1988 and 2001).

6.2.2 Affected Environment: Route 9 System

6.2.2.1 Treatment Plant: Route 9

Groundwater Conditions: Route 9 Treatment Plant

Characterization of groundwater occurrence and flow in the vicinity of the Route 9 site is based on the regional system described in Regional Groundwater Conditions Common to All Systems, but has been modified based on site-specific data. The site-specific data include 11 onsite geotechnical borings with piezometers drilled for the Brightwater project; 10 onsite borings drilled for site characterization prior to the Brightwater project; well logs from the conveyance routes; numerous well logs from Ecology and the Seattle

Area Geologic Mapping Project (SGMP, 2003); and published area groundwater studies (Golder Associates, 2000; Thomas et al., 1997). Detailed descriptions of groundwater issues and the geologic units discussed below are provided in Appendix 6-B, Geology and Groundwater. See Chapter 4 for descriptions of the geologic deposits in which project area aquifers occur.

Groundwater in the vicinity of the Route 9 site can be considered as occurring in three main aquifers. Groundwater is also present in less permeable deposits, but the permeability of these deposits (the rate at which groundwater can flow through them) is orders of magnitude lower than for the three aquifers. These aquifers are as follows:

1. **The Shallow Unconfined Aquifer**, at the ground surface of the Route 9 site, consisting of groundwater in alluvium, fill, and Vashon Recessional Outwash deposits at the site (similar to the Qal and Qvr Aquifers discussed under Affected Environment Common to All Systems)

2. **The Vashon Advance Outwash (Qva) Aquifer,** not present at the Route 9 site, but located up-gradient and to the east of the site, is partially confined

3. **The Undifferentiated Pre-Fraser (Qu) Aquifers,** consisting of older coarse-grained glacial and nonglacial fluvial deposits generally more than 100 feet below ground surface that are present beneath the site and are believed to extend several miles around the site

The locations of the three aquifers are shown in the schematic cross-section in Figure 6-3.

Shallow Unconfined Aquifer

Groundwater levels in the Shallow Unconfined Aquifer located at the Route 9 site are typically 10 feet or less below ground surface (bgs). It is estimated that the overall permeability of the aquifer is moderate to high. Flow generally follows the ground contours, moving west-southwest across the site. Flow to the Shallow Unconfined Aquifer is believed to originate primarily from surface infiltration and leakage from the Vashon Advance Outwash Aquifer located up-gradient to the east of the site. In the immediate vicinity of Little Bear Creek and the other minor streams in the area, high stream flows may contribute minor amounts of groundwater to the Shallow Unconfined Aquifer, but flow is typically from the aquifer into Little Bear Creek.

Vashon Advance Outwash (Qva) Aquifer

The Qva Aquifer has previously been characterized by other investigators as a deposit generally 100 to 250 feet thick, underlying a till cap, ranging all across the uplands to the east of the Route 9 site, and referred to as the Cross Valley Aquifer (Golder Associates, 2000). Recent borings at the Route 9 site indicates that this Qva Aquifer is not present at the Route 9 site (see Figure 4-2 in Appendix 6-B). Also, reevaluation of the Cross Valley Water District (CVWD) well logs suggest that the Vashon Advance Outwash may be a thinner deposit, typically 50 to 100 feet thick. The permeability of this deposit is relatively high. Although there appear to be several water supply wells in the Vashon Advance Outwash in the upgradient areas to the east of the site, it now appears that the high-production wells, especially many of those supplying the CVWD, draw water from deeper, older deposits that are separated from the Vashon Advance Outwash by less permeable deposits of silt, clay, and silty or clayey sand (Figure 6-3).

Pre-Fraser (Qu) Aquifers

Pre-Fraser, highly permeable, coarse-grained glacial deposits were encountered at 100 to 150 feet bgs in one deep boring at the Route 9 site. A piezometer in this deposit has measured artesian heads[2] 15 feet above the ground surface at the boring location. The permeability of the material is relatively high. In the lower (western) portions of the site, this aquifer is believed to have greater groundwater pressure heads than the overlying Shallow Unconfined Aquifer. Low-permeability deposits separate the Qu Aquifers from the Shallow Unconfined Aquifer, where most of the treatment plant structures would be located.

Many of the CVWD's deep water supply wells east of the Route 9 site appear to draw water from pre-Fraser coarse-grained glacial or nonglacial fluvial deposits, referred to as the Cross Valley Aquifer. It is believed that the deep, highly permeable aquifer at the Route 9 site is either the same geologic unit as the high-productivity Cross Valley Aquifer to the east or is hydraulically connected to the Cross Valley Aquifer. This belief is based on material descriptions and the artesian head in this aquifer at the site.

Water Supply Wells: Route 9 Treatment Plant

The Route 9 site lies outside and immediately west of CVWD's wellhead protection area and overlaps CVWD's sole-source aquifer boundary (Figure 6-4). The CVWD supplies water to residents, businesses, and public schools in the vicinity of the Route 9 site. Approximately 89 percent of the water is from groundwater sources. Additional sources of drinking water for this area are under development through the Clearview Pipeline Project. The CVWD is participating in the Clearview project, and the distribution of its water supply sources may change within the next few years. Further information about CVWD may be found in Appendix 6-B, Geology and Groundwater.

The CVWD has 10 water supply wells that serve 4,430 connections. Well locations are shown in Figure 6-4. The capacity of the 10 wells is 2.4 million gallons per day (mgd). The closest CVWD water supply well to the Route 9 site is the Woodlane well,

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[2] Artesian groundwaters are groundwaters where the water is confined under pressure by less permeable formations and the potential energy of the water, or "head," is above the ground surface. When artesian groundwaters are intercepted during well drilling or other excavation, they are forced upward by pressure above the surface of the ground.

approximately 3,000 feet east of and upgradient from the site. The other nine wells are also upgradient. Water districts are required to enact measures within their wellhead protection areas to minimize threats to the water supply from potential contaminant sources. The CVWD has mapped and modeled wellhead protection zones for each of its water supply wells, also shown in Figure 6-4. The wellhead protection zones define areas from which water travels to each well or well cluster during pumping over periods of 1, 5, and 10 years. The 10-year zones for the CVWD wells are shown in Figure 6-4.

Three other water districts serve residents and businesses in the vicinity of the site: the Alderwood Water District, the Silver Lake Water District, and the Woodinville Water District. Groundwater does not serve as a source for any of these water districts. The City of Woodinville installed two water supply wells in 1994 but did not obtain a water right to use them for municipal supply. The two wells are approximately 2 miles southeast (cross-gradient) of the site, and the city maintains them for emergency use only.

Figure 6-5 shows the number of water supply wells (documented in Ecology files) in the vicinity of the Route 9 site. None of the wells in the immediate neighborhood of the site appear to draw from the Shallow Unconfined Aquifer.

Surface Water Conditions: Route 9 Treatment Plant

The Route 9 treatment plant site is located in the Little Bear Creek basin, a tributary to the Sammamish River. Little Bear Creek flows parallel to the west side of the Route 9 site and is separated from the site by SR-9. Figure 6-6 illustrates surface water conditions at the site. Three streams—Howell Creek, 228th Street Creek, and Unnamed Creek—are situated onsite. These three streams flow from the site directly to Little Bear Creek via culverts under SR-9. The site also includes a recently constructed fish-rearing pond within the 228th Street Creek subbasin. Six fully or partially piped watercourses (Watercourses 3 through 8) convey surface water through and from the site. A seventh watercourse (Watercourse 9) is a small tributary to Unnamed Creek. The number of watercourses has been revised since the Draft EIS, following additional site-specific evaluation at the Route 9 site. Three watercourses identified in the Draft EIS are now characterized as tributaries to the three onsite streams. All of the watercourses are tributary to Little Bear Creek. More information on the streams discussed in this section can be found in Appendix 6-E, Route 9 Site Runoff Effects on the Geomorphology of Little Bear Creek.

Little Bear Creek

Little Bear Creek is approximately 7.4 miles long and drains a basin of 15 square miles. It begins southeast of the City of Everett, flows south to approximately the Route 9 site and then flows southwest to discharge into the Sammamish River at river mile (RM) 5.4. The headwaters and upper 5.6 miles of Little Bear Creek are in Snohomish County. The lower 1.8 miles and mouth of the stream are in the City of Woodinville in King County.

Little Bear Creek is separated from the Route 9 site by SR-9 and properties along the west side of SR- 9.

Little Bear Creek is categorized under two classification systems, depending on the land use regulations of local jurisdictions. The lower 1.8 miles of Little Bear Creek lies within Woodinville and is regulated under its land use code. Upstream of Woodinville, Little Bear Creek is in unincorporated Snohomish County and is subject to Snohomish County land use regulations. The City of Woodinville uses a three-tier stream classification system. Snohomish County's stream classification system is similar to the state's interim five-tier water typing criteria (WAC 222-16-031). Little Bear Creek is identified as a shoreline of statewide significance for approximately 0.25 mile upstream from its mouth (WAC 173-18-210). This reach is categorized as a Class 1 stream under the City of Woodinville land use code. From this point upstream to the city limits, Little Bear Creek is categorized as a Class 2 stream under the City of Woodinville code. Within Snohomish County in proximity to the Route 9 site, the stream is classified as a Type 2 stream for the purpose of administering local (Snohomish County) critical areas regulations.

WA DNR is in the process of revising its stream typing system to three types. Once mapping is completed, it is anticipated that the lower 0.5 mile of Little Bear Creek would be classified as a Type S stream (replacing the Type 1 stream designation). The remaining length upstream to its headwaters would be classified as a Type F stream (replacing the Type 2 and 3 stream designations).

For purposes of water pollution control, Washington State rates Little Bear Creek and its tributaries as Class AA water bodies (WAC 173-201A, using the existing standards). Using the new standards proposed by Ecology, Little Bear Creek and its tributaries are designated for salmon and trout spawning, core rearing, migration; and extraordinary primary contact recreation. King and Snohomish Counties have collected water quality and discharge data for Little Bear Creek for years. Despite results that vary by location and year, several trends have been observed:

- Flow near the mouth of Little Bear Creek have ranged from about 3 to 260 cfs, with an average discharge of about 20 cfs (Bouchard, 2002). Flow in Little Bear Creek is influenced by stormwater runoff from numerous developed areas.
- Temperature has increased, although King County samples have met state water quality standards more than 90 percent of the time.
- Conductivity has increased, likely due to cumulative impacts of urbanization throughout the Little Bear Creek basin. There is no state water quality standard for conductivity; however, conductivity is useful for characterizing overall water quality.
- Fecal coliform bacteria counts have declined, perhaps because the number of livestock and hobby farms in the watershed has declined. However, the creek consistently has not met state water quality standards for fecal coliform bacteria.

- Dissolved oxygen levels do not always meet state standards, a condition that might be expected given the observed high water temperatures and high nutrient concentrations, both of which affect dissolved oxygen concentrations.
- Benthic invertebrate index scores for Little Bear Creek at and adjacent to the Route 9 treatment plant site ranged from “very poor” in 1994 to “fair” in 2000.

Little Bear Creek is listed on the 1998 CWA 303(d) list for fecal coliform bacteria at three locations. To date, Ecology has not initiated any TMDL study or basin action plan for Little Bear Creek.

Streams and Watercourses Tributary to Little Bear Creek

Streams and watercourses, both free flowing and piped, within the boundaries of the Route 9 site are described in this section. Figure 6-6 illustrates the watercourse locations on and adjacent to the site.

Howell Creek

The main stem of Howell Creek flows northwest across the extreme southern end of the Route 9 site through a confined, armored channel. Howell Creek has one tributary that enters the creek on the Route 9 site. This tributary is entirely piped within the boundaries of the site (Figure 6-6) and joins the main stem of Howell Creek east of SR-9. Howell Creek flows via a culvert under SR-9. The confluence of Howell Creek and Little Bear Creek is located north of the SR-9/SR-522 interchange, west of SR-9. Downstream from the treatment plant site, the stream flows through a wetland mitigation area constructed by the Washington State Department of Transportation (WSDOT).

228th Street Creek

The 228th Street Creek flows through two channels: Channels A and B (Figure 6-6). Channel A is confined to a narrow, straight, ditch-like channel that separates the developed southern portion of the site from the undeveloped northern portion. Flow from this channel drains through a culvert into a constructed fish-rearing pond. Channel B is almost completely piped within the Route 9 site boundaries. The only open channel is a short segment immediately downstream from the railroad tracks that runs along the eastern boundary of the site. The remaining portion of Channel B is piped to a flow splitter near the fish-rearing pond that diverts a portion of the channel’s water to the fish-rearing pond and another portion into adjacent detention ponds east of the fish-rearing pond. The detention ponds discharge into the fish-rearing pond.

The fish-rearing pond sits east of SR-9 in the northwestern corner of the existing developed portion of the treatment plant site. Constructed in 1998 as mitigation for impacts on Channel B from development of the StockPot Culinary Campus, the fish-rearing pond is fed by flows from Channels A and B and stormwater from the StockPot property. A series of constructed weirs functions as a fish ladder connecting the pond to a new culvert under SR-9.

Unnamed Creek

Unnamed Creek is a small stream that flows southwestward through the northern portion of the site. The stream originates north of the site and is fed by overflow from nearby farm ponds, offsite and onsite wetland seeps, and flow from under the railroad. The stream enters the site via a culvert constructed under an abandoned logging road. It then meanders south and west through a mature mixed coniferous/deciduous forest. From the forest, the stream flows through several hundred feet of culvert under the yard of a landscape business and then flows in an open channel through another patch of forest to SR-9. Unnamed Creek flows under SR-9 via a small culvert and enters a system of roadside ditches that conveys it south to Little Bear Creek. The culvert under SR-9 has been observed to clog with debris. When this clogging occurs, flow is diverted to a roadside ditch adjacent to the eastern road shoulder. Flow in the ditch on the east side of the road passes under SR-9 to Little Bear Creek via the culvert at the outlet of the fish-rearing pond.

Other Watercourses

Seven small watercourses originate east of the site from groundwater seeps or surface drainage (Figure 6-6); several of these watercourses appear to receive runoff from the site. Flow is conveyed west across the Route 9 site through a series of pipes and/or ditches. Most of the site area that currently drains to these watercourses appears to have been constructed prior to the establishment of Snohomish County's current stormwater design standards; that is, there is no stormwater treatment or retention. Watercourses 3 through 6 are entirely piped through the site. Watercourses 7 and 8 are piped for approximately half of their length within the site. Watercourses 3 and 4 are tributary to the Howell Creek subbasin and join Howell Creek west of SR-9. Watercourses 5 through 8 discharge to a roadside conveyance ditch east of SR-9 and flow directly into Little Bear Creek via a single culvert south of Watercourse 7. As stated previously, Watercourse 9 is a tributary to Unnamed Creek.

Water Quality: Route 9 Treatment Plant

Groundwater

No information on groundwater quality testing specific to the Route 9 site is available at this time. A limited evaluation of potential groundwater contamination sources at, adjacent to, or upgradient from the Route 9 site was conducted by Environmental Data Resources (EDR 2001). One property (Woody's Auto Wrecking) is on Ecology's Confirmed and Suspected Contaminated Sites List, indicating a possible need for investigation under MTCA. Past and current industrial uses of many of the site's properties suggest that other contamination may be present.

Field screening was conducted for volatile organic compounds during the geotechnical exploration to determine handling and disposal procedures for soil cuttings generated during drilling and for observation well development. No contamination was found in groundwater from the 11 preliminary geotechnical borings. Nevertheless, the oily appearance of some near-surface soil samples and the presence of automotive-related land uses on the site suggest that contaminated groundwater could be present. Potential contamination would be analyzed and delineated in later phases of this project if the Route 9 site is selected.

The Cross Valley Water District (Golder Associates, 2000) identified a total of 23 point sources (primarily industrial businesses) as potential contaminant sources to the wellhead protection area of the Cross Valley Aquifer; six are believed to present a medium risk to the water source and the remainder are low risk. However, U.S. Geological Survey (USGS) sampling of 20 wells installed in the Cross Valley Aquifer in 1993 (Golder Associates, 2000) showed that water quality met primary drinking water standards in all wells and exceeded standards for iron and manganese in 12 of 15 wells. Arsenic was detected at levels below 0.05 μg/L.

Surface Water

Water quality information for surface waters crossing through the Route 9 site is not available; neither Snohomish County nor Ecology has studied onsite surface water quality. The streams on the Route 9 site may be considered to have assigned uses similar to those of Little Bear Creek (fish spawning and rearing) because they are tributaries to the creek. Nevertheless, it is likely that some or all of these surface waters do not always meet state water quality standards. Only runoff from the 228th Street Creek, the area of the most recent development, receives stormwater treatment or detention. Water quality in most onsite surface waters is likely to be strongly influenced by runoff from commercial and industrial development in each subbasin. Water quality in the onsite streams and watercourses would be monitored prior to construction of a treatment plant, as required in support of local, state, or federal permit requirements. Future site-specific monitoring protocols and parameters would be developed through consultation with regulatory agencies following the application for project-specific permits.

6.2.2.2 Conveyance: Route 9–195th Street Corridor

This section describes the water resource environment along the Route 9–195th Street conveyance corridor. Tunnel depths in this corridor could range from 40 to more than 450 feet below land surface. Final tunnel depths would be determined during the final design phase for the selected alternative. Discussions of tunnel access portals are subdivided into primary and secondary portals. The corridor and portal siting areas are shown in Figure 6-7. Figures showing the area surrounding each portal siting area can be found in Chapter 7.

Conveyance Corridor and Primary Portal Siting Areas

The primary portals associated with the 195th Street corridor are discussed below, listed in Table 6-4, and shown on Figure 6-7.

Groundwater Conditions Along the Route 9–195th Street Corridor

The 195th Street corridor crosses the entire Brightwater project area. Groundwater conditions along this corridor, therefore, reflect the regional conditions discussed earlier under Affected Environment Common to All Systems. The same aquifers and aquitards are present; the groundwater recharge, flow, and quality are similar (see Appendix 6-B Geology and Groundwater). Because the 195th Street corridor extends east-west across the area, the eastern two-thirds of the corridor is at right angles to the predominantly southerly groundwater flow direction. The western one-third of the corridor more closely parallels the westerly groundwater flow pattern.

The influent portion of the 195th Street corridor begins near Lake Washington at Portal Siting Area 11. This area is underlain by a thick sequence of river alluvium and a correspondingly thick Qal Aquifer. The influent portion then heads northward and would pass into the deeper Qu Aquifers and Aquitards before reaching Portal Siting Area 44. Because the influent portion of the corridor from Portal Siting Areas 11 to 44 is near Lake Washington, groundwater flow in the area is southward toward the lake. The combined influent/effluent tunnel from Portal Siting Area 44 eastward to the Route 9 Site is described in the following paragraph.

The effluent portion of the 195th Street corridor begins at the Route 9 plant site, where the tunnel would be entirely within the deeper Qu Aquifers and Aquitards. Groundwater flow in the Qu Aquifers in this area is thought to be generally to the west or southwest toward Lake Washington. The tunnel would continue in the Qu Aquifers and Aquitards to the west until it reaches the North Creek Valley, where it would enter the Qal or Qvr Aquifer within the valley sediments. Groundwater flow in the North Creek valley aquifer would generally parallel the southerly direction of streamflow. Further west, the tunnel would come within approximately 50 feet of the surface in the Swamp Creek valley and then would pass deep beneath the western uplands through the Qu Aquifers and Aquitards. The distribution of aquifers and aquitards is quite complex in the pre-Fraser deposits, but the existing data indicate relatively extensive water-bearing zones below sea level between Portal Siting Area 41 and Swamp Creek valley, near elevation 100 feet at the Lyon Creek crossing, and near sea level west of Lake Ballinger.

The overlying Qva Aquifer is also present along the entire 195th Street corridor except where interrupted by stream valleys, but is the most continuous and has the greatest saturated thickness west of Lyon Creek. The maximum saturated thickness is estimated to be 75 feet in this area. East of Lyon Creek, the Vashon Advance Outwash deposits are present but typically contain little water. This is probably because the aquifer drains into the major stream valleys.

Groundwater Use Along the Route 9–195th Street Corridor

The 195th Street corridor passes through the Lake Forest Park Water District wellhead protection area about 2,000 feet north of the district's wellfield. Lake Forest Park Water District operates eight artesian wells installed in a shallow water-bearing zone (likely the Qva Aquifer) and four deeper wells in the Qu Aquifers (see Appendix 6-B, Geology and Groundwater). The shallow wells are approximately 20 feet deep; the deeper wells range from 161 to 216 feet deep. All the wells are situated within approximately 100 yards of one another. Groundwater in the deeper Qu Aquifer at this location appears to be present in a discontinuous zone at an elevation of 100 to 150 feet above sea level. Little groundwater appears to be present above or below this elevation.

The 195th Street corridor also extends to the western edge of the sole-source aquifer area for the CVWD, and passes about 600 feet south of the wellhead protection area for the Olympic View Water and Sewer District's primary water source (Deer Creek Spring). It also passes within 2,000 feet of wells used by Holyrood Cemetery. The CVWD was described previously. The other water districts are described in the following paragraphs.

- Olympic View Water and Sewer District serves approximately 15,000 residents in the south Edmonds area of Snohomish County and draws water from the Deer Creek Spring complex. In addition, the water district maintains an intertie with the City of Seattle. The spring source discharges from the Qva Aquifer about 200 feet above sea level at an average rate of 690 gallons per minute (gpm) with a historical range between 300 and 1,000 gpm (Robinson & Noble, 1999). The 195th Street corridor is about 4,000 feet south of the spring and approximately 200 feet lower in elevation within the pre-Fraser deposits.
- Holyrood Cemetery uses two wells for nonpotable irrigation water. Water rights certificates (Appendix 6-B, Geology and Groundwater) and pump test results reported on water well logs indicate well yields of 150 and 225 gpm. Both wells are quite deep, with one screened at approximately 250 feet below sea level and the other with an apparent open bottom at approximately 75 feet below sea level. These wells are installed in the Qu Aquifers.

Groundwater Quality Along the Route 9–195th Street Corridor

Groundwater quality along the 195th Street corridor is essentially the same as described for the region. The corridor, including the influent tunnel near NE Bothell Way in Kenmore and the effluent tunnel west of Portal Siting Area 5, passes through a few areas of commercial or light industrial development where contamination is possible. In the vicinity of Portal 19, at the southern end of the Chevron Richmond Beach Asphalt Terminal property, there is documented contamination. According to investigations by Converse Consultants NW (1992), six areas containing free hydrocarbon product (termed "separate phase hydrocarbons" in the report) were identified at the Chevron property. Two of these areas, where product appears to be floating on the water table, are in the south portion of the property. The hydrocarbons present are described as in the gasoline, diesel, and motor oil range. Remediation efforts have been underway at this property for more than a decade under the jurisdiction of Ecology.

Groundwater Conditions at the Route 9–195th Street Corridor Primary Portal Siting Areas

Hydrogeologic conditions at the primary portal siting areas are summarized as follows:

Portal Siting Area 11. This portal siting area, situated near where the Sammamish River enters Lake Washington, would be constructed within the unconfined Qal/Qvr Aquifer. The water table in this area would be close to, but slightly higher than, lake elevation and close to the ground surface.

Portal Siting Area 41. This portal siting area would be constructed within the Qal Aquifer in the North Creek Valley. The water table is typically less than 10 feet bgs in this area.

Portal Siting Area 44. This portal siting area is located in the Swamp Creek valley. Depending on the site selected, the portal would extend either through a thin section of Qvr Aquifer and then into dense Vashon and pre-Fraser deposits, or directly into the dense deposits. A laterally extensive water-bearing zone under confined pressure, the Qu Aquifer, appears to be present near the base of the portal.

Portal Siting Area 5. This portal siting area is near McAleer Creek and would likely extend downward through a section of the Qvr Aquifer up to 30 feet thick, through Vashon Till, through the unconfined Qva Aquifer, and then through a predominantly fine-grained portion of the pre-Fraser deposits (the Qu Aquitards). The Qva Aquifer at this location appears to be about 50 feet thick with 40 feet of saturation.

Portal Siting Area 19. This portal siting area, situated at the Puget Sound shoreline, would extend through predominantly water-bearing Qu Aquifer deposits. Portal siting area 19 is about 6,000 feet from Deer Creek Spring.

Detailed information on groundwater resources along the conveyance corridors can be found in Appendix 6-B, Geology and Groundwater.

Surface Water Conditions at the Route 9–195th Street Primary Portal Siting Areas

Impacts to streams as a result of Route 9–195th Street Brightwater project activities, including discharge of dewatering, could occur at or near five primary portal siting areas. Stream basins associated with primary portal siting areas are listed in Table 6-4, followed by general basin descriptions. Details are provided in Appendix 6-A, Affected Environment: Surface Water.

Table 6-4. Stream Basins in Primary Portal Siting Areas on the Route 9–195th Street Corridor

Primary Portal Siting Area[a]	Associated Stream/Drainage Basin
Influent portion of the corridor	
11	Sammamish River
Effluent portion of the corridor	
5	McAleer Creek
19	Puget Sound
Combined influent/effluent portion of the corridor	
41	North Creek/Sammamish River Tributary
44	Swamp Creek

[a] Locations of portal siting areas shown in Figure 6-7.

Swamp Creek

Swamp Creek originates in the city of Everett at the outlet of Lake Stickney, southeast of Paine Field. The creek flows south through the cities of Lynnwood, Brier, Mountlake Terrace, and Bothell, entering the Sammamish River at RM 0.6 near Kenmore. The main stem of the creek is 10.9 miles long. For water years 1992 through 1994 and for 2000, the average wet-season discharge at a site near the mouth was 40.4 cfs and the average dry-season discharge was 8.8 cfs (King County 2002d). Swamp Creek is on the 1998 CWA 303(d) list for dissolved oxygen and fecal coliform bacteria. Water quality data are currently being collected by King and Snohomish Counties.

North Creek

North Creek originates in Everett near Everett Mall, flows south through unincorporated Snohomish County and the city of Mill Creek, and enters the Sammamish River at RM 4.4 in King County near the City of Bothell. The main stem of the creek is 12.6 miles long. For water years 1995 through 2001, the average wet-season flow of North Creek at the Snohomish-King County line was 82.8 cfs, and the corresponding average dry-season flow was 21.6 cfs (Snohomish County, 2002). North Creek is on the 1998 CWA 303(d) list for dissolved oxygen and fecal coliform bacteria. Water quality data are currently being collected by King and Snohomish Counties.

Sammamish River

The Sammamish River is described above in Regional Surface Water Conditions Common to All Systems.

McAleer Creek

McAleer Creek flows south from Lake Ballinger through the cities of Mountlake Terrace and Shoreline and unincorporated King County to enter Lake Washington near the city of

Lake Forest Park. For water years 1992 through 1994 and for 2001, the average wet-season flow in McAleer Creek was 13.0 cfs and the average dry-season discharge was 7.0 cfs (King County, 2002c). McAleer Creek is on the 1998 CWA 303(d) list for fecal coliform bacteria. Water quality data are currently being collected by King County.

Puget Sound

Puget Sound is described in the Puget Sound Conditions section under Affected Environment Common to All Systems.

Portal 41 Influent Pump Station Option

The affected environment for the 195th Street corridor Portal 41 influent pump station (IPS) option is the same as that described for Portal Siting Area 41 above. Portal Siting Area 41 is located in the North Creek stream valley.

Secondary Portal Siting Areas: Route 9–195th Street Corridor

Secondary portal siting areas are listed in Table 6-5 and shown in Figure 6-7. At this time, secondary portal siting areas are not expected to be used. Secondary portals would be constructed only if unanticipated conditions arose, such as the need to provide ground improvement at depth or ventilation to the tunnel.

Groundwater Conditions at the Route 9–195th Street Secondary Portal Siting Areas

Groundwater conditions at the secondary portal siting areas for the 195th Street corridor are as follows:

Portal Siting Area 45. Portal Siting Area 45, situated near an unnamed drainage, would extend through a 20- or 30-foot section of Advance Outwash (Qva Aquifer) and into low-permeability Qu Aquitard deposits. The Advance Outwash appears to be saturated from near the land surface downward. This portal siting area is about 1,500 feet from the Lake Forest Park Water District’s wellhead protection area at a probable cross-gradient location, and about 4,500 feet from the wellfield itself.

Portal Siting Area 7. This portal siting area is in the Lyon Creek drainage. A thin layer of Vashon Till may be present at this location, underlain by a thicker section of Qva Aquifer than is present at Portal Siting Area 45. It appears that about 50 feet of Lawton Clay underlies the Qva Aquifer and extends to near the base of the portal siting area. Portal Siting Area 7 is about 6,000 feet from the Lake Forest Park Water District’s wellfield at a probable cross-gradient location.

Portal Siting Area 27. This portal siting area is immediately south of Lake Ballinger. A thin layer of Vashon Till may also be present here at the surface. If not, the portal would extend through the Qva Aquifer, about 50 feet thick at this location, through about 40 feet of Lawton Clay and into predominantly fine-grained Qu Aquitards. The water table in the Qva Aquifer is within 10 to 20 feet bgs.

Portal Siting Area 23. This portal siting area would extend directly downward through approximately 200 feet of Advance Outwash, through a thin layer of Lawton Clay, and then into 125 feet of pre-Fraser deposits. The Qva Aquifer in the outwash deposit has a saturated thickness of about 75 feet, with the water table at a depth of more than 100 feet bgs. The upper part of the pre-Fraser deposits appears to contain a laterally extensive Qu Aquifer, underlain by a thick Qu Aquitard section of nonglacial lacustrine sediments. Portal Siting Area 23 is approximately 500 feet from the southern edge of the wellhead protection area for Deer Creek Spring, at a probable cross-gradient location.

Surface Water Conditions at the Route 9–195th Street Secondary Portal Siting Areas

Impacts to streams as a result of activities related to the Brightwater project could occur at or near five secondary portal siting areas. Stream basins associated with secondary portal siting areas are listed in Table 6-5, followed by general basin descriptions. Details are available in Appendix 6-A, Affected Environment: Surface Water.

Table 6-5. Stream Basins in Secondary Portal Siting Areas on the Route 9–195th Street Corridor

Secondary Portal Siting Area [a]	Associated Stream/Drainage Basin
Effluent portion of the corridor[b]	
45	Unnamed drainage between Swamp Creek and Lyon Creek drainages
7	West Fork of Lyon Creek[c]
27	Lake Ballinger, source of McAleer Creek
23	Storm Creek in Middle Puget Sound–Shoreline basin, at a location probably cross-gradient to Deer Creek Spring

[a] Locations of portal siting areas are shown in Figure 6-7.
[b] There are no secondary portal siting areas in the influent and combined influent/effluent portions of the corridor.
[c] Shown on Figure 6-1

Swamp Creek

Swamp Creek is described above under Surface Water Conditions: Route 9–195th Street Corridor, Primary Portal Siting Areas.

Lyon Creek/West Fork Lyon Creek

Lyon Creek originates in a wetland in south Snohomish County and flows south through the cities of Mountlake Terrace, Brier, and Lake Forest Park before flowing directly into the north end of Lake Washington. The main stem of the creek is 3.8 miles long. For the water years 1992 through 1994 and for 2001, the average wet-season flow was 4.4 cfs and the average dry-season flow was 2.0 cfs (King County, 2002c). Water quality data are currently being collected by King County for Lyon Creek. Information on West Fork Lyon Creek is not available.

Lake Ballinger

Lake Ballinger is an approximately 100-acre lake located in the cities of Mountlake Terrace and Edmonds. The watershed is highly urbanized with the lakeshore surrounded by single-family residential units. The maximum lake depth is 31 feet, with an average depth of 20 feet (Mountlake Terrace, 1993). The major lake inflow is from Hall Creek and the only surface outflow is to McAleer Creek, which drains to Lake Washington. Historic water quality problems in the lake have included severe algal blooms, an anoxic hypolimnion, and bacterial contamination. These problems were attributed to excessive nutrient and wastewater loading to the lake (Mountlake Terrace, 1993). The lake has been characterized as eutrophic (Mountlake Terrace, 1993).

McAleer Creek

McAleer Creek is described above under Surface Water Conditions: Route 9–195th Street Corridor, Primary Portal Siting Areas.

Storm Creek

Storm Creek originates in seeps and wetlands in southeast Snohomish County. Storm Creek flows south and then southwest from the headwaters in Snohomish County through the city of Shoreline to Puget Sound. The City of Shoreline has collected water quality data for Storm Creek; these data are available from the City.

6.2.2.3 Conveyance: Route 9–228th Street Corridor

This section describes the water resource environment along the 228th Street conveyance corridor. Tunnel depths in this corridor would range from 40 to more than 450 feet below land surface. The final tunnel depth would be determined during the final design phase for the selected alternative. Discussions of tunnel access portals are subdivided into primary and secondary portal siting areas. The tunnel and portal siting areas are shown in Figure 6-7. Figures showing the area surrounding each portal siting area can be found in Chapter 7.

Conveyance Corridor and Primary Portal Siting Areas

The primary portal siting areas associated with the 228th Street corridor are described below, listed in Table 6-6, and shown on Figure 6-7.

Groundwater Conditions Along the Route 9–228th Street Corridor

Groundwater occurrence and flow conditions across the 228th Street corridor are similar to those described for the 195th Street corridor. The primary differences are that the effluent tunnel for the 228th Street corridor would be deeper and would be contained completely within the Qu Aquifers and Aquitards. In addition, groundwater elevations are generally higher, reflecting the proximity of this corridor to the upland recharge areas.

Groundwater Use Along the Route 9–228th Street Corridor

The 228th Street corridor reaches the edge of the Cross Valley Sole Source Aquifer area at the Route 9 plant site, as does the 195th Street corridor, but the western part of the corridor passes directly through the center of the wellhead protection area for the Olympic View Water and Sewer District's Deer Creek Spring. Refer to Appendix 6-B, Geology and Groundwater, for an illustration of the wellhead protection area. At its closest point, the effluent tunnel would be about 3,500 feet upgradient from Deer Creek Spring, but 200 feet lower in elevation. The tunnel would be separated from the Qva Aquifer, which is the source of the spring, by up to 150 feet of Lawton Clay Aquitard and by interbedded low-permeability Qu Aquitards.

The 228th Street Corridor also passes directly by the Olympic View Water and Sewer District's 228th Street well. The district has been working on this well for several years under a water permit from the Washington Department of Ecology, and although not currently using it, may do so in the future. Recently, the deeper aquifer, in which the well was originally completed, was found to have unacceptable quality, so the well was modified to allow development of the shallower aquifer, the Qva Aquifer (Robinson & Noble, 2003).

Groundwater Quality Along the Route 9–228th Street Corridor

Groundwater quality along the 228th Street corridor is similar to the regional conditions described previously. However, the corridor passes through a smaller area of commercial and industrial development compared to the other corridors. Because of this and its greater depth, there is less potential for existing groundwater contamination.

Groundwater Conditions at the Route 9–228th Street Portal Siting Areas

Anticipated hydrogeologic conditions at the primary portal siting areas on the Route 9–228th Street corridor are shown in Appendix 6-B, Geology and Groundwater, and are summarized as follows:

Portal Siting Area 39. This portal siting area is on the eastern edge of the North Creek valley, near several small unnamed tributaries. It is believed that the near-surface sediments consist of saturated Vashon Recessional Outwash (Qvr Aquifer), with the water table relatively close to the ground surface. The portal would extend through this water-bearing zone into either Vashon or pre-Fraser deposits. The pre-Fraser deposits likely contain groundwater (Qu Aquifers) under confined pressures.

Portal Siting Area 33. The Portal Siting Area 33 is situated near Swamp Creek. Subsurface conditions are believed to consist of a thin section of Qal/Qvr Aquifer overlying extensive Qu Aquifer zones. Artesian pressures above the ground surface are likely in the Qu Aquifers.

Portal Siting Area 26. The Portal Siting Area 26 lies astride Hall Creek. Subsurface conditions are believed to consist of a thin section of Qal/Qvr Aquifer overlying up to 150 feet of the Qva Aquifer. The Qal/Qvr and Qva Aquifers are apparently in direct contact at this location, with the water table at or near the elevation of Hall Creek. The remaining 60 feet at the base of the portal penetrates both the Lawton Clay and Qu Aquitards. Portal Siting Area 26 is approximately 5,000 feet upgradient from the eastern upgradient edge of the Deer Creek Spring wellhead protection area.

Portal Siting Area 19. Portal Siting Area 19 was described previously for the 195th Street corridor.

Portal Siting Area 11. Portal Siting Area 11 was described previously for the 195th Street corridor.

Portal Siting Area 41. Portal Siting Area 41 was described previously for the 195th Street corridor.

Portal Siting Area 44. Portal Siting Area 44 was described previously for the 195th Street corridor.

Surface Water Conditions at the Route 9–228th Street Primary Portal Siting Areas

Stream basins associated with primary portal siting areas are listed in Table 6-6, followed by general basin descriptions. Details are available in Appendix 6-A, Affected Environment: Surface Water.

Table 6-6. Stream Basins in Primary Portal Siting Areas on the Route 9–228th Street Corridor

Primary Portal Siting Area[a]	Associated Stream/Drainage Basin
Influent portion of the corridor	
41	North Creek, Sammamish River Tributary
44	Swamp Creek
11	Sammamish River
Effluent portion of the corridor	
39	North Creek, Palm Creek
33	Swamp Creek
26	Hall Creek, draining into Lake Ballinger, then McAleer Creek
19	Puget Sound

[a] Locations of portal siting areas are shown in Figure 6-7.

North Creek

North Creek is described above in the discussion of the 195th Street corridor.

Swamp Creek

Swamp Creek is described above in the discussion of the 195th Street corridor.

Sammamish River

The Sammamish River is described above in Regional Surface Water Conditions Common to All Systems.

Lake Ballinger/Hall Creek

Lake Ballinger is approximately 100 acres in size and is located in the cities of Mountlake Terrace and Edmonds. It is the source of McAleer Creek. Hall Creek, which originates at the outlet of Hall Lake in the city of Lynnwood, is the major surface water inflow to Lake Ballinger. Hall Creek's watershed is highly urbanized and receives runoff from industrial areas, highways, and freeways (Mountlake Terrace, 1993).

Puget Sound

Puget Sound is described in the Puget Sound Conditions section under Affected Environment Common to All Systems.

Portal 41 Influent Pump Station Option

The affected environment for the 228th Street corridor Portal 41 influent pump station option is the same as that described for the 195th Street corridor.

Secondary Portal Siting Areas: Route 9–228th Street Corridor

Secondary portal siting areas are listed in Table 6-7 and shown in Figure 6-7. At this time, secondary portal siting areas are not expected to be used. Secondary portals would be constructed only if unanticipated conditions arose, such as the need to provide ground improvement at depth or ventilation to the tunnel.

Groundwater Conditions at the Route 9–228th Street Secondary Portal Siting Areas

Groundwater conditions at the secondary portal siting areas for the 228th Street corridor are described as follows:

Portal Siting Area 37. Portal Siting Area 37 is situated at the western edge of the North Creek valley. The creek channel passes just east of the edge of the siting area. Depending on the selected site, the portal may or may not extend through a thin veneer of recessional outwash, the Qvr Aquifer, before reaching Vashon or pre-Fraser deposits. Groundwater appears to be present in the older deposits as a thin zone of saturation in the Qva Aquifer and as a 50-foot Qu Aquifer zone near the base of the portal. The Qu Aquifer would likely be under artesian pressures at this location.

Portal Siting Area 30. This portal siting area is situated on the edge of the Lyon Creek drainage near East Fork Lyon Creek. The portal would be about 250 feet deep, with the upper half penetrating the Qva Aquifer and water-bearing Qu Aquifer zones and the lower half penetrating fine-grained Qu Aquitard deposits. Lyon Creek appears to be connected hydraulically with the Qva Aquifer at this location, and the water table elevation would be at or near the creek elevation.

Portal Siting Area 24. Portal Siting Area 24 would be about 300 feet deep. The portal would extend downward through 150 feet of Qva Aquifer, with the water table at approximately 75 feet bgs. Below the Qva Aquifer is a thin layer of Lawton Clay Aquitard, followed by interlayered Qu Aquifers and Aquitards to the base of the portal. Portal Siting Area 24 is within the Deer Creek Spring wellhead protection area, about 6,000 feet upgradient from the spring itself.

Portal Siting Area 22. This portal siting area overlaps Portal Siting Area 23, a secondary portal siting area for the 195th Street corridor; subsurface conditions at the two portals are similar.

Surface Water Conditions at the Route 9–228th Street Secondary Portal Siting Areas

Stream basins associated with secondary portal siting areas on the 228th Street corridor are listed in Table 6-7. General stream descriptions are located in previous sections. Details are available in Appendix 6-A, Affected Environment: Surface Water.

Table 6-7. Stream Basins in Secondary Portal Siting Areas on the Route 9–228th Street Corridor

Secondary Portal Siting Area [a]	Stream/Drainage Basin
Effluent portion of the corridor[b]	
37	North Creek
30	Lyon Creek
24	Puget Sound
22	No major water body nearby; overlaps Portal 23 in Middle Puget Sound–Shoreline basin

[a] Locations of portal siting areas shown in Figure 6-7.
[b] There are no secondary portal siting areas in the influent and combined influent/effluent portions of the corridor.

6.2.2.4 Outfall: Route 9

Water and sediment quality for outfall Zone 7S are as described in Affected Environment Common to All Systems.

6.2.3 Affected Environment: Unocal System

6.2.3.1 Treatment Plant: Unocal

Groundwater Conditions: Unocal Treatment Plant

Groundwater conditions described in this section for the Unocal site are not based on the regional system described earlier under Regional Groundwater Conditions Common to All Systems. Rather, they are based on the extensive explorations completed at the site by EMCON (1994) and Maul, Foster, and Alongi (2001, 2002) and on geologic mapping by Minard (1983).

Two distinct groundwater zones are present at the Unocal site:

1. Perched water within a geologic unit termed "Transitional Beds" of the upper portions of the site

2. The regional groundwater table situated in the Whidbey Formation geologic unit, which is believed to underlie the site at approximately elevation 18 feet (18 feet MLLW) beneath the upper yard, and in the overlying alluvium, which is present in the lower yard

Figure 6-8 shows a typical cross-section through the site and illustrates the presence of both the perched groundwater zones and the regional groundwater table associated with the Whidbey Formation and alluvium.

The Transitional Beds (Figure 6-9) were deposited in rivers and lakes in advance of the Vashon glaciers (Minard, 1985) and include layers and lenses of low-permeability silt and clay within deposits that are primarily interlayered nonplastic and low-plasticity sandy silt and silty sand. All of the unit is very dense or hard. The sandier portions are of low-to-moderate permeability; the clay and silt portions are of low permeability. Groundwater tends to perch both on top of the entire deposit and on top of the lower permeability silt and clay layers deeper within the deposit.

The perched groundwater zones are reported to be only a few feet thick (Maul, Foster, and Alongi, 2001), from 3 feet to more than 52 feet bgs in the upper yard (see Figure 6-8). The groundwater level fluctuates about 4 feet in depth from season to season.

The Whidbey Formation, which underlies the Transition Beds in the upper yard, consists of medium- to coarse-grained sand with varying amounts of gravel and silty sand with interbeds and lenses of silt. The Whidbey Formation may underlie recently (post glacially) deposited alluvium in the lower yard, or may have once been present and been eroded and replaced by alluvium. The alluvium consists of fine-to-medium sand with minor amounts of silt, gravel, and organic material and interbeds of silt and sandy silt. The alluvium has relatively high permeability. The Whidbey Formation and the adjacent, hydraulically similar alluvium may be part of the regional Qu aquifer. Where groundwater has been measured in the lower yard, its depth was between 3 and 10 feet bgs and varied with the tide from nearby Puget Sound.

Water Supply Wells: Unocal Treatment Plant

One water supply well is situated within a 1-mile radius of the Unocal site, about 800 feet east of the eastern boundary of the upper yard. It was drilled for the Deer Creek Hatchery. The purpose of this well was to augment the hatchery surface water supply as needed during periods of turbid runoff. According to the hatchery manager, the well has never been used, does not have a pump, and is unlikely to be used in the future because of its low yield (Thompson, 2003). Ecology well records and the recollection of the hatchery manager indicate that the well was constructed in 1991with a screen from 50 to 55 feet bgs, which is well above the elevation of the regional aquifer at the Unocal site.

Surface Water Conditions: Unocal Treatment Plant

The surface waters addressed in this section are Willow Creek, Shelleberger Creek, and two local watercourses that fall within or are tributary to the Unocal treatment plant site. (The Edmonds Marsh is discussed in Chapter 7.) Surface water features are shown in Figure 6-10. Puget Sound water conditions are summarized above under Affected Environment Common to All Systems (Puget Sound Conditions). Additional detail is available in Appendix 6-A, Affected Environment: Surface Water.

Willow Creek

Willow Creek originates from springs in the Town of Woodway, approximately 1.5 miles upstream from the Unocal plant site. Land use in the upper basin (as far as the Pine Street/SR-104 intersection) is mainly residential. A corrugated metal culvert conveys flow under Pine Street. The stream continues past the Deer Creek Hatchery, and serves as the water source. A weir diverts water from the stream in the late winter and spring during the seasonal operation of the hatchery. Downstream from the hatchery, the stream is extensively braided until it reaches Edmonds Marsh, where it is impounded by several beaver dams. Downstream from Edmonds Marsh, the stream flows along the western edge of the Unocal site within a straight, excavated channel. It then crosses under the Burlington Northern-Santa Fe (BNSF) railroad tracks through two 24-inch-diameter culverts, flows briefly in an open channel, and enters Puget Sound through a culvert 0.25 mile long and 48 inches in diameter. The stream discharges to Puget Sound several hundred feet south of the southern breakwater of the Port of Edmonds Marina. From its mouth to upstream of its confluence with Shelleberger Creek, Willow Creek is tidally influenced. Measured flow in Willow Creek ranges from less than 1 to roughly 2 cfs. Peak flows for a major storm (statistical probability of occurring once every 100 years) have been modeled at 56 cfs (R.W. Beck, 1991).

The nature of Willow Creek within the Edmonds Marsh has changed over the years. When the Port of Edmonds Marina was developed in 1962, a tidegate east of the railroad tracks effectively eliminated tidal exchange within the marsh. The tidegate was opened permanently in 1995 to allow for fish passage to Willow Creek and to return tidal influence to parts of the marsh (FHWA et al., 1995). An additional description of the Edmonds Marsh may be found in Chapter 7.

Shelleberger Creek

Shelleberger Creek (Figure 6-10) originates in a wetland near 8th Avenue and Elm Street in the city of Edmonds and drains areas surrounded by residential development. The stream flows northwest for approximately 1 mile before crossing into Edmonds Marsh via a culvert under SR-104. The stream joins Willow Creek in the marsh east of a detention basin in the lower yard of the Unocal site; only the lower-most 50 feet of Shelleberger Creek flows within the site boundaries.

Other Watercourses

Edmonds Way Drain

Runoff from a 945-acre subbasin in the upper Willow Creek basin is collected in an enclosed drainage system referred to as the Edmonds Way Drain (Figure 6-10). The Edmonds Way Drain also collects much of the stormwater runoff from SR-104. This drainage system does not transport runoff from the Unocal site itself. The 72-inch diameter pipe for the drain passes under the Unocal site and discharges to Puget Sound approximately 850 feet north of the Edmonds Pier. Historically, the drain has experienced capacity problems resulting in local flooding beyond the boundaries of the site during storms (R.W. Beck, 1991).

Unocal Site Drainage System

The storm drainage system installed during active operations at the Unocal site remains in place and functioning (Brearly, 2002). A series of catch basins serving both yards of the site conveys stormwater to Detention Pond 1, which discharges into Willow Creek (EMCON, 1994). Water from an oil/water separator is conveyed to a second detention pond (Detention Pond 2), which also discharges to Willow Creek. During large storm events, water from Detention Pond 2 can enter Detention Pond 1 via a spillway.

Water Quality: Unocal Treatment Plant

Groundwater

The Unocal site is a state-listed hazardous site with a Washington Ranking Method rank of 1, the highest ranking for cleanup. Under an Agreed Order between Ecology and the Unocal Corporation, the site is undergoing cleanup. A draft remedial investigation/ feasibility study (RI/FS) has been prepared, and remedial action is in progress under Model Toxics Control Act (MTCA) with oversight by Ecology. Additional information about onsite contamination is included in Chapter 4.

The site is contaminated from past uses that involved storing, blending, and distributing various petroleum products, including gasoline, diesel fuel, and bunker fuel. In addition, an asphalt plant operated at the site between 1953 and the late 1970s. Contamination has been detected in the soil, in groundwater, and floating on the groundwater beneath the property. The primary sources of contamination are the former above-ground storage tanks and interconnecting piping, the former asphalt plant, the former truck loading racks, the former railroad spur, the former underground storage tanks, and Detention Pond 1, situated in the lower yard area.

Summaries of the nature and extent of contamination and remedial actions to date at the site are provided in Appendix 6-B, Geology and Groundwater. Ecology is writing a

Cleanup Action Plan for the entire site. Cleanup of the lower yard is expected to begin in summer 2005 (Edmonds 2002).

Surface Water

Willow Creek is a tributary to Puget Sound and therefore its classification is established by the high quality of that water body. Using the new Ecology standards, Willow Creek is designated for salmon and trout spawning, core rearing, and migration and for extraordinary primary contact recreation. However, its quality is not always consistent with all water quality standards. Water quality standards violations have been measured for pH, temperature, fecal coliform bacteria counts, and dissolved oxygen. Elevated levels of nutrients, metals such as lead and zinc, and conductivity have also been observed. Willow Creek's water quality appears to be similar to that of other urban streams in the Seattle area, partly due to natural causes. For example, pH values in Willow Creek may result partly from natural soil and geologic factors in the watershed, and low dissolved oxygen concentrations may be due to oxygen depletion in the marsh (FHWA et al. 1998).

Shelleberger Creek is tributary to and would have the same water quality classification as Willow Creek. No water quality data are available for Shelleberger Creek, the Edmonds Way Drain, or the Unocal site stormwater system. Data are not available, but runoff in Shelleberger Creek and Edmonds Way Drain is probably consistent with water quality from urban subbasins with residential and commercial areas and roadways. Water in the Unocal site drainage system is probably typical of runoff from an industrial site.

6.2.3.2 Conveyance: Unocal

This section describes the water resources environment along the Unocal influent conveyance corridor. This corridor would encounter topographic, geologic, hydrogeologic, and surface water conditions very similar to what is described earlier for the Route 9 corridors.

Primary Portal Siting Areas: Unocal Corridor

The primary portal siting areas for the Unocal corridor are discussed below, listed in Table 6-8, and shown in Figure 6-7.

Groundwater: Unocal Corridor, Primary Portal Siting Areas

Hydrogeologic Conditions Along the Unocal Corridor

Groundwater occurrence and flow conditions in the western half of the Unocal corridor are similar to those described for the Route 9 corridors, but are different in the eastern half. Because it crosses the north end of Lake Washington and approximately parallels the Sammamish River, the eastern half of the Unocal corridor is near the downgradient discharge point for the Qva and Qu Aquifers. Groundwater levels are correspondingly closer to the ground surface and the lake and river elevation, although flowing artesian conditions are possible for the Qu Aquifers in this area. The Unocal conveyance tunnel would also be much shallower than the Route 9 tunnels and generally within the Qal or Qvr Aquifers, except where it passes beneath the upland separating the Swamp Creek and North Creek Valleys.

Groundwater Use Along the Unocal Corridor

The Unocal corridor passes directly through the center of the wellhead protection area for the Olympic View Water and Sewer District's Deer Creek Spring and within about 2,500 feet of the 228th Street well. Refer to Appendix 6-B, Geology and Groundwater, for an illustration of the wellhead protection area for the Olympic View Water and Sewer District. At its closest point, the influent tunnel is about 2,000 feet upgradient from Deer Creek Spring, but 125 feet lower in elevation. Like the 228th Street tunnel, the Unocal tunnel would be separated from the Qva Aquifer, which is the source of the spring, by up to 150 feet of Lawton Clay Aquitard and by interbedded low-permeability Qu Aquitards.

The Unocal corridor also passes through the extreme southwestern corner of the Lake Forest Park Water District's wellhead protection area. At this location, the tunnel would be downgradient in terms of groundwater flow in the Qu Aquifer and would be more than 100 feet lower in elevation.

Groundwater Quality Along the Unocal Corridor

Groundwater quality along the Unocal corridor is similar to the regional conditions described previously. However, the corridor passes through more areas of commercial and industrial development compared to the Route 9 corridors. For this reason and because the tunnel would be closer to the ground surface, there is more potential to encounter existing groundwater contamination along the Unocal corridor.

Hydrogeologic Conditions at Primary Portal Siting Areas on the Unocal Corridor

Anticipated hydrogeologic conditions at the primary portal siting areas on the Unocal corridor are shown in Appendix 6-B, Geology and Groundwater, and are summarized as follows:

Portal Siting Area 14. This portal siting area is at the junction of the North Creek and Sammamish River Valleys near Portal Siting Area 41. Conditions at this portal siting area are therefore similar to those described previously (Affected Environment: Route 9 System) for Portal Siting Area 41.

Portal Siting Area 11. Portal Siting Area 11 was described previously for the Route 9–195th Street corridor.

Portal Siting Area 7. Portal Siting Area 7 is situated where the West Fork of Lyon Creek and McAleer Creek come together (but do not join) in the same valley. Subsurface conditions are believed to consist of a thin veneer of Qvr and/or Qva Aquifer overlying Qu Aquifers and Aquitards. The Qvr/Qva Aquifers are apparently in direct contact with both creeks at this location, with the water table likely slightly higher than creek surface elevations.

Portal Siting Area 3. Portal Siting Area 3 is close to secondary Portal Siting Area 24 on the Route 9–228th Street corridor, and subsurface conditions at both portal siting areas are similar. The apparent difference is a greater preponderance of Qu Aquitard at Portal Siting Area 3 as compared to Secondary Portal Siting Area 24. The portal at Portal Siting Area 3 would extend downward through 150 feet of Qva Aquifer, with the water table at approximately 75 feet bgs. Below the Qva Aquifer is a thin layer of Lawton Clay Aquitard, followed by interlayered Qu Aquifers and Aquitards to the base of the portal. Portal Siting Area 3 is within the Deer Creek Spring wellhead protection area, about 4,000 feet upgradient from the spring itself.

Surface Water Conditions: Unocal Corridor, Primary Portals

The Unocal corridor would involve tunnel construction, with aboveground construction activities taking place at four primary portal siting areas. Surface water conditions for the Unocal corridor are generally similar to those for the Route 9–195th Street corridor. Stream basins associated with identified primary portal siting areas are listed in Table 6-8. Brief descriptions of these streams are presented above in previous sections. See Appendix 6-A, Affected Environment: Surface Water, for detailed information about these stream basins.

Table 6-8. Stream Basins in Primary Portal Siting Areas on the Unocal Corridor

Primary Portal Siting Area[a]	Associated Stream/Drainage Basin
14	North Creek
11	Sammamish River
7	West Fork of Lyon Creek[b]
3	Puget Sound (Middle Puget Sound–Shoreline basin)

[a] Locations of portal siting areas are shown in Figure 6-7.
[b] Shown on Figure 6-1.

Secondary Portal Siting Areas: Unocal Corridor

Secondary portal siting areas are listed in Table 6-9 and shown in Figure 6-7. At this time, secondary portal siting areas are not expected to be used. Secondary portals would be constructed only if unanticipated conditions arose, such as the need to provide ground improvement at depth or ventilation to the tunnel.

Groundwater Conditions: Unocal Corridor, Secondary Portal Siting Areas

Groundwater conditions at secondary portal Siting Areas on the Unocal corridor are described as follows:

Portal Siting Area 13. Subsurface conditions have not been explored at Portal Siting Area 13. However, the portal siting area is near the confluence of an unnamed creek with the Sammamish River, and the area is underlain by Vashon Recessional Outwash and Recent Alluvium. The portal at this location might be constructed completely within the Qvr/Qal Aquifers or might penetrate a short distance into underlying Vashon or pre-Fraser deposits. The water table is likely shallow, within about 10 feet bgs.

Portal Siting Area 12. This portal siting area is situated within the Swamp Creek drainage near its confluence with the Sammamish River. Subsurface conditions consist of a shallow water table within the Qvr Aquifer overlying 20 to 25 feet of Vashon Till. Beneath the till and extending to the base of the portal are saturated sands of the Qva Aquifer. The till appears to pinch out to the west, allowing direct hydraulic connection between the Qva Aquifer and the Qvr Aquifer. The groundwater elevation for the Qvr Aquifer would be at or near the creek elevation.

Portal Siting Area 10. Portal Siting Area 10 is near the discharge point of Lyon Creek into Lake Washington, in an area underlain by Vashon Recessional Outwash and Recent Alluvium. The portal at this location might be constructed completely within the Qvr/Qal Aquifers or might penetrate a short distance into underlying Vashon or pre-Fraser deposits. The water table is shallow at this location, within about 10 feet bgs. Portal Siting Area 10 is approximately 1,500 feet downgradient from the southern border of the Lake Forest Park Water District's wellhead protection area.

Portal Siting Area 5. This portal siting area was described previously as a primary portal siting area for the 195th Street corridor.

Surface Water Conditions: Unocal Corridor, Secondary Portal Siting Areas

Stream basins associated with secondary portal siting areas on the Unocal corridor are listed in Table 6-9. Brief descriptions of these streams are presented above in previous sections. See Appendix 6-A, Affected Environment: Surface Water, for detailed information about these stream basins.

Table 6-9. Stream Basins in Secondary Portal Siting Areas on the Unocal Corridor

Secondary Portal Siting Area[a]	Associated Stream/Drainage Basin
13	Sammamish River
12	Swamp Creek
10	Lyon Creek
5	McAleer Creek

[a] Locations of portal siting areas are shown in Figure 6-7.

6.2.3.3 Outfall: Unocal

Water and sediment quality for outfall Zone 6 are as described in Affected Environment Common to All Systems.

6.3 Impacts and Mitigation

A variety of approaches were used to analyze project impacts to water resources. These are summarized below.

To characterize groundwater impacts at the treatment plant sites and the conveyance corridors, potential impact mechanisms—such as groundwater withdrawal during treatment plant and portal construction or treatment plant underdrains and leakage into a conveyance line during operations—were identified and quantified. These analyses were based on proposed treatment plant and conveyance design and construction methods and on an estimated range of groundwater volumes during construction and operation.

The approach for modeling potential groundwater impacts at the treatment plant sites during both construction and operation included:

- Conservative assumptions on the vertical and horizontal extents of the aquifers. For example, at the Route 9 site, the Unconfined Shallow Aquifer beneath the site was assumed to extend infinitely and be directly connected to both the Vashon Advance Outwash Aquifer and the deeper pre-Fraser Aquifers that Cross Valley Water District uses for their well supply system.

- Selecting conservative properties that were based on site-specific soil properties and published aquifer properties from the Cross Valley Water District (which were based on in situ pump tests). For the Route 9 and Unocal sites, site specific pumping tests were not performed for this Final EIS because the assumed conservative aquifer properties adequately characterized the possible worst case conditions.

For evaluating the conveyance system, in developing aquifer parameters for the upper-bound case, consideration was given to the existing regional data versus new corridor-specific pumping tests. It was decided to use the existing regional data for the following reasons:

- The upper-bound analysis is effectively a regional model and the existing data provide a reasonable data set for the range of parameters present within the region.

- A prohibitive number of pumping tests would be necessary to approximate the existing data set, and could be less accurate.

The approach for evaluating conveyance system construction impacts was different from that used for evaluating operational impacts, and the terminology is correspondingly different. The terms *expected case* and *cumulative upper-bound case* are used for construction of the tunnel and portals and both are derived from previous, soft ground, tunneling experience. The terms *best case* and *worst case* are used for long-term operation of the conveyance system and are derived from engineering calculations based on tunnel liner permeability and the difference between internal and external pipeline hydraulic pressures.

For the conveyance system construction phase:

- The expected case reflects the top limit of the actual seepage that design team experience has shown will occur given planned methods for construction of the portals and tunnels. This seepage rate is largely independent of specific geologic conditions, and is instead governed by the construction methods and materials. In a sense, the expected rate could occur anywhere in the United States where similar construction methods are used. The rate, as described later for tunneling reaches, is 50 gallons per minute. This means that the design engineers expect groundwater inflow rates to be no higher than 50 gpm, and to actually be between 0 and 50 gpm.
- The cumulative upper-bound case was also developed for EIS purposes to provide an upper limit potential impacts during construction. Groundwater inflow rates for this case were typically 2 to 3 times higher than the expected rate. The cumulative upper-bound case is considered to be practically impossible and beyond a worst case in that it accumulates the highest possible groundwater inflow rate from each source for the entire length of the tunnel reach (section between primary portals) and assumes uniformly water-bearing sediments along this entire length. In fact, large sections of the tunnels will be constructed in non-water bearing sediments, where little or no water will enter the tunnel.

For the conveyance system operation phase:

- The best and worst case represents the range of long-term seepage expected in the conveyance system following construction. The actual seepage is expected to occur somewhere between the high- and low-end estimates. These estimates were obtained by calculating worst-case infiltration/exfiltration rates and then adjusting those rates for the expected geologic conditions and long-term tunnel integrity.

An analysis of potential effects was conducted using the upper and lower cases. Initially, a qualitative evaluation of the expected case rates for construction was conducted with the conclusion there would be little observable impact on project area aquifers at these rates. A quantitative analysis was then conducted using the higher cumulative upper-bound rates and other conservative assumptions. Results from the quantitative analysis are considered to be beyond an upper limit potential aquifer impacts, as described above. The U.S. Geological Survey code MODFLOW-96 (McDonald and Harbaugh, 1988) was used as the principal quantitative analysis tool for both construction and operation conveyance analyses.

Dewatering flows at the plant sites were computed by a variety of methods, including finite element model MicroFEM and simplified analytical methods. Further details concerning development of the numerical analysis are included in Appendix 6-B, Geology and Groundwater.

The surface water evaluation for the freshwater environment was conducted by reviewing available surface water resources documentation, water quality and quantity data, and other information characterizing the treatment plant sites and conveyance corridors. Field reconnaissance of the Unocal and Route 9 sites was conducted, and site visits were made to all portal siting areas.

The reconnaissance identified environmentally sensitive areas for purposes of siting project facilities. After site selection, detailed baseline studies would be conducted for streams, wetlands, and water bodies during the predesign process for the Brightwater System conveyance system. These studies would generate the information needed for finalizing site-specific mitigation measures.

Two numeric models were used to evaluate stormwater runoff from the treatment plant sites and for preliminary stormwater facility sizing. The stormwater runoff volumes for the 6-month statistical recurrence interval storm, used to size the water quality ponds, were estimated by the Santa Barbara Unit Hydrograph Method (Ecology 2001) as implemented by the hydrology model StormShed. The volumes and sizes of detention ponds were estimated by using Ecology (2001) Western Washington Hydrological Model (WWHM) for the Route 9 sites. Further information on these stormwater models can be found in Appendix 6-D, Permanent Stormwater Management at the Treatment Plant Sites.

Over the long term, Little Bear Creek would receive treated stormwater from the Route 9 site. An existing HSPF (Hydrologic Simulation Program-FORTRAN) (U.S. Geological Survey 1997) hydrology model for Little Bear Creek, was used to evaluate the flow impacts of the project on that creek. Additional subbasins were delineated, the pre- and post-project flows from the site were calculated, and changes in peak flows in Little Bear Creek below the project site were determined. More information on this model can be found in Appendix 6-E, Route 9 Site Runoff Effects on the Geomorphology of Little Bear Creek.

Initial dilution of secondary treated effluent in Puget Sound was estimated from EPA's PLUMES mathematical model (EPA, 2003). The modeled scenarios captured the full range of possible conditions (see Appendix 6-H, Predesign Initial Dilution Assessment).

King County used the Princeton Oceanographic Model to model effluent transport throughout the Central Basin of Puget Sound (King County 2002g). This model was applied to Puget Sound through a cooperative effort by the University of Washington and King County (King County, 2002g). The Princeton Oceanographic Model allows for the prediction of plume dilutions at locations beyond the zone of initial mixing, and accounts for effluent diffusion through the water column, and transport via tides, wind, and currents. King County estimated annual average effluent dilutions (e.g., steady-state) using the Puget Sound basin-scale model (Cokelet et al. 1991). The basin-scale model was developed and calibrated to estimate annual mean concentrations within the major basins of Puget Sound (Cokelet et al. 1991). Results from the initial dilution model, the Princeton Oceanographic Model, and the basin-scale model were combined to derive overall effluent dilutions at a variety of Puget Sound locations (Parametrix and Intertox, 2002).

Screening concentrations used to assess protection of aquatic life and human health in Puget Sound were derived from available state or federal guidelines. To address effluent constituents for which no federal or state water quality standards exist, King County established screening concentrations that would be protective of aquatic life and human health and developed criteria for assessing impacts on aquatic life. Further detail on this process is described in Appendix 6-I, Effluent Quality Evaluation for the Membrane Bioreactor and Advanced Primary System, and in Parametrix and Intertox (2002).

Potential water quality benefits associated with elimination of the outfalls for the Edmonds and Lynnwood treatment plants under the 72 mgd sub-alternative for the Unocal treatment plant are not evaluated in this Final EIS.

Sediment quality and benthic/epibenthic community structure in the two alternative outfall zones were evaluated to establish baseline conditions prior to operation of the outfall and to identify any contamination issues that would need to be addressed prior to and during construction (King County, 2002a). Sediment was collected for evaluation of sediment quality from the uppermost 3.9 inches (10 centimeters), the area of sediment in which biological activity occurs. Offshore deep surface sediment samples were collected for chemical analysis and evaluation of the benthic/epibenthic community structure from three randomly selected potential diffuser locations in each alternative outfall zone. Nearshore surface sediment samples were collected from six locations along the 20-foot bathymetric contour in the two alternative outfall zones and analyzed for the same suite of chemical analytes.

Potential impacts to sediment quality near the diffuser were assessed using two approaches. First, sediment quality and potential impacts near the diffuser for King County's south treatment plant were assessed (King County, 2001b). Second, potential changes to sediment quality were calculated based on predicted Brightwater effluent quality (Parametrix and Intertox, 2002).

6.3.1 Impacts and Mitigation Common to All Systems

6.3.1.1 Construction Impacts Common to All Systems

Construction Impacts Common to All Systems: Treatment Plant

The potential groundwater and surface water impacts associated with construction of the treatment plant are largely unique to the proposed alternatives—the Route 9 site and Unocal site—and are therefore discussed in detail in following sections pertaining to impacts specific to these alternatives.

Construction Impacts Common to All Systems: Conveyance

Construction of the conveyance system would include excavation of large-diameter tunnels and of smaller tunnels (connections to existing systems), the excavation of vertical shafts (portals) for TBM access, and some near-surface pipeline construction (connections to existing systems). Construction of underground components of the conveyance system is expected to take place largely below the water table and would therefore require groundwater control.

Subsurface construction has the potential to affect groundwater hydrology and quality in three ways:

- Movement of water between interconnected aquifers. Inadequate sealing between aquifers that are penetrated by portals or tunnels could cause groundwater to flow from the aquifer with higher head to the aquifer with lower head. This movement in turn could cause a groundwater elevation decline in the higher-head aquifer and an increase in the lower-head aquifer. This process could also cause contamination to move from one aquifer to another.
- Groundwater inflows. Groundwater inflows could cause declines in groundwater elevations outside portals or tunnels under construction, which could in turn cause reductions in spring flow, discharge to streams, or water levels in water supply wells.
- Aquifer contamination from use of chemicals. Release of fuels, lubricants, and other compounds could potentially contaminate aquifers exposed during portal or tunnel construction.

Comments on the Draft EIS questioned whether other conveyance construction activities could affect aquifers. None of the construction activities mentioned in these comments are considered as threats to the groundwater regime. These activities and the reasons that they would not impact the aquifers are as follows:

- **Groundwater flow along the outside of a tunnel would drain an aquifer**. As indicated in Appendix 3-B, Project Description: Conveyance, and Appendix 3-G, Construction Approach and Schedule, grout would be placed within any void space that may exist between the outside of the tunnel lining and the excavated earth surface. This grout would be injected, under moderate pressure, directly through the tunnel's initial lining (segments) into a void space as the tunnel excavation advances. Additionally, over time, the sediments surrounding the tunnel would compress onto the tunnel lining and grout, further sealing the structure. Because of these actions (grout filling and earth compression), groundwater would be restricted along the outside of the tunnel and would not flow along it.
- **Grouting for ground improvement purposes would reduce the permeability of an aquifer**. The volume of aquifer material that would be displaced by the tunnel and any associated grouting is insignificant relative to the total volume of aquifers in the project area. Loss of this volume therefore represents no significant impact to the groundwater resource.
- **Tunnels would block groundwater flow**. Although there is a remote chance that a portion of a tunnel segment in the conveyance system could partly block a thin water-bearing interval within the Qu Aquifer, it is highly unlikely that such a blockage would affect overall groundwater flow or aquifer yield.
- **Breaks in the conveyance tunnel or pipeline would "drain an aquifer" or release wastewater into an aquifer**. Pipelines can break if they cross a slope that experiences a major landslide. The project tunnels would generally be quite deep and be unaffected by landslides (see Chapter 4). Earthquakes typically do not damage pipelines, because the pipe tends to move with the ground. A pipe that crosses a fault along which differential movement occurs during an earthquake could be damaged. No faults with active movement are known or expected to cross any of the conveyance corridors. If, during final design, it is determined that a potentially active fault does cross the alignment, the tunnel's lining would be designed with enough ductility to withstand the design event.

Groundwater Construction Impacts Common to All Systems: Portal Siting Areas

The following analysis of portal construction impacts to groundwater focuses on primary portal siting areas only. Based on current understanding of the geology, secondary portal siting areas are not likely to be used. If deemed necessary during construction, portals at these sites would be constructed to allow ground improvement at depth or ventilation to the tunnel (after the tunnel boring machine has passed). The construction methods used to provide either ground improvement or ventilation would involve drilling using cased boreholes, similar to the type of drilling used to perform geotechnical explorations. They would not involve mass excavation or human entry. Figure 6-7 shows the locations of the proposed conveyance corridors and portal siting areas.

An understanding of groundwater conditions associated with the 72-acre portal siting areas was developed based primarily on one site-specific exploratory boring and/or extrapolation from other nearby borings and regional hydrogeologic interpretations. Characterization of groundwater conditions and associated potential groundwater impacts at candidate portal sites within the portal siting areas is not possible without additional exploratory borings. Consequently, groundwater conditions at individual candidate portal sites are not discussed in this chapter. They are addressed only in the context of the larger 72-acre portal siting areas.

A wide variety of methods are being considered for primary portal construction, as summarized in Table 6-10. All methods use structural support systems designed to prevent water from flowing through the portal walls, and combine either ground improvement or depressurization to control groundwater flow through the floor. The estimated range of groundwater inflow volumes at each primary portal is provided in Appendix 6-B, Geology and Groundwater.

The analysis of impacts to groundwater from portal construction included the potential for interconnection of aquifers, for groundwater inflow, and for contamination from use of chemicals:

- **Interconnection of aquifers**. The excavation support methods to be used for the portals are self-sealing where they penetrate aquitards and would essentially prevent flow between aquifers. Table 6-10 provides a summary of the potential for interconnection of aquifers at each of the primary portal siting areas, taking into account geologic conditions and anticipated shoring methods. The potential is deemed “none” if the portal would be completely contained within one aquifer and “negligible” if the portal would penetrate two or more aquifers with sealing of the intervening aquitards. As shown in Table 6-10, there would be negligible to no impact resulting from the interconnection of aquifers during portal construction. Mitigation measures are therefore not required.
- **Groundwater inflows during portal construction**. The results of this analysis are presented in the discussion of the individual conveyance corridors.
- **Contamination from use of construction chemicals**. Groundwater would flow into a portal during construction, thus largely preventing any released contaminants from moving out into an adjoining aquifer.

Table 6-10. Primary Portal Construction Methods and the Potential for Interconnection of Aquifers for All Conveyance Corridors

Alignment	Portal Siting Area	Estimated Portal Diameter (ft)	Estimated Portal Depth (ft)	Potential for Interconnection	Discussion	Construction Support Method / Groundwater Control
Route 9 – 195th Street Corridor	19	50	40	None	Entire shaft is within one water-bearing zone.	Interlocking steel sheetpiles/jet-grouted bottom plug
	5	30	180	Negligible	Slurry wall or concrete caisson construction would seal aquitards, separating the upper Qva Aquifer and the lower Qu Aquifers.	Concrete caisson or concrete slurry walls to 75 ft, followed by sequential excavation and concrete lining to invert
	44	50	80	Negligible	Slurry wall construction will seal the aquitard, separating the shallow Qal/Qvr Aquifer from the Qu Aquifers.	Concrete slurry wall / jet-grouted bottom plug, open sump
	41	50	90	None	Entire shaft is within the Qal/Qvr Aquifer.	Concrete slurry wall / jet-grouted bottom plug, open sump
	11	50	45	None	Entire shaft is within the Qal/Qvr Aquifer.	Interlocking steel sheetpiles, open sump
Route 9–228th Street Corridor	11	50	45	None	Entire shaft is within the Qal/Qvr Aquifer.	Interlocking steel sheetpiles, open sump
	44	50	80	Negligible	Slurry wall construction will seal the aquitard, separating the shallow Qal/Qvr Aquifer from the Qu Aquifers.	Concrete slurry wall / jet-grouted bottom plug, open sump
	41	50	90	None	Entire shaft is within the Qal/Qvr Aquifer.	Concrete slurry wall / jet-grouted bottom plug, open sump
	19	50	40	None	Entire shaft is within one water-bearing zone.	Interlocking steel sheetpiles / jet-grouted bottom plug
	26	30	200	Negligible	Ground freezing would seal shaft. Also, only the upper Qva Aquifer appears to be present; no significant Qu Aquifers at this location.	Ground freezing, local sump pump to control seepage through invert of excavation
	33	50	100	Negligible	Slurry wall construction would seal aquitards, separating the Qal/Qvr Aquifer from Qu Aquifers.	Concrete slurry wall / open sump

Table 6-10. Primary Portal Construction Methods and the Potential for Interconnection of Aquifers for All Conveyance Corridors (cont.)

Alignment	Portal Siting Area	Estimated Portal Diameter (ft)	Estimated Portal Depth (ft)	Potential for Interconnection	Discussion	Construction Support Method / Groundwater Control
Unocal Corridor	39	50	110	Negligible	Slurry wall construction would seal aquitards, separating the Qal/Qvr Aquifer from Qu Aquifers.	Concrete slurry wall / open sump
	3	30	280	Negligible	Ground freezing will seal shaft.	Ground freezing, local sump pump to control seepage through invert of excavation
	7	50	120	Negligible	Concrete slurry walls installed into impermeable soils below invert with local sump pump to de-pressurize the invert.	Concrete slurry wall / local sump to depressurize excavation bottom
	11	50	60	None	Entire shaft is within the Qal/Qvr Aquifer.	Interlocking steel sheetpiles, open sump
	14	30	50	None	Entire shaft is within the Qal/Qvr Aquifer.	Interlocking steel sheetpile / open sump

bgs = below ground surface.

Groundwater Construction Impacts Common to All Systems: Tunnels

Most of the conveyance system would be constructed by tunneling using tunnel boring machines (TBMs). Some smaller conveyance pipelines connecting to the existing wastewater system would be constructed by microtunneling. Other construction methods such as open-cut construction may also be used for constructing pipelines that connect new tunnels and pump stations to existing facilities. For a detailed discussion of each type of construction, refer to Chapter 3 and Appendix 3-B, Project Description: Conveyance.

The TBM-excavated tunnels would be lined with bolted and gasketed precast concrete segments. “Second pass” lining would be used in combined tunnel sections where influent and effluent pipes are in the same tunnel or where additional lining is required because of internal or external pressure or to control groundwater infiltration or exfiltration. The final lining, whether single pass or second pass, would be designed to ensure that there are no significant impacts to groundwater through treated effluent leakage out or groundwater leakage in.

Groundwater inflows during tunnel construction would be directed to launching portals for surface disposal. Any water generated from the construction would be treated at the portal site and discharged into local sewers, drainage culverts, or water bodies in accordance with regulatory requirements (see Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites).

The water removed from the launching portal is expected to consist mostly of water (such as cooling water) pumped into the tunnel to service the TBM operation. It is expected that the initial lining system would provide a nearly dry tunnel for this project and that significant seepage, if it does occur, would occur for a limited duration via leakage through the excavation chamber of the TBM. Total flow to launching portals, including the flows associated with portals, is expected to range between 5 and 50 gpm. Note that flows from recovery portals will be discharged separately.

A cumulative upper-bound estimate of flows was also developed (described in Appendix 6-B, Geology and Groundwater, and summarized in Table 6-11). Table 6-11 lists estimated maximum volumes associated with the various elements of tunnel inflows (TBM face, header, and liner) and provides an estimate of high-face inflow volumes. High-face inflows are relatively sudden short-lived inflows of groundwater, that are rare but that sometimes occur when the groundwater is under high head and the tunnel operation passes from a less permeable zone into a more permeable zone. High-face inflow events could occur for periods of up to 2 weeks. In Table 6-11, the upper-bound estimates are termed “maximum sustained” and the high-face inflow estimate is termed “peak for 2 weeks.”

Expected groundwater inflows are unlikely to cause any significant groundwater-level impacts because the inflow rates are relatively low and the inflow would spread laterally along some distance of tunnel. In addition, the point of highest groundwater inflow, typically the tunnel face, would constantly move as tunneling progressed; it would not remain at one location for a prolonged period. Because of these factors, impacts on aquifer levels would be temporary and likely indistinguishable from natural variations.

To be conservative and to evaluate an upper bound for groundwater impacts, a numerical analysis was performed for a cumulative upper-bound inflow case. The cumulative upper-bound case is considered to be practically impossible (beyond a worst case) because it uses the following assumptions:

- Groundwater can seep into portals and tunnels in all areas—no adjustment is made for low-permeability zones within the Qu Aquifer. This is a highly conservative assumption given the significant presence of low-permeability silts, clays, and tills throughout the project area within the pre-Fraser deposits.
- Seepage rates would be the highest estimated for each of the various flow components. This is a highly conservative assumption because summing individual upper-bound estimates results in a cumulative seepage rate that is unrealistically high.

Table 6-11. Estimated Cumulative Upper-Bound Tunnel and Primary Portal Construction Inflow Quantities for All Conveyance Corridors

Tunnel Segment	Launching Portal	Tunnel Construction Duration (years)	Combined Portal/Tunnel Discharges at Launching Portal (gpm)	
			Maximum Sustained	Peak for 2 Weeks
Route 9–195th Street				
From Portal 19 to 5	19	3.5 – 4	40 to 140	250
From Portal 44 to 5	44	4	40 to 150	250
From Portal 41 to 44	41	3.5 – 4	50to 120	250
From Portal 41 to TP	41	3	50 to 120	250
From Portal 11 to 44	11	2 – 2.5	50 to 100	250
From Kenmore PS to Portal 11 (microtunnel)	Kenmore PS	0.5	10 to 40	NA
From Swamp Cr. Int. to Portal 44	NA	1	5 to 10	NA
From N. Creek PS to 41 (microtunnel)	N.Creek PS	1	10 to 40	NA
Route 9–228th Street				
From Portal 19 to 26	19	3.5	40 to 150	250
From Portal 33 to 26	33	1	50 to 150	250
From Portal 39 to 33	39	3 – 3.5	50 to 130	250
From Portal TP to 39	TP	3	40 to 100	250
From Kenmore PS to Portal 11 (microtunnel)	Kenmore PS	0.5	10 to 40	NA
From Portal 44 to 11	44	2 – 2.5	50 to 100	250
From Portal 41 to 44	41	3 - 3.5	40 to 110	250
From Portal 41 to TP	41	2.5 – 3	50 to 120	250
From N. Creek PS to Portal 41 (microtunnel)	N. Creek PS	1	10 to 40	NA
Unocal				
From Portal 11 to 14	11	1	50 to 140	250
From Portal 7 to 11	7	3.5 – 4	50 to 140	250
From Portal 7 to 3	7	3	40 to 120	250
From Kenmore PS to Portal 11 (microtunnel)	Kenmore PS	0.5	10 to 40	NA
From N. Creek PS to 14 (microtunnel)	N.Creek PS	0.5	10 to 40	NA
From TP (Unocal) to Portal 3	TP	1	40-100	250

Summaries of the estimated cumulative upper-bound groundwater level declines for tunnel segments are presented in the following sections pertaining to the specific impacts associated with conveyance alternatives. The following is a summary of the key findings of the analysis:

- **Shallow aquifers—Qvr, Qal, and Qva Aquifers**. The results of the upper-bound analysis indicate that the maximum drawdown in the shallow aquifers during construction would be less than 1 foot at the axis of the tunnel. The declines would be progressively less with distance from the tunnel. There would therefore be no significant impact on these aquifers, springs, public water supply wells, or private wells installed in these aquifers, and no mitigation is required.
- **Deep aquifers—Qu Aquifers**. Water pressure declines in the Qu Aquifers (the Qu Aquifers are largely confined) during construction are expected to have no significant impact. Predicted cumulative upper-bound case declines are generally less than 15 feet, but range up to a maximum of 26 feet. If drawdowns were in the upper-bound range, deep private wells within a few hundred feet of the corridor could show water level declines of comparable magnitude. Wells that are further away, up to several thousand feet, could also have declining water levels, but the magnitude would be a few feet or less. A combination of the following design measures will be undertaken to prevent these impacts:

    1. The tunnel vertical profile would be raised or lowered, based on detailed geotechnical explorations, to place the tunnel within fine-grained deposits to the degree possible.

    2. Detailed geotechnical explorations will be undertaken before construction to define high-pressure water-bearing zones; tunnel design and construction will require special precautions in these areas. Special precautions include advance grouting to improve the ground and the application of full-face pressure in the TBM to control flows.

- **High-face inflow**. The numerical analysis for the cumulative upper-bound 14-day high face inflow event results in estimated short-lived drawdowns of up to 2 feet in the Qva Aquifer and of up to 132 feet in the Qu Aquifers at the point of inflow (effectively a single point in the aquifer). If these worst-case conditions were to occur, there could be short-term effects on deep public or private wells located within a few hundred feet of the inflow point. However, locations of these wells would be identified during design and the additional design and construction measures would be implemented to prevent high-face inflow in these sensitive areas. In the unlikely event that a high-face inflow event affected a local water supply well, King County would implement a potable water replacement plan (also referred to as the Water Supply Contingency Plan) (see Proposed Mitigation Common to All Systems and Chapter 17).

- **Effects on streamflow**. Under expected conditions, groundwater inflow into tunnels during construction would have little overall effect on groundwater levels or flow directions in the project area. There would be correspondingly negligible effect on surface waters, and no need for mitigation. At maximum upper-bound flow rates, there is the potential to impact five streams where the tunnels are relatively close to the ground surface: Lyon Creek, Sammamish River, Swamp Creek, North Creek, and Little Bear Creek. The potential impact at these stream crossings is discussed in more detail in following sections that cover each of the conveyance alternatives. A combination of the following design measures would be undertaken to prevent adverse impacts:

    1. The tunnel vertical profile would be raised or lowered, based on detailed geotechnical explorations, to place the tunnel within fine-grained deposits to the degree possible.

    2. Detailed geotechnical explorations would be undertaken to define the hydraulic relationship between tunnel zone and surface water, and tunnel construction specifications would be developed to protect against excessive inflows. Special precautions could include advance grouting to reduce seepage and the application of full-face pressure in the TBM to control flows.

Surface Water Construction Impacts Common to All Systems: Conveyance

Within the active construction area, construction may remove vegetative cover or otherwise disturb large areas. This would expose fresh soil to erosion from rainfall and runoff generated on the construction site. Insufficiently protected soil could be carried away in stormwater runoff or could be spread by vehicles. Eroded material that reaches surface water resources would increase turbidity, suspended and settleable solid loads, and the concentrations of nutrients and other parameters associated with the sediment. If erosion is not controlled, the Water Quality Standards for turbidity and possibly other parameters would be violated regularly. The sediment washed from the project site could settle in the receiving stream, possibly to the detriment of fish, other aquatic organisms, and habitat values. The use of construction best management practices (described in the mitigation section), along with compliance with stormwater pollution prevention plans, would minimize the possibility of erosion, turbidity, and sedimentation.

Impacts to surface water could also result from discharge of groundwater from construction dewatering to the surface water system. This disposal method would be selected if dewatering volumes are large, subsurface conditions are inappropriate for infiltration within a reasonably sized area, and there are no substantial impacts to the surface water. Release of groundwater from construction dewatering into nearby surface waters would be controlled to minimize the potential for erosion, turbidity, and sedimentation. Specific dewatering discharge locations and impacts are discussed in impacts and mitigation sections for the Route 9 and Unocal Systems.

Water Quality Construction Impacts Common to All Systems: Conveyance

Groundwater Quality

Groundwater extracted during construction can sometimes contain silt, clay, and sand (a condition referred to as turbidity), particularly during initial pumping. If this water is released to surface waters, excessive turbidity discharged to surface waters can result in undesirable impacts (such as damage to salmonid habitat) and is regulated by state Water Quality Standards. To minimize turbidity, all water from dewatering operations would pass through sediment removal facilities as needed prior to its eventual discharge either to infiltration trenches or designated receiving water bodies. After initial pumping, the turbidity level in water from pumping wells is typically very low.

A reduction in groundwater quality could result if disturbance of existing contaminated materials during construction causes these materials to migrate into surrounding groundwater. However, the potential for this to occur would be low. Because of groundwater pressures in area aquifers, water would be flowing into tunnel excavations rather than out from the excavations into the surrounding aquifer. Any contaminated water removed would be treated onsite to a level sufficient to protect the quality of the receiving stream (if discharged) or else disposed of in accordance with applicable regulations. Disposal options could include discharge to a local sewer if permitted by the local sewer utility.

The use of grout and/or a bentonite slurry may be necessary during construction of conveyance tunnels and some treatment plant structures. These materials form a seal to control the movement of groundwater into the area being excavated. A variety of materials may be used for grouting, but the most common include Portland cement and sodium silicate chemical grouts. The pH and the total dissolved solids concentration in groundwater immediately adjacent to the outer edge of the grouted zone would increase until the grout has hardened and cured or until it is removed by the tunneling machine. After the grout has cured or been removed, there would be no remaining impact to groundwater quality. Bentonite slurry—a mixture of soap, bentonite (a naturally occurring clay mineral), and polymers—typically is injected directly in front of the tunnel boring machine and is not likely to cause any effects greater than a temporary local increase in turbidity.

Ground freezing methods are planned at some portals. This method involves circulating either nitrogen or a brine solution in the area to be frozen within a closed-loop piping system. Once the ground freezing operation is completed, the pipes are removed. The brine solution typically contains sodium chloride, calcium chloride, and/or potassium chloride. Because the brine is completely contained, there is no potential for impact to groundwater quality.

Surface Water Quality

Fuel, lubricants, drilling fluids, corrosion control chemicals, odor control agents, and other substances could cause contamination of water resources. The severity of impacts would depend on the nature and quantity of the spill, the time between the event and the response, proximity of water resources to the spill site, local topography, and local geology. A wide variety of environmental impacts is possible, from temporary water quality degradation to long-term habitat damage. However, controls such as a spill prevention plan and a temporary erosion and sedimentation prevention plan, as well as observance of all applicable safety regulations for handling potentially hazardous substances, would be in place to minimize the potential for such risks.

It is also possible that existing contamination in construction areas could be disturbed during construction and could reach surface water. All contaminated areas would be addressed in accordance with regulatory guidance. Soil and groundwater contamination are known to be present at the Unocal site and are likely to be present (given current land uses) at the Route 9 site as well. Contamination is less likely to be present in deep sections of the conveyance tunnel (since they are in soils that have not been subjected to human disturbance) but could be encountered in shallower sections less than 100 feet bgs. Adherence to the controls described above (spill prevention plan, temporary erosion and sedimentation control plan, and compliance with regulations for cleanup of hazardous materials) would minimize the potential for impact.

Other than chemical contamination, groundwater pumped from relatively great depths can sometimes be low in dissolved oxygen relative to surface water. Groundwater from the lower aquifer would be tested; if dissolved oxygen were found to be low, the water would be aerated prior to discharge into streams.

Construction Impacts Common to All Systems: Outfall

On-land open-cut construction activities during outfall construction could require dewatering. Use of sheeted trench construction methods onshore is preferred to minimize the volume of excavation and disturbance of potentially contaminated soil. Groundwater control/containment methods in addition to trench sheeting will be evaluated during final design. Any groundwater withdrawn would be treated (if contamination is present) and discharged to Puget Sound.

Pile driving, placement of the outfall pipe, and spills of excavated material would disturb existing sediments in Puget Sound, creating local increases in turbidity and the potential for burial of the benthic/epibenthic community in the immediate vicinity of construction activities. Such increases in turbidity may be expected primarily during the nearshore construction of the outfall. The length of the in-water open-cut construction zone would be approximately 700 feet for Route 9 Zone 7S to 950 feet for Unocal Zone 6. The construction width of these trenches would be up to 20 feet wide in the sheeted sections, and up to 100 feet wide in the unsheeted sections. Increases in turbidity as the result of excavation would be short-term and would be quickly dissipated by the currents in the area (Ebbesmeyer et al., 2002).

Because the large-scale oceanographic features of Puget Sound (tides and currents) would affect both alternative outfall zones similarly, there would be no difference in construction impacts such as turbidity, aside from the length of the nearshore trench, between the two zones. In addition, there is no indication of contaminated sediments at either outfall zone. Therefore, localized disruption of the sediments would result only in short-term turbidity at the construction site.

Nearshore open-cut construction is anticipated to last for 2 to 3 months. The presence of sheet piling would reduce turbidity and trench width, but could result in a short-term (up to 3 months) disruption of the longshore drift along the eastern shoreline. This impact would not create significant alteration in shoreline stability or structure.

Barges would be used to transport materials and potentially to remove excavated sediment during construction of the marine outfall in both alternative outfall zones.

6.3.1.2 Operation Impacts Common to All Systems

Operation Impacts Common to All Systems: Treatment Plant

Groundwater Operation Impacts Common to All Systems: Treatment Plant

In many locations, existing groundwater is near the ground surface. Underdrains are proposed for some structures to reduce upward hydrostatic pressure from groundwater at the base of the structure; the underdrains would further lower the local groundwater surface. Conversely, stormwater infiltration ponds and swales tend to raise the groundwater surface around them. A benefit of underdrains is that contaminated groundwater from offsite sources could be detected in the underdrains, thereby providing an early warning system.

Surface Water Operation Impacts Common to All Systems: Treatment Plant

Construction of wastewater treatment facilities would result in the creation of new impervious surface area, which in turn would generate additional stormwater runoff. Impervious areas tend to increase runoff from an area while at the same time decreasing the amount of time it takes for the runoff to reach a receiving water such as a local stream. Both of these effects typically result in large increases in peak flow from a site that is converted to impervious surface. The higher and more frequent flows can, in turn, result in erosion of the stream channel, downstream sedimentation, and degradation of habitat value. In addition, water flowing over paved surfaces and highly managed landscapes can collect sediments, nutrients associated with fertilizers, metals and petroleum products associated with vehicles, and pesticides and herbicides associated with lawns and gardens. These pollutants diminish water quality and habitat values in the receiving waters. It is King County's policy to minimize or eliminate the use of pesticides and herbicides on County-maintained lands.

Stormwater runoff at the Brightwater Treatment Plant would be managed in accordance with the Ecology Manual (Ecology, 2001). The Ecology Manual guidelines indicate that if new project facilities and associated roads exceed 5,000 square feet in impervious area, the project must implement specific stormwater management measures at the site. These measures usually include construction of stormwater facilities to treat the runoff and reduce peak flows prior to leaving the project site. Runoff volume from impervious areas below this size threshold is likely to be small in comparison to the flow of adjacent surface waters and is not likely to create significant impacts. However, some jurisdictions require stormwater management measures for facilities that are smaller than the Ecology Manual threshold of 5,000 square feet. Stormwater management is highly specific to an individual project site. Further information on this topic can be found in the impacts and mitigation sections for the Route 9 and Unocal Systems.

Water discharged from the stormwater ponds may contribute to higher stream temperature during the warmer summer months, unless measures are taken to minimize the warming of the collected stormwater.

Water Quality Operation Impacts Common to All Systems: Treatment Plant

Groundwater

Leakage through cracks in the process basins, joints in the effluent piping, or cracks in the chemical storage tanks could result in leakage of untreated effluent or chemicals to the groundwater. The risk of such leakage, however, is slight, for the following reasons:

- Additional reinforcing steel would be used for crack control.
- Joints would have flexible water stops.
- Piping would have flexible connections.
- Construction specifications would require a strict quality control program.
- Hydrostatic testing would be performed on all water-holding structures.
- Routine maintenance inspections of task/structure integrity will be part of normal plant operations and maintenance.

Groundwater monitoring via the underdrain or leak detection systems would allow for prompt leak detection and repair of structures.

Surface Water

The treatment plant design would include extensive source control measures to minimize the risk of contamination from spills and leaks. The measures would be designed to prevent spills and leaks from reaching the plant's stormwater system and subsequent discharge offsite. Measures would include the following:

- Secondary containment for chemical and fuel storage tanks
- Sumps for chemical and fuel transfer areas
- Isolated drainage for areas subject to drips or spills of contaminated material, washdown areas, vehicle maintenance area(s), and the biosolids loading area

Operation Impacts Common to All Systems: Conveyance

Groundwater Operation Impacts Common to All Systems: Conveyance

Long-term groundwater leakage into a tunnel or portal structure could potentially cause water levels to decline in unconfined aquifers or water pressure to decline in confined aquifers. However, all below-grade conveyance structures would be designed to be largely watertight. Analysis indicates that long-term maximum aquifer drawdowns associated with tunnels for the best case would be one foot, and for the worst case, 5 feet. These are based on long-term infiltration rates of 166 gpm and 500 gpm, respectively, as calculated for the 195th Street alternative. See Appendix 6-B, Geology and Groundwater, for a more detailed discussion of the conveyance drawdown analysis.

The potential exists for portals to serve as a conduit for preferential flow between aquifers at different levels along the vertical shaft. This potential would be eliminated by backfilling and/or grouting to ensure that groundwater could not flow vertically.

Groundwater Water Quality Operation Impacts Common To All Systems: Conveyance

There are three potential sources of water quality impacts from tunnels during operation of the conveyance system. However, none of these potential sources is expected to result in adverse impacts. Potential impacts and the design and construction features proposed to avoid them are as follows:

- **Compounds remaining in an aquifer from grouting operations during tunnel construction**. These compounds are inert after they have cured, and thus are not a source of contamination.
- **Effluent leakage out of tunnels (exfiltration)**. The tunnel lining would be designed to meet Ecology design standards and would limit exfiltration in segments where internal tunnel pressures exceed exterior groundwater pressures. In areas where groundwater pressure exceeds tunnel pressure, any leakage would be into (rather than out of) the tunnel and thus would not affect the surrounding groundwater quality.

- **Contact of pipe and tunnel construction materials with groundwater**. All materials used for pipeline and tunnel construction would conform with strict standards of the American National Standards/NSF International (ANSI/NSF 61, a non-profit, non-governmental agency that develops standards) for materials in contact with municipal water and would therefore not adversely impact water quality.

Surface Water Operation Impacts Common to All Systems: Conveyance

Conveyance facilities would generate little stormwater runoff because the majority of these facilities would be underground. The small paved areas associated with portals would not generate significant quantities of runoff. There would be no long-term dewatering discharges to streams in the conveyance corridor.

Emergency Overflows

As noted in Chapter 3, one of the overriding purposes of the Brightwater System is to prevent emergency overflows that would occur with the existing system north of Lake Washington and the Sammamish River if Brightwater System were not built. Therefore, it is anticipated that with implementation of this project, emergency overflows would be reduced or eliminated and adverse impacts to surface water quality would be mitigated in those areas. However, to protect public and environmental health, it is necessary and prudent to plan for extreme storm events and provide a safety relief point.

For both the Route 9 and Unocal conveyance systems, a safety relief point would be located in Kenmore just below the point where the Sammamish River flows into Lake Washington. The safety relief point would be used as a last resort, only after all other flow management options had been exhausted. For the Unocal corridor and the influent portions of the Route 9 corridors, this safety relief point would discharge influent into the Sammamish River about 0.5 mile upstream of the point where the river empties into Lake Washington. Emergency overflows could occur at two other places in the system of the Unocal System is selected: (1) to Puget Sound through the Brightwater System outfall as a result of power failure at a treatment plant at the Unocal site.

In an emergency, some of the wastewater flow could be diverted to the South Treatment Plant in Renton and/or the West Point Treatment Plant in Seattle. In addition, flows could be temporarily stored at three locations in the system that have a combined storage capacity of 11.3 million gallons.

The estimated frequency of overflows is expected to be less than once every 100 years during the initial phase of the Brightwater project prior to buildout in 2050, and only once every 75 years after buildout. The project would result in a considerably lower frequency of overflows than occurs at present. The increased reliability would be accomplished through provision of multiple additional mechanical and electrical redundancies at the pump stations and through provision of additional storage volume in the new influent tunnel. During an overflow event, modeling results show that the discharge plume would likely extend the width and depth of the Sammamish River and would extend downstream approximately 3,800 feet into Lake Washington. Modeling results also show that surface water quality standards or criteria would not be met at the edge of the plume for ammonia, copper, lead, mercury, and turbidity. These water quality exceedances could last for hours or possibly days afterward. Further information on overflows can be found in Appendix 3-E, Flow Management and Safety Relief Point.

King County would lessen impacts to the Sammamish River and Lake Washington by implementing emergency cleanup actions, as appropriate. King County would monitor water quality in the vicinity of the overflow to determine when bacteria concentrations return to levels consistent with Water Quality Standards. Most contaminants would be broken down biologically or chemically or diluted, and water quality would return to its original condition. However, some pollutants, such as heavy metals or those that do not break down in water, could be retained in sediments and thus have a longer-term localized effect on Lake Washington and/or the Sammamish River.

Emergency flows discharged through the deep-water outfall as a result of power failure at the Unocal treatment plant site would be rapidly diluted into Puget Sound waters, minimizing the potential impacts. In the event of an emergency discharge to Puget Sound, King County would examine water quality in the vicinity of the discharge to assess and monitor for potential adverse impacts.

Operation Impacts Common to All Systems: Outfall

The large-scale oceanographic features that are responsible for the dilution and transport of the effluent plume during the operation of the Brightwater Treatment Plant are uniform between the two alternative outfall zones. No difference is expected in operation impacts between the two locations.

The marine outfall could discharge at a peak flow of up to 170 mgd (54 mgd alternative) or 235 mgd (72 mgd alternative for Unocal sub-alternative) of treated wastewater into Puget Sound. This input is very small (0.001 percent) relative to the total volume of Puget Sound and is not expected to impact circulation (King County, 2002g). With tidal current speeds in Puget Sound at about 1 foot per second, the discharged effluent would be quickly entrained into the tidal currents and diluted throughout Puget Sound (Ebbesmeyer, et al., 2002). Under numerous effluent discharge scenarios modeled, the median dilution at the edge of the chronic mixing zone (where discharge is regulated) ranged from 300:1 to 1,821:1 (see Appendix 6-H, Predesign Initial Dilution Assessment). Ecology guidelines recommend a minimum 100:1 dilution at the edge of the chronic mixing zone.

Small amounts of microbiological and chemical contaminants would be discharged into the marine environment. Tables 6-12 and 6-13 present the concentrations of toxicants with standards or criteria for which we have data. The concentrations listed include offshore Puget Sound Water column, estimated end-of-pipe effluent, acute and chronic standards or criteria, and the estimated concentrations expected at the edge of the acute and chronic mixing zones. Where sufficient data were available (copper, silver, diazinon, heptachlor and 4,4'-DDT), concentrations are estimated for blended MBR/APT effluent; otherwise, South Treatment Plant effluent was assumed to be the next best representation of the Brightwater Treatment Plant effluent.

As can be seen from the table estimated concentrations at the edge of the acute and chronic mixing zones meet all applicable standards or criteria. Outside the regulatory mixing zone, concentrations of these pollutants are anticipated to meet water quality criteria for the protection of aquatic life and human health for all discharge rates and environmental conditions including tidal return of previously discharged effluent (Parametrix and Intertox, 2002; Appendix 6-I, Effluent quality Evaluation for the Membrane Bioreactor and Advanced Primary System). Refer to Chapter 9 for additional discussion of water quality evaluation results relating to human health and to Chapter 7 for additional discussion of water quality evaluation results relating to plants and animals.

The discharge of Brightwater System effluent would increase the level of nutrients in the form of nitrogen into the Central Basin of Puget Sound. These nutrients could stimulate production and growth of microscopic algae. In addition to causing unsightly water conditions, such growth could deplete oxygen, with potentially harmful effects on fish and shellfish. In areas of low water circulation, nutrients can also accumulate, causing local increases in plankton. However, high flushing rates in the waters surrounding the outfall zones would minimize the opportunity for nutrients to accumulate (Ebbesmeyer, et al., 2002; Parametrix and Intertox, 2002). Additionally, the diffuser would be designed to dilute the discharged effluent and trap the discharged plume below the depth in the water column in which there is sufficient light for plankton growth.

Large-scale modeling of effluent plume transport suggests that some effluent may move into areas, such as Possession Sound, with naturally occurring low oxygen concentrations. However, any changes that may occur in oxygen levels would comply with Washington State Water Quality Standards. The maximum predicted change in dissolved oxygen concentrations from effluent discharge under any scenario was calculated to be 0.08 mg/L. This value is less than half of the allowable change in marine water dissolved oxygen (WAC 172-201A; Appendix 6-I, Effluent Quality Evaluation for the Membrane Bioreactor and Advanced Primary System). Therefore, Brightwater System effluent is not expected to contribute to ongoing low oxygen concentrations in these areas. The maximum predicted change in dissolved oxygen concentrations accounts for potential changes in sediment oxygen demand through evaluation of biochemical oxygen demand in the water column. Refer to Appendix 6-J, Effluent Quality Evaluation, Membrane Bioreactor and Advanced Primary System, for a full analysis of dissolved oxygen.

Table 6-12. Offshore Puget Sound and effluent concentrations (end-of-pipe, edge of acute and chronic mixing zones) based on minimum possible dilutions (54:1 and 131:1 for acute and chronic mixing zones, respectively).

Parameter	Mean Puget Sound Offshore Concentrations (µg/L)	End-of-Pipe Concentration (µg /L)	Edge of Acute Mixing Zone Concentration (µg /L)	Acute Standard (µg /L)	Edge of Chronic Mixing Zone Concentration (µg /L)	Chronic Standard (µg /L)
Aluminum	N/A	125	2.3088	750	0.9517	87
Antimony	0.08	<30	<0.6321	1,467	<0.3064	500
Arsenic	1.12	<56	<2.1363	69	<1.5389	36
Cadmium	0.07	<3	<0.1209	42	<0.0890	9.3
Chromium(VI)	0.006	<14	<0.2651	1,100	<0.1127	50
Copper	0.43	9.5	0.5931	4.8	0.4943	3.1
Lead	0.03	<32	<0.6196	210	<0.2716	8.1
Mercury	0.00036	0.27	0.0053	1.8	0.0024	0.025
Nickel	0.45	<24	<0.8899	74	<0.6336	8.2
Selenium	<0.15***	<50	<0.9259***	290	<0.3817***	71
Silver	<0.06***	1	0.0185***	1.9	0.0076***	0.12
Zinc	0.52	35	1.1525	90	0.7801	81
Ammonia*	21.3	<1000	<39.4241	8,235	<28.7710	1,318
Cyanide**	N/A	<20	<0.3630	9.1	<0.1496	2.8
Bis (2-ethylhexyl)phthalate	1.64	8.2	1.7611	400	1.6899	360
Chlorpyrifos	<0.032***	0.0176	0.0003***	0.011	0.0001***	0.0056
Diazinon	<0.041***	0.06	0.0011***	0.1	0.0005***	0.1
gamma-BHC (Lindane)	<0.005***	<0.048	<0.0009***	0.16	<0.0004***	0.08
Heptachlor	<0.005***	<0.050	<0.0009***	0.053	<0.0004***	0.0036
Pentachlorophenol	<0.112***	<0.95	<0.0176***	13	<0.0073***	7.9
Phenanthrene	0.022	<0.57	<0.0322	7.7	<0.0263	4.6
4,4'-DDT	<0.005***	<0.05	<0.0009***	0.13	<0.0004***	0.001

N/A = Not analyzed
*acute and chronic ammonia standards transformed from total ammonia (ug-(NH_3)/L) to ammonia-nitrogen (ug-(NH_3-N)/L)
**weak acid-dissociable CN-
***when the offshore Puget Sound concentration is below the method detection limit for a given parameter, the concentration in ambient water is unknown. Therefore, the edge of the mixing zone concentrations represent the theoretical maximum increase due to the discharge.

Table 6-13. Offshore Puget Sound and effluent concentrations (end-of-pipe, edge of acute and chronic mixing zones) based on maximum possible dilutions (1,300:1 and 10,000:1 for acute and chronic mixing zones, respectively).

Parameter	Mean Puget Sound Offshore Concentrations (µg/L)	End-of-Pipe Concentration (ug/L)	Edge of Acute Mixing Zone Concentration (ug/L)	Acute Standard (ug/L)	Edge of Chronic Mixing Zone Concentration (ug/L)	Chronic Standard (ug/L)
Aluminum	N/A	125	0.0959	750	0.0125	87
Antimony	0.08	<30	<0.1010	1,467	<0.0810	500
Arsenic	1.12	<56	<1.1622	69	<1.1255	36
Cadmium	0.07	<3	<0.0689	42	<0.0669	9.3
Chromium(VI)	0.006	<14	<0.0167	1,100	<0.0073	50
Copper	0.43	9.5	0.4320	4.8	0.4259	3.1
Lead	0.03	<32	<0.0522	210	<0.0308	8.1
Mercury	0.00036	0.27	0.0006	1.8	0.0004	0.025
Nickel	0.45	<24	<0.4720	74	<0.4562	8.2
Selenium	<0.15***	<50	<0.0385***	290	<0.0050***	71
Silver	<0.06***	1	0.0008***	1.9	0.0001***	0.12
Zinc	0.52	35	0.5453	90	0.5224	81
Ammonia*	21.3	<1000	<22.0528	8,235	<21.3979	1,318
Cyanide**	N/A	<20	<0.0151	9.1	<0.0020	2.8
Bis (2-ethylhexyl)phthalate	1.64	8.2	1.6450	400	1.6407	360
Chlorpyrifos	<0.032***	0.0176	0.00001***	0.011	0.000002***	0.0056
Diazinon	<0.041***	0.06	0.00005***	0.1	0.00001***	0.1
gamma-BHC (Lindane)	<0.005***	<0.048	0.00004***	0.16	0.000005***	0.08
Heptachlor	<0.005***	<0.050	0.00004***	0.053	0.00001***	0.0036
Pentachlorophenol	<0.112***	<0.95	<0.0007***	13	<0.0001***	7.9
Phenanthrene	0.022	<0.57	<0.0225	7.7	<0.0222	4.6
4,4'-DDT	<0.005***	<0.05	<0.00004***	0.13	<0.00001***	0.001

N/A = Not analyzed
*acute and chronic ammonia standards transformed from total ammonia (ug-(NH_3/L) to ammonia-nitrogen (ug-(NH_3-N)/L)
**weak acid-dissociable CN-
***when the offshore Puget Sound concentration is below the method detection limit for a given parameter, the concentration in ambient water is unknown. Therefore, the edge of the mixing zone concentrations represent the theoretical maximum increase due to the discharge.

Chemicals in treated effluent may contribute to contamination of the sea surface microlayer (uppermost layer of the sea surface). A literature review on the Puget Sound microlayer (Herrera and Parametrix, 2002) suggests that urban runoff in urban bays is likely the largest contributor of microlayer contamination. Analysis for the Brightwater System concluded that any chemicals released in the microlayer would be transported away from shorelines and out of Puget Sound, with minimal transport back to shoreline areas. Additional work regarding the Brightwater System's contribution to the sea surface microlayer is detailed in Appendix 6-G, Assessment of Buoyant Materials and the Microlayer.

Nutrients are sometimes suggested as possible contributors to harmful algal blooms. However, a causative link has never been established between nutrient loading and the increase in organisms that cause paralytic shellfish poisoning or the harmful algal blooms commonly known as red tides. Additional discussion of nutrients and other chemicals and their impacts to marine plants and animals is included in Chapter 7.

Salinity, turbidity, and temperature may affect water quality in Puget Sound. However, the degree of mixing between the treated effluent and Puget Sound water suggests that impacts beyond the regulatory mixing zone would be too small to measure.

Evaluation of sediments near the diffuser for King County's South Treatment Plant (King County, 2002f) shows that all chemicals meet sediment standards and no impacts to benthic organisms are observed form changes in sediment quality near the diffuser. This supports the predictions that the Brightwater outfall would not impact nearby sediments (Parametrix and Intertox 2002).

6.3.1.3 Proposed Construction Mitigation Common to All Systems

This section presents mitigation measures that would avoid or effectively reduce potential impacts to water resources from project construction. Mitigation measures for specific alternatives are presented in the impacts and mitigation sections for the Route 9 and Unocal Systems later in this chapter.

Construction Mitigation Common to All Systems: Treatment Plant

There are numerous mitigation measures that would be applicable to both the Unocal and Route 9 Treatment Plant site, even though site specific impacts may vary to some degree.

Groundwater Mitigation

Potential adverse impacts of dewatering would be mitigated either by reducing the need for dewatering or by reinfiltrating the pumped water to groundwater or discharging to surface water downgradient or away from the excavations. Also during construction dewatering, the drawdown of groundwater levels in the area of dewatering and adjacent sensitive areas will be monitored to assess the performance of the dewatering system design. These monitoring systems will provide information to assess the performance of the dewatering system and to decide if modifications to the dewatering system are necessary.

For very deep excavations, dewatering would not be required or the volume would be substantially reduced with the use of groundwater cutoff techniques. These techniques involve placement of a relatively watertight wall or barrier to limit the flow of water into the excavation. Sheetpiles, ground freezing, secant piles, and slurry walls can be installed through more permeable soils to a low-permeability soil cutoff layer. Where no suitable low-permeability cutoff layer is present, the excavation can be made "in the wet" by excavating through saturated soil inside a watertight shaft or wall enclosure, pouring a concrete seal through the water in the bottom of the excavation, and then pumping out the water. Sheetpiles, secant piles, slurry walls, and caissons are examples of soil support used with this method.

Where dewatering is used, the majority of the dewatering flows would be returned to the groundwater via infiltration and/or released to the surface water. Disposal to a sanitary sewer is also an option where permitted by the local sewer utility. Mitigation to reduce potential impacts include limiting the area (both laterally and vertically) where groundwater can be lowered, meeting turbidity and other water quality discharge standards in receiving waters, maintaining a specified minimum water level in wetlands, and monitoring compliance with these stipulations. One or more techniques, such as pump aeration or short, vertical drops in the discharge pipeline, would be used to ensure adequate aeration of the flow. Prior to construction, King County would prepare a groundwater monitoring plan for all areas considered sensitive for review and comment by resource agencies and water purveyors. Permits specifying treatment and discharge conditions would be obtained before construction.

A Water Supply Contingency Plan would be developed in case of disruption to local potable water service during construction. During construction, there may be occasions where water service to residences or businesses could be interrupted for short durations, in most cases lasting no more than a few hours. During the project design phase, King County will contact affected water purveyors to identify the potential for and coordinate any necessary system disruptions. Further geotechnical evaluation will also be conducted to assess the potential for drawdown of wells. For those areas that are identified to have a greater potential for drawdown, wells would be measured. In order to ensure all water service is accounted for, King County will also be completing an analysis to identify any unrecorded wells that could be impacted by project construction.

A number of options will be considered as mitigation for potential water system disruptions, depending on the individual situation. For short-term disruptions, bottled water would be provided or water would be trucked in. In some instances where longer-term disruptions are anticipated, temporary hookups and service would be provided. In these cases, the system and hookups would be installed prior to Brightwater construction activities to provide continuous service. King County would pay for the construction of and service for individuals connected to the temporary system. In situations involving private wells, connections would be made to nearby frontage services or new wells would be drilled if impacts were permanent. Additional discussion is provided in Chapter 6.

A number of approaches are available to treat and dispose of dewatering discharge. To further reduce particulates, a treatment chain can be employed that uses several measures such as settling ponds, bioswales, and land application in series, as in the following example:

- The dewatering discharge is pumped to a settling pond to allow for settling of larger particulate materials, and then routed through a sand filter.
- Chemical treatment occurs in the settling pond using coagulants to accelerate the removal of nearly all of the particulates suspended in the water. Chemical treatment would require Ecology approval

Once the dewatering discharge is treated to meet applicable water quality standards, it would be re-infiltrated or discharged into adjacent surface waters. Treatment and disposal methods would be selected on the basis of site-specific conditions.

Surface Water Mitigation

Erosion and sedimentation control measures suitable for the construction site conditions would be included as part of the project design to minimize sediment-laden runoff and windblown dust. A comprehensive erosion and sediment control (ESC) plan would be required before construction begins. This ESC plan would be developed as part of the project's Storm Water Pollution Prevention Plan (SWPPP) approved by Ecology and the local agency. At a minimum, the plans would include elements for controlling disturbed earth surfaces, protecting slopes and soil stockpiles, protecting and stabilizing drainage ways, and retaining sediment. All construction activity would be required to use ESC best management practices (BMPs) to minimize erosion and sedimentation impacts. The project would also be required to comply with conditions of the individual NPDES stormwater permit for construction.

The following measures may be used to prevent construction-related runoff and erosion:

- Establish access and staging areas with stabilized ground surface to reduce tracking of soils onto roadways; wash vehicle wheels; and collect washwater for proper disposal.
- Maintain vegetative growth and provide adequate surface water runoff systems.
- Minimize the area that is to be cleared and graded at one time; mark the area clearly; and schedule construction soon after clearing.
- Apply straw-bale and brush barriers, straw wattles, vegetated strips, or silt fences to treat sheet-flow shallow runoff.

- Construct temporary ponds to detain runoff waters; trap sediment from erosion-prone areas through use of gravel filter berms, geotextile-encased check dams, or other methods.
- Revegetate disturbed areas as soon as possible after completion of construction.
- Stabilize soil stockpiles with seed, sod, mulch, plastic covers, erosion control blankets, mats, chemical binders, or polyacrylamide. Between October 1 and April 30, stabilize exposed soils that have not been worked for more than 2 days. Between May 1 and September 30, stabilize exposed soils that have not been worked for more than 7 days.
- Avoid steep slopes when possible. Design, construct, and manage slopes to minimize water flow and velocity on the slope face (e.g., place straw, mulch, or commercially available erosion control blankets on slopes that require additional protection). Terrace slopes, divert flows in mid-slope, install pipe slope drains and subsurface drains, and/or roughen slope surface (e.g., straw bales) to reduce runoff velocity.
- Intercept and redirect upslope drainage around the sloped area.
- Stabilize channels and outlets for peak discharge velocities for the 2-year, 24-hour storm, using grass, riprap, or other materials. Install check dams in steeper channels. Place straw bales or silt fences to reduce runoff velocity; collect, transport, and dispose of surface runoff generated in the construction zone.
- Suppress windborne movement of soils offsite by spraying the soils with water or using other dust control materials.
- Sweep the streets or use other means to remove vehicle-tracked soil near the entrances to major construction sites. Schedule project activities to minimize erosion potential; inspect and maintain structural BMPs; monitor weather and install extra measures in anticipation of severe storms; monitor compliance with the site ESC and local regulatory requirements; remove gear and restore the site.

During construction, onsite monitoring of the erosion control facilities would be actively carried out in accordance with the SWPPP. An ESC supervisor would conduct daily inspections of erosion control measures during the wet season and weekly inspections during the dry season and inspections after large storm events. Discharges of treated stormwater would be monitored to evaluate the effectiveness of BMPs. Parameters such as turbidity, pH, temperature, and other parameters (such as soil contaminants found at the site) identified in the monitoring plan as part of the SWPPP would be monitored. Each stream that would receive runoff from project construction activities would be monitored for turbidity and temperature weekly during the dry season and daily during the wet season, both upstream and downstream of the inflows from the project site during the construction period. If increases in turbidity levels in the creek exceed 5 nephelometric turbidity units (NTUs) as the result of project discharges, measures would be undertaken to reduce turbidity levels to meet state Water Quality Standards. These measures could include advanced stormwater treatment, as necessary, to reduce the turbidity of the site discharges to compliant levels. More information can be found in

Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites.

The discharge of dewatering flows to a stream would result in increases in streamflow. This, in turn, could result in physical, chemical, or biological impacts to the receiving stream that could negatively impact the stream or its biota. To avoid this possible impact, the project would follow Ecology guidelines for dewatering releases. If dewatering discharge to a stream would be likely to exceed 10 percent of the stream's seasonal flow, a hydrologic study would be performed. This study would evaluate flow increases in the stream and the potential change in water chemistry, temperature, and other factors that could impact the stream biota. If substantial impacts on the stream or its biota are identified, the dewatering flow would be reduced to acceptable levels, and/or other means of dewatering disposal would be identified. The potential flow impacts at each treatment plant site and portal location are reviewed later in this chapter. Nitrogen and phosphorus levels in discharges to Little Bear Creek from dewatering flows would be comprised entirely of native groundwater at the site and would therefore not change from the levels in groundwater currently being discharged to the creek. These constituents could be included in the monitoring plan, as part of the SWPPP.

Water Quality Mitigation

A remedial investigation has been performed at the Unocal site (Maul, et al., 2001). The purpose of these studies was to identify areas of known or potential contamination, some of which are being cleaned up now at the Unocal site, the remainder of which would be removed during the site demolition phase.

For the Route 9 site, a records search for activities that have historically been contaminant sources (see Appendix 4-D, Phase I Environmental Site Assessment—Route 9 Parcels) has been performed, and a subsurface environmental sampling and testing program (Phase II assessment) is underway.

Groundwater monitoring wells have been installed at both the Route 9 and Unocal sites. During design, decisions will be made regarding whether the existing groundwater quality monitoring wells at these sites would be monitored during construction (or operation) as part of a contamination mitigation plan design, and whether additional groundwater quality monitoring wells would be installed.

During construction, treatment plant underdrain systems would include leak detection below the water-holding basins. Spill containment would be provided around construction fuel and chemical storage tanks. Brightwater System construction specifications would also include provisions for monitoring soil and groundwater during excavation activities, handling and disposing of contaminated soil and water if encountered, and accommodating required upgrades to worker personal protection equipment as appropriate. In addition, the construction contractor would be required to develop plans to address the handling of any hazardous materials encountered and/or any spills. These plans could include a Spill Prevention, Containment and Control Plan

(SPCCP), hazardous waste contingency plans, and stormwater pollution prevention plans as required by the plant's NPDES permit.

Construction Mitigation Common to All Systems: Conveyance

Groundwater Mitigation

The preliminary project design includes measures to avoid impacts such that the project would not adversely affect groundwater resources or water districts in the area. Therefore, additional mitigation measures are not necessary. However, some precautionary measures and contingency planning are advisable given the size and complexity of the project and the importance of the groundwater resource to area residents and the natural environment. These precautionary measures are described below.

A conveyance construction groundwater monitoring plan would be prepared prior to the initiation of tunneling; the plan would be implemented during construction. The purpose of the monitoring program is to provide early warning of declining water levels in all areas considered to be sensitive. The monitoring plan would be prepared by King County in conjunction with the appropriate regulatory agencies and other stakeholders, such as major water districts or individual well owners. It is anticipated that existing groundwater monitoring wells and piezometers would be used to the extent practicable, but that additional new monitoring wells would be installed as necessary.

Surface water monitoring would also be part of the program, either by establishing new stations or by using existing water gauging locations. In addition to this monitoring program, should a substantial short-term inflow of groundwater, such as a high face inflow, occur in a section of tunnel that lies within 100 feet of the ground surface, daily flow monitoring or daily water level monitoring will be carried out on any stream or wetland, respectively, located within one-quarter mile of the tunnel inflow. This monitoring will continue for a period of two weeks following cessation of the inflow event.

A Water Supply Contingency Plan would be developed in case of disruption to local potable water service during construction. During construction, there may be occasions where water service to residences or businesses could be interrupted for short durations, in most cases lasting no more than a few hours. During the project design phase, King County will contact affected water purveyors to identify the potential for and coordinate any necessary system disruptions. Further geotechnical evaluation will also be conducted to assess the potential for drawdown of wells. For those areas that are identified to have a greater potential for drawdown, wells would be measured. In order to ensure all water service is accounted for, King County will also be completing an analysis to identify any unrecorded wells that could be impacted by project construction.

A number of options will be considered as mitigation for potential water system disruptions, depending on the individual situation. For short-term disruptions, bottled water would be provided or water would be trucked in. In some instances where longer-term disruptions are anticipated, temporary hookups and service would be provided. In these cases, the system and hookups would be installed prior to Brightwater construction activities to provide continuous service. King County would pay for the construction of and service for individuals connected to the temporary system. In situations involving private wells, connections would be made to nearby frontage services or new wells would be drilled if impacts were permanent.

Surface Water Mitigation

Mitigation for conveyance system surface water impacts during construction would be the same as described above for the treatment plant.

Water Quality Mitigation

Mitigation for conveyance system water quality impacts during construction would be the same as described above for the treatment plant.

Construction Mitigation Common to All Systems: Outfall

To protect water quality, construction will comply with all local, state, and federal regulations concerning construction of the outfall structures. These regulations include, but are not limited to, permit requirements from the U.S. Army Corps of Engineers, Washington State Department of Natural Resources (WA DNR), Ecology, Washington State Department of Fish and Wildlife (WDFW), U.S. Fish and Wildlife Service, National Oceanographic and Atmospheric Association (NOAA) Fisheries, and all applicable shoreline regulations. King County will also coordinate with WDFW and WA DNR regarding construction methods and measures for site restoration.

On-land construction of outfall pipeline segments would utilize groundwater mitigation measures similar to those described for the treatment plant and conveyance systems.

In accordance with uniform building codes, seismic concerns will be addressed in the engineering design of structures. Geotechnical studies prepared during predesign and design will identify potential liquefaction areas and methods to limit the effects of liquefaction. Additional mitigation is outlined in Chapter 4.

All in-water construction would be subject to spill containment requirements. In the unlikely event that a construction accident releases contaminants into the environment, BMPs (such as oil booms) would be used to minimize their spread.

6.3.1.4 Proposed Operation Mitigation Common to All Systems

This section presents mitigation measures that would avoid or effectively reduce potential impacts to water resources from project operations. Specific mitigation measures for each alternative system are presented in subsequent sections of this chapter.

Operation Mitigation Common to All Systems: Treatment Plant

Groundwater Mitigation

Underdrains are commonly used beneath large water-holding basins to reduce uplift and lateral loads from groundwater. These drains lower the groundwater for some distance around the structure. Underdrains would be used only where lowering the water table would have no potential adverse impacts, such as changing the character of a wetland or significantly reducing the productivity of a water supply aquifer or where other engineered systems to counteract hydrostatic uplift pressures are more appropriate (e.g., deep foundation piling at the Unocal lower yard area).

If infiltration ponds are proposed during design, the potential increase in groundwater levels around the ponds, would be evaluated. The amount of flow to ponds would be limited, if necessary, so that locally increased water levels would not cause damage to adjacent roadways, structures, or other facilities.

Surface Water Mitigation

As noted above, the Brightwater System would be designed to incorporate stormwater management measures consistent with the Ecology Manual (Ecology, 2001) and would be operated according to the requirements of the NPDES operating permit. The manual provides guidance on both detention (to reduce peak runoff rates) and treatment (to enhance water quality prior to discharge) of stormwater generated at the site. Applicable management approaches vary based on the nature and development of the site and the receiving water into which stormwater would be discharged. The specific stormwater management approaches proposed for the Route 9 and Unocal sites are described under the impacts and mitigation sections specific to each alternative later in this chapter.

Stormwater facilities would be designed to minimize solar heating effects. Measures include north-south orientation of ponds, where feasible; establishment of trees near the edges of stormwater ponds; avoidance of rock-lined outlet channels; installation of shaded discharge channels; and introduction of cooler water (underdrain flow) where available.

Low-impact development (LID) measures would be implemented to minimize the amount of stormwater generated by the project. LID measures such as porous pavement, bioretention swales, amended soils, and green roofs would be considered for stormwater management during the project design phase. These measures slow and retain runoff on the site, reducing the amount of stormwater that must be handled by the site's stormwater facilities. Further information on LID measures can be found in Appendix 6-D, Permanent Stormwater Management at the Treatment Plant Sites.

Water Quality Mitigation

At the treatment plant site, contaminated runoff could occur at certain process locations, where there is risk of chemical spills or wastewater contact. These locations include chemical storage areas, chemical transfer locations, biosolids truck loading areas, and truck parking or maintenance areas. Material removal from the grit chamber at the headworks and the fine screens at the primary clarifiers presents another potential for spillage of contaminated material. The project will be designed to hydraulically isolate the exposed ground surfaces surrounding these areas so that local runoff or washdown water does not mix with stormwater from other portions of the site. The runoff from these isolated locations will instead either flow to a designated sump and be held for pumpout and proper disposal, or be routed to the treatment plant, where it will be fully treated and discharged in the effluent line. These comprehensive source control methods will greatly reduce, if not entirely eliminate, the potential that contaminants from the wastewater treatment process could enter the stormwater system or ultimately impact a stream.

The project design will be closely coordinated with Ecology and the local permitting agency to determine the potential implementation of LID measures and the consequent need for enhanced stormwater treatment.

With regard to the plant processes, redundant tankage, and equipment would be provided to allow isolation of individual units for inspection and repair. Process tankage would be designed with water stops at the joints to allow movement and prevent leakage. Construction specifications would require leak testing prior to acceptance to ensure that tanks are watertight before operation begins. Piping would be designed with flexible couplings to allow for differential movement over time without leakage. During operation, chemical and process treatment tankage, piping, and equipment would be dewatered, cleaned, inspected, and tested on a routine basis to prevent spills and leaks. Spill prevention and response plans would be developed to prepare for and handle leaks or spills resulting from numerous credible events, including a catastrophic seismic event. Such plans could include redirecting flows to other existing treatment plants, storing flows in conveyance tunnels, and pumping or trucking tank contents to adjacent serviceable tanks to allow for immediate repair of the damaged units. Plans would be developed to monitor conformance and to respond if a spill or leak is detected.

Operation Mitigation Common to All Systems: Conveyance

Operation of the conveyance system is not expected to adversely impact groundwater levels or quality in the project area. However, some general precautionary measures are advisable, including the following:

- Operations and maintenance. Operations and maintenance programs are already an established part of King County Wastewater Treatment Division operating protocols to ensure the ongoing integrity of large-diameter wastewater interceptors and tunnels.
- Groundwater monitoring. It may be advisable to monitor groundwater levels and groundwater quality in critical or sensitive areas for a period after construction to assure area residents of the safety of their water supply. The program could be developed as an extension of the construction monitoring program, using existing monitoring wells and surface water gauging stations, and could be co-managed and co-maintained with affected water districts or other regulatory agencies.

Operation Mitigation Common to All Systems: Outfall

Mitigation for potential effects from the discharge of treated effluent would be incorporated into the design of the treatment plant, outfall, and diffuser. The use of membrane bioreactor (MBR) treatment technology, with ballasted sedimentation for peak flows, would reduce annual loading of suspended solids to Puget Sound by about 75 percent relative to conventional activated sludge treatment. In addition, the outfall has been sited to maximize dilution of the effluent with the marine water. Performance of the outfall and diffuser would be ensured by regular maintenance, including cathodic protection monitoring and periodic visual inspection of steel pipelines. Inspection and maintenance of the cathodic protection system would be performed periodically by King County staff, and in-water inspection of the outfall would occur every 2 to 5 years.

The effluent discharge for the Brightwater System will be strictly regulated by Ecology through the NPDES operating permit. Extensive current studies and computer simulation were conducted to assure that the location and design of the outfall achieve a high level of dilution of the treated effluent. Effluent dilution achieved through mixing dynamics would enable receiving waters and marine sediment at the mixing zone to comply with current state and federal Water and Sediment Quality Standards. King County will implement numerous measures to ensure that a consistently high-quality effluent is discharged to Puget Sound. These measures include extensive training of all maintenance and operations staff, a comprehensive maintenance program throughout the entire Brightwater System, and an ongoing monitoring program of the offshore water column, marine sediments, and nearshore environment. King County’s proposed routine monitoring program for the Brightwater System marine outfall is included in Appendix 3-I, Proposed Routine Monitoring Plan for the Receiving Environment in the Vicinity of the Brightwater Treatment System Marine Outfall.

Potential Mitigation

Other potential mitigation measures for outfall operation include restoration of offsite habitat, stewardship of new or existing marine protected areas, and removal of derelict fishing gear or creosoted logs.

6.3.2 Impacts and Mitigation: Route 9 System

The following text focuses on additional impacts specific to the Route 9 treatment plant site, conveyance corridors, and outfall zone.

6.3.2.1 Treatment Plant: Route 9

Construction Impacts: Route 9 Treatment Plant

Groundwater Construction Impacts: Route 9 Treatment Plant

Groundwater was measured within a few feet of the existing ground surface at the Route 9 site. Activities in the construction phase such as site grading, excavation for structures, and construction of the influent pump station (IPS) would require lowering the groundwater level.

Treatment Structures and Site Grading

Dewatering for site grading and excavation for structures is anticipated to occur over approximately 3 years and to remove an average of 350 gpm, with a peak up to 550 gpm, of groundwater from the Shallow Unconfined Aquifer, including dewatering for IPS construction. Some increased leakage of groundwater from the Qva Aquifer and the Qu Aquifers would also occur because the hydraulic gradient through the aquitards that separate these aquifers from the Shallow Unconfined Aquifer would be increased by dewatering. However, because the permeability of these aquitards is low, the amount of leakage would be very small. Appendix 6-B, Geology and Groundwater, provides detailed plots of the calculated dewatering over time and the methods used to determine these estimates. As noted in Appendix 6-B, conservative assumptions relative to aquifer properties and connections between aquifers and aquitards have been made in modeling potential groundwater impacts in order to evaluate the "worst case". This was done to ensure that even under worst case unlikely conditions, appropriate groundwater mitigations would be available and could be successfully implemented. In addition, aquifer data and properties from the Cross Valley Water District were reviewed to assist in assigning appropriate aquifer properties for the Brightwater treatment plant groundwater analyses. The Cross Valley Water District aquifer properties were developed, in part, from in situ aquifer pump tests conducted by the District. If the Route 9 site is selected for construction of the Brightwater Treatment Plant, aquifer pump tests will be conducted during the design phase of the project to verify and refine the modeling assumptions and results. The results of the pump tests would then be used to optimize, if necessary, the groundwater mitigation approaches for construction and operation phases of the treatment plant.

Drawdown of the water table during construction of the treatment structures and site grading is expected to be substantially contained within the site boundaries as shown in Figure 6-11. Offsite drawdown of groundwater is anticipated to the north of the site as shown in figure 6-11 and is estimated at two feet or less of drawdown in the Shallow Unconfined Aquifer, and potentially the Qva Aquifer. The estimated amount of drawdown is less than seasonal fluctuations.

A portion of the groundwater removed by pumping from the Shallow Unconfined Aquifer may be reintroduced to the aquifer downgradient from the excavations in infiltration ponds associated with the temporary stormwater system. The water that cannot be infiltrated would be discharged to Little Bear Creek after testing, and treatment if necessary, to meet Water Quality Standards.

Influent Pump Station Construction

The proposed IPS construction methods and their potential effects on groundwater are discussed in detail in Appendix 6-B, Geology and Groundwater. IPS construction could require withdrawals of approximately 100 gpm to reduce pressures in a potentially artesian layer of the Qu Aquifers located approximately 115 to 160 feet below finish grade. This depressurization, which is included as a contingency only, would occur over approximately 6 to 10 months during slurry diaphragm wall construction. The upper-bound estimate of drawdown in the Qu Aquifers associated with this depressurization is shown in Figure 6-12. The potential effect at the Woodlane Well, the nearest Cross Valley Water District well, is less than 1 foot of drawdown—a very small impact.

When excavation inside the IPS shaft reaches a depth of 195 feet below finish grade, dewatering would be needed at the base of the diaphragm wall to maintain base stability. Preliminary calculations indicate that removal of approximately 100 gpm over a duration of 6 to 8 months would be needed. The water would be pumped from wells on tight spacing, screened in low-permeability deposits below the Qu Aquifers. Modeling shows that the drawdown associated with pumping from these low-permeability soils would be unmeasurable outside the immediate vicinity of the IPS. This dewatering would occur after the contingency depressurization of part of the Qu Aquifers has ceased.

Potentially, dewatering could remove groundwater that has already been contaminated by existing or former tenants at the site and this groundwater could be discharged to Little Bear Creek. To avoid this potential adverse impact, environmental assessments would be conducted during design to identify properties with potential contamination, to sample and test groundwater from the at-risk properties, and to implement a treatment plan if contamination is found.

Surface Water Construction Impacts: Route 9 Treatment Plant

Contaminated Soil

Given the history of land use at the Route 9 site, areas of contaminated soil may be present. (Refer to Chapter 4 for a discussion of onsite soil contamination.) Removal of contaminated soil during construction would be conducted in accordance with Ecology regulations. This conformance with Ecology regulations would greatly reduce but not eliminate the potential for erosion of small quantities of contaminated soil. Following completion of the project, remaining exposed soils would be revegetated.

Erosion

Construction at the Route 9 site would disturb approximately 71 acres of land associated with the treatment plant facilities. Approximately 15 additional acres north and south of the treatment plant may be disturbed to create or enhance stream and wetland buffers. The project site includes 12 piped and open water bodies that ultimately discharge to Little Bear Creek. Many of these water bodies would be relocated during site construction as part of the proposed stream enhancement mitigation. Because this relocation would require earthwork in and around the streams, there is the potential for increased sediment loads to Little Bear Creek, even with implementation and monitoring of erosion and sediment control BMPs. Significant discharges of sediments to Little Bear Creek could result in increased turbidity, suspended and settleable solid loads, and nutrient concentrations—possibly to the detriment of fish, other aquatic organisms, and habitat values.

Dewatering Effects on Little Bear Creek

Water quality impacts during construction would be regulated by Ecology under an individual NPDES construction stormwater permit.

During site construction, dewatering would produce flows averaging 0.8 cfs (350 gpm), with a peak flow of 1.2 cfs (550 gpm). Based on guidelines established by Ecology, dewatering discharges exceeding 10 percent of streamflow could cause impacts to the water quality, channel morphology, and aquatic biota of the stream. The lowest monthly average flow in Little Bear Creek is 7.3 cfs during August (Appendix 6-E, Route 9 Site Runoff Effects on the Geomorphology of Little Bear Creek). The peak dewatering discharge would add an additional 16 percent to the average August flow, exceeding the 10 percent guideline.

A geomorphologic analysis of channel stability has been conducted on the portion of Little Bear Creek adjacent to and downstream of the project site. The channel is mildly incised and somewhat over-widened, likely as a result of increased runoff due to development within the stream basin. However, there is no indication of channel down-cutting and only a minor amount of active streambank erosion. It was concluded that the channel of Little Bear Creek is relatively stable. The addition of up to 1.2 cfs of dewatering flow would not negatively affect the stability of the stream, including water quality and biota.

Little Bear Creek is on the state's 303(d) list for fecal coliform bacteria. The creek occasionally does not meet dissolved oxygen and temperature standards. Dewatering flows from the project site would consist primarily of pumped groundwater, and thus the coliform levels and water temperature would be low. The dewatering water intended for surface discharge would be piped and released to a stabilized channel near the edge of the project site. One or more techniques, such as pump aeration or short vertical drops in the pipeline, would be used to ensure adequate aeration of the flow. The flow released to Little Bear Creek would therefore meet Water Quality Standards and would preserve the water quality in the creek.

The mean concentrations of nitrate and phosphorus in Little Bear Creek are 1.28 mg/L and 0.053 mg/L, respectively. The regional mean concentrations in groundwater are generally less than 0.6 mg/L and 0.1 mg/L. Therefore, the addition of dewatering flows to Little Bear Creek is not expected to substantially change the nutrient concentrations in the creek.

Although the majority of the dewatering flow would be pumped groundwater that would have a very low level of suspended solids and a low level of turbidity (generally less than 5 NTUs), it may be necessary to pump accumulated surface water that may collect in low areas around the project site. This surface water would typically contain high levels of suspended solids, which could seriously degrade water quality. Water pumped from sumps or low-lying areas would need to be handled separately. Advanced treatment may be necessary to reduce turbidity to acceptable levels. If chemical treatment is proposed, review and approval from Ecology would be needed. Further information on water quality treatment can be found in Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites.

Operation Impacts: Route 9 Treatment Plant

Groundwater Operation Impacts: Route 9 Treatment Plant

Site grading and operation of underdrains beneath the major treatment structures would lower the local groundwater table. Long-term flow from the underdrains is estimated to be approximately 350 gpm. The drawdown is anticipated to be similar to that described for construction.

There would be no operation drawdown impacts associated with the influent pump station located at the Route 9 treatment plant site; the station would be a sealed structure capable of withstanding full hydrostatic pressures.

Over the long-term there is potential for leakage of wastewater from treatment basins and pipelines. The risk is low, however, because pressure testing of pipes and hydrostatic testing of water-holding structures would be done during construction. In addition, design would include corrosion considerations, and the underdrain systems would provide leak detection.

Surface Water Operation Impacts: Route 9 Treatment Plant

Stormwater Runoff

The stormwater system would collect runoff from the impervious surfaces at the treatment plant. The impervious surfaces would cover about 36 acres for the 54-mgd treatment plant on the Route 9 site.

The treatment plant is classified as an industrial use, and therefore the runoff would require enhanced stormwater treatment according to Ecology Manual guidelines (Ecology, 2001). Enhanced treatment as defined by Ecology includes treatment of total suspended solids and metals (including lead, copper, zinc). Detention with Ecology-specified release rates would also be required because the receiving water (Little Bear Creek) is a salmon-bearing stream. The detention facilities would be sized using the Western Washington Hydrology Model (WWHM), with stormwater treatment and release rates that emulate those of a site under forested predevelopment conditions. Using WWHM and assuming the site is in a predevelopment, forested condition, approximately 22 acre-feet of detention volume would be required for a 54-mgd plant (refer to Table 6-14). Runoff from roofs and other nonpolluting surfaces, such as the forested areas and the low-maintenance landscaping areas, would not require water quality treatment. These flows would be segregated and conveyed directly to detention. Runoff from the remaining portion of the treatment plant would be conveyed to water quality treatment facilities totaling about 2.9 acre-feet of stormwater treatment volume. More information can be found in Appendix 6-D, Permanent Stormwater Management at the Treatment Plant Sites.

The stormwater management facilities would be located along the western third of the treatment plant site, immediately downgradient from the plant. Clean runoff from roofs and other nonpolluting surfaces would be conveyed to the canal, a major architectural feature of the site, for detention. Immediately west of the canal, two stormwater quality treatment and detention systems (on either side of 228th Street) would receive runoff from the roads, parking lots, and other pollutant-generating areas on the site. These ponds would provide the required enhanced stormwater treatment. Depending on the final site layout, some underground pipe detention within the treatment plant may be provided as well. The proposed stormwater management facilities are shown in Figure 3-4 (Chapter 3) and summarized in Table 6-14. The values shown in this table are conservative in that no low impact development (LID) measures have been assumed. LID measures would be incorporated during the design phase and would likely reduce site runoff and detention requirements shown in the table.

Table 6-14. Volumes, Areas, and Peak Flow Rates of Proposed Stormwater Facilities at the Route 9 Site

Receiving water	Little Bear Creek
Detention volumes:	
Canal detention volume (acre-feet)	8
Ponds detention volume (acre-feet)	13
Underground pipes detention volume (acre-feet)	3
Total detention volume (acre-feet)	24
Water quality treatment ponds volume (acre-feet))	2.7
Total area of ponds (acres)	10
100-year design storm peak flow rate without detention (cfs)	50
100-year design storm peak flow rate with detention (cfs)	4

Stormwater released from the canal and the ponds would be conveyed along a series of shallow swales on the western side of the project site. The swales would form additional terrestrial and wetland habitat on the site and would also provide additional treatment and an opportunity for some infiltration of the stormwater. This flow would be directed into culverts under SR-9 and then to Little Bear Creek.

Most stormwater from the treatment plant site would be collected and conveyed through the stormwater management system. However, to prevent possible fuel or chemical spills, washdown water, or untreated or partially treated wastewater from entering this system, a small portion of the stormwater would be collected from the chemical loading/unloading, chemical storage, and wastewater byproduct handling areas and would be routed to the headworks of the treatment plant or other containment/treatment facility.

Only a limited amount of stormwater treatment and detention is currently provided for the existing commercial and industrial activities at the project site. The stormwater management system planned for a treatment plant at the Route 9 site would therefore provide substantially cleaner stormwater than that which currently occurs in the watercourses crossing the site. The cleaner water would improve water quality in Little Bear Creek, and the detention provided by the project would reduce peak storm flows in Little Bear Creek downstream of the project site (see below).

After construction of the 36 mgd treatment plant, permanent flow from treatment plant underdrains would be about 0.8 cfs and could be as high as 1.6 cfs under ultimate development. The underdrains would intercept flow from the shallow aquifer underlying the project site. This same aquifer contributes flow to Little Bear Creek, a short distance downgradient. The underdrain system would continue to direct this flow to the creek, and there would be little or no long-term impact to creek flow. Little Bear Creek would be monitored for a period of 5 years following construction to assure that water releases from the treatment plant site do not negatively impact the creek.

Rerouting of Watercourses

In addition to the construction impacts described previously, impacts to water resources at the Route 9 site would be caused by the rerouting of watercourses. Of the 12 watercourses and streams crossing the site, 7 are largely piped and 5 are all or mostly open channels. All would require relocation or reconfiguration for construction of the treatment plant.

The incremental historic development of the Route 9 site has resulted in the fragmentation of surface waters on the site. Much of the historically available open-channel fish habitat has been enclosed in pipes or straightened and ditched. Baseflow from watercourses has been diverted to roadside ditches. As part of the Brightwater project, Watercourses 3 through 8 would be redirected south to Howell Creek. Channels A and B (228th Street Creek) would be redirected north to Unnamed Creek.

Both Howell and Unnamed Creeks would be restored. The combined flows from the relocated streams and watercourses would be sufficient to support more surface water habitat than is presently available. Diversion of these streams and watercourses would result in increased flows within the restored Howell and Unnamed Creeks. The average monthly post-project flows in both streams would range from about 0.3 cfs in July to 1 cfs in January. The peak flows in Howell Creek would increase 50 to 100 percent. The existing 18-inch culvert conveying Howell Creek under SR-9 is inadequately sized to handle the peak flows that Howell Creek would carry after the diversions. Additional culvert capacity would need to be constructed at this location.

After the diversions, both average monthly and peak flows in Unnamed Creek would increase about fourfold. However, the creek would be rerouted 900 feet south, away from its present culvert crossing of SR-9. It would be rerouted to flow under the existing fish-passable culvert near the fish mitigation pond. The latter culvert already conveys the flows from Channels A and B and would have adequate capacity to accept the rerouted stream. The rerouting and restoration designs for both streams would take into account the increased flows. Detailed hydraulic analyses would be conducted to assure that the channel designs were adequate to handle high flow conditions while providing the flow depths and velocities to support fish habitat at lesser flows. Further information on Unnamed and Howell Creeks can be found in Appendix 6-E, Route 9 Site Runoff Effects on the Geomorphology of Little Bear Creek. More information on stream relocation can be found in Chapter 7.

Primarily as a result of the runoff detention provided by the project, there would be a 3 percent reduction in peak 100-year flow in Little Bear Creek adjacent to the project site. This would have a small beneficial effect on flooding conditions along the creek.

Relocating and combining watercourses and streams within an onsite mitigation area (see Surface Water Mitigation section below) could result in temporary increases in turbidity and sedimentation of these surface waters and Little Bear Creek, during construction; however, erosion and sediment control measures would be implemented to minimize these increases. Once the mitigation areas have been created, the amount of contaminants and sediment that currently flows into these watercourses and streams (and into Little Bear Creek) would decrease, resulting in a net benefit to the stream system. The rerouted streams would also be enhanced, providing important fish habitat onsite where little currently exists. (Refer to the Surface Water Mitigation section below for additional discussion of stream mitigation and enhancement measures.)

With the exception of the Howell Creek culvert (discussed above), the remaining culverts along SR-9, adjacent to the project site, have adequate capacity to handle the project runoff.

Floods

The Federal Emergency Management Agency Flood Insurance Rate Map (1992) indicates that approximately 0.24 acre of the site along the western boundary adjacent to SR 9 is located within the 100-year floodplain for Little Bear Creek. (A 100-year floodplain is any area that would be inundated by the peak flow that has a 1 percent chance of occurring in any given year.) Currently, the area inside the floodplain includes a parking lot, fish ladder, and the roadside conveyance ditch east of SR-9; the footprint of the treatment plant is outside the floodplain. The Brightwater Treatment Plant would be designed to withstand floods that could reasonably be projected to occur within its design lifetime. The plant would be designed in accordance with Ecology guidelines for flood-proofing. These guidelines would protect the plant against damage due to a 100-year flood but would not ensure protection against larger catastrophic events.

No permanent 100-year floodplain impacts would occur as a result of construction or operation of the plant. Stormwater conveyance facilities would be located immediately adjacent to the flood fringe, and stormwater improvements and wetland and stream mitigation would be constructed to avoid reduction of the flood storage volume provided by areas within the 100-year floodplain. Stormwater detention provided by the project would reduce flood flows by about 3 percent, slightly decreasing the area inundated by the 100-year flood.

Emergency Overflows

Emergency overflows to freshwater would not occur at the Route 9 plant site because the low point in the influent system is located in Kenmore. Under catastrophic emergency conditions, such as a complete failure of the influent pump station at Route 9, the gravity conveyance system would continue to convey flows to Route 9. The conveyance system would provide some storage until flows reached system capacity. The safety relief outfall would release excess flows to the Sammamish River and the north end of Lake Washington. Potential impacts to these water bodies are described earlier, under Impacts and Mitigation Common to All Systems.

The Route 9 site would also have the ability to temporarily route untreated effluent around the facility contained in underground piping in the case of a localized plant emergency if both primary and secondary power feeds are de-energized, the treatment plant is operating on standby power, previous flow management strategies have been utilized, and an overflow event is still imminent. In such instances, influent would be temporarily conveyed in a bypass around the plant to the effluent tunnel and combined with treated effluent until the problem could be corrected. Up to 170 mgd of dilute untreated or partially treated wastewater could bypass the treatment processes at the plant site and flow into the effluent conveyance system for eventual discharge into Puget Sound. This would result in an overflow at a deep water, offshore outfall in a highly mixed marine environment rather than in an urban freshwater body. Impacts to Puget Sound water quality are discussed in the Surface Water Operation Impacts: Unocal Treatment Plant section that follows.

Proposed Mitigation: Route 9 Treatment Plant

Construction Mitigation

Mitigation for construction of the Route 9 treatment plant would be as described under Impacts and Mitigation Common to All Systems. In addition, if temperature impacts to Little Bear Creek are detected during construction, additional potential mitigation measures could include on-site infiltration or irrigation of detained stormwater, and planting of bioswales with shading vegetation early in the construction process.

Operation Mitigation

Groundwater Mitigation: Route 9 Treatment Plant

Groundwater removed from the Shallow Unconfined Aquifer would be reintroduced by infiltration and direct discharge to the aquifer and Little Bear Creek downgradient from the excavations and underdrains. To protect the water quality of Little Bear Creek, treatment of discharges could be required in order to reduce turbidity and potential chemical contamination. One or more techniques, such as pump aeration or short vertical drops in the pipeline, would be used to ensure adequate aeration of the flow.

Surface Water Mitigation: Route 9 Treatment Plant

Up to three stormwater management systems would be constructed. One would handle clean runoff and provide detention, only. The remaining two systems would provide both water quality treatment and detention. Water released from these systems would flow to wetlands and/or swales where there would be opportunity for further treatment and infiltration. Water leaving the site would discharge to Little Bear Creek.

Onsite watercourses would be rerouted and enhanced, as discussed under Rerouting of Watercourses above. The improvements would be planned and designed in close coordination with the Washington State Department of Fish and Wildlife, Snohomish County, U.S. Fish and Wildlife Service, National Oceanographic and Atmospheric

Administration (NOAA) Fisheries, and U.S Army Corps of Engineers, all of whom have permitting authority over this project. Affected tribal government representatives will also provide input. Because of the current degraded state of onsite water resources, the mitigation plan is expected to provide water quality and habitat improvement over the existing conditions at the Route 9 site.

The restoration and enhancement of Unnamed Creek and Howell Creek would be integrated with the wetland and upland habitat mitigation areas proposed at the north and sound ends of the site, respectively (see Chapter 7). The northern mitigation area would incorporate the two tributaries of 228th Street Creek and the rerouting of Unnamed Creek. The 228th Street Creek tributaries and Unnamed Creek tributaries would be rerouted through a sinuous channel that incorporates the existing wetlands and a reconfigured fish-rearing pond. The piped portion of Unnamed Creek that now runs under a landscape business work area and driveway would be daylighted in a new channel. These rerouted streams would flow to the existing culvert that conveys 228th Street Creek to Little Bear Creek.

Howell Creek, on the south portion of the site, would be combined with the watercourses and restored to create an open-channel stream along the southern site boundary. The existing culvert under SR-9 at Howell Creek would be replaced to accommodate the additional flows and fish passage. As discussed above, the detention and water quality treatment provided to site stormwater would benefit nearby Little Bear Creek. Peak flows in this creek would be reduced, and the water quality would be expected to improve.

For a period of 5 years following the rerouting of Howell and Unnamed Creeks, the channel of these two creeks and the channel of Little Bear Creek, downstream of their inflow points, would be monitored for signs of substantial channel erosion. Adaptive management could then be used to remedy any project-related channel stability problems identified through the monitoring.

A special study of the effects on stream biota of the discharge of dewatering flows proposed for Little Bear Creek would be carried out in coordination with Ecology. The objective would be to determine a scheme for releases of dewatering flows that is protective of the biological resources of the stream.

Routine system maintenance would be sufficient to mitigate the potential risk of leaks from the treatment plant to groundwater. Maintenance would include execution of appropriate spill control procedures; routine inspection, maintenance, testing, and monitoring; and timely repairs. The pipes would be sealed using gaskets, and the piping would be connected with flexible joints to allow for differential movement without leakage. Other design features would be incorporated to provide additional protection against the potential risk of leaks to groundwater from the plant. Spill response planning would be undertaken to facilitate prompt containment and cleanup of spills of hazardous materials, as described in Chapter 9.

King County would coordinate with Snohomish County regarding measures to improve habitat in Little Bear Creek. This could include seeking opportunities to acquire, preserve, and enhance riparian buffer along the creek.

6.3.2.2 Conveyance: Route 9–195th Street Corridor

Construction Impacts: Route 9–195th Street Corridor

Groundwater Construction Impacts: Route 9–195th Street Corridor

The 195th Street conveyance corridor passes close to the Olympic View Water and Sewer District's Deer Creek Spring wellhead protection area, and through the wellhead protection area for the Lake Forest Park Water District, as shown on Figures 3-1 and 3-4 in Appendix 6-B, Geology and Groundwater. The corridor also reaches, but does not extend into, the sole source aquifer for the Cross Valley Water District, and passes by several larger Group B water systems including the Friends of Youth and the Holyrood Cemetery.

The 195th Street tunnel would cross near or beneath a number of surface water features (Lyon, McAleer, Swamp, North, and Little Bear Creeks, and Lake Ballinger) at a relatively shallow depth compared to the 228th Street tunnel. The tunnel would be within 50 feet of the base of North Creek and Swamp Creek, but 100 feet or more below the other creeks and Lake Ballinger.

Deer Creek Spring is the primary source of water for the Olympic View Water and Sewer District. Deer Creek Spring issues from the Qva Aquifer. The 195th Street corridor passes about 4,000 feet south of Deer Creek Spring and is approximately 250 feet lower in elevation.

The Lake Forest Park Water District obtains most of its supply from four deep wells in the Qu Aquifer. The district also obtains some supply from shallower wells installed in the Qva Aquifer. The 195th Street corridor passes about 2,000 feet north of the Lake Forest Park Water District's wellfield, at an elevation similar to the wellfield production zone.

Portal Siting Areas

The primary portal siting areas associated in the 195th Street corridor are shown on Figure 6-7. Potential primary portal impacts unique to the 195th Street corridor are summarized in Table 6-15. No significant impacts on groundwater and surface quality are anticipated. Each portal siting area has a number of candidate portal sites. The groundwater impacts within a portal siting area would not vary substantially among the individual candidate sites.

Secondary portal sites are considered only to allow ground improvement at depth or ventilation to the tunnel (after the tunnel boring machine has passed). The construction methods used to provide either ground improvement or ventilation involve drilling using cased boreholes, similar to the type of drilling used to perform geotechnical explorations. These methods would not involve mass excavation or human entry. Based on current understanding of the geology, secondary portals are not likely to be used.

Table 6-15. Potential Groundwater-Inflow Construction Impacts at Primary Portal Siting Areas on the Route 9–195th Street Corridor

Portal Siting Area	Water District	Estimated Drawdown (feet) at portal	Discussion
19	Olympic View Water and Sewer District	Negligible	No impact. Interlocking steel sheetpiles and jet-grouted bottom plug expected to result in < 10 gpm groundwater inflow.
5	Mountlake Terrace	Negligible	No impact. Slurry wall or concrete caisson construction expected to result in < 10 gpm groundwater inflow.
44	Northshore Utility District	Negligible	No impact. Concrete slurry wall with jet-grouted bottom plug expected to result in < 10 gpm groundwater inflow.
41	Bothell	7-60	Drawdown at 500 feet radial distance expected to be between 1 and 2 feet.
11	Northshore Utility District	8-60	Drawdown at 500 feet radial distance expected to be approximately 2 feet.

Tunnels

At expected groundwater inflow rates, there would be no significant impact to groundwater, as described in Appendix 6-B, Geology and Groundwater. Estimated cumulative upper-bound groundwater level declines related to tunnel construction are shown in Table 6-16. Even under these beyond-worst-case conditions, no significant impacts are expected to the Olympic View Water and Sewer District area during the construction phase. The cumulative upper-bound analysis for the 195th Street corridor predicts that drawdown in the Qva Aquifer at Deer Creek Spring would be less than 0.4 feet. Actual drawdown would be substantially less and would likely be indistinguishable from seasonal fluctuations in the water table. No mitigation would be required.

Table 6-16. Estimated Upper-Bound Groundwater Level Declines for the Route 9–195th Street Corridor During Construction

Segment (Launching – Recovery Portal)	Max. Drawdown at Launching Portal (ft)		Max. Drawdown at Recovery Portal (ft)	
	Qva/Qal	Qu	Qva/Qal	Qu
Portal 19 – Portal 5	0.32	6.7	0.20	12.3
Portal 44 – Portal 5	0.60	3.4	0.80	10.0
Portal 41 – Portal 44	0.65	5.3	0.72	6.6
Portal 41 – Route 9 Site	0.62	6.5	0.63	15.5
Portal 11 – Portal 44	0.30	5.2	0.67	7.3

For Lake Forest Park Water District, the cumulative upper-bound numerical analysis predicts a maximum of 7 feet of drawdown in the Qu Aquifers at the wellfield from construction of the 195th Street tunnel. Actual drawdown would be substantially less than this, given the conservative nature of the analysis. To further reduce this already limited potential, the following additional design measures would be taken:

- Additional geotechnical engineering explorations and evaluations of the 195th Street profile would be done to determine the feasibility of placing the tunnel entirely within the low-permeability deposits that appear to comprise the majority of sediments below approximately 75-foot elevation in this area. These favorable ground conditions would further reduce seepage, and lowering the elevation of the tunnel could remove it from water-bearing zones potentially connected to the Lake Forest Park Water District's wellfield production zones.
- The geotechnical investigations would also provide additional data on the hydrologic relationship between water-bearing zones along the tunnel alignment and the wellfield production zone as a means of ensuring that the final design would incorporate measures protective of the wellfield.

Potential impacts on streams related to loss of stream baseflow from tunneling along the 195th Street corridor would be as follows:

- **Swamp Creek.** The tunnel would cross beneath Swamp Creek at approximately 30 to 50 feet bgs. A thin mantle of saturated Recent Alluvium overlies saturated Vashon Recessional Outwash in this area. Leakage into the tunnel would therefore come from groundwater in the deeper outwash, and possibly from alluvium. Because of the low leakage rates predicted for even the worst-case condition and because dry-weather flows in Swamp Creek average 8.8 cfs (4,000 gpm), little effect is estimated for this stream. Therefore no mitigation is required.
- **North Creek**. The 195th Street tunnel would pass through the loose, saturated alluvial deposits (Qal Aquifer) in the North Creek Valley, within 40 feet of the

base of North Creek. Leakage into the tunnel during construction would come principally from the Qal Aquifer; and if the leakage were sufficiently large and occurred directly beneath or close to the stream, it could theoretically result in reduced North Creek flow. However, the estimated upper bound leakage along the 3,000 feet of tunnel segment crossing the North Creek Valley is 50 gpm (0.1 cfs). This rate is 0.5 percent of the 21.6 cfs average dry-weather flow rate in North Creek. Therefore no mitigation is required.

- **Little Bear Creek.** No discernible loss of groundwater recharge to the creek is anticipated. The tunnel would be constructed at least 100 feet below the base of the creek in glacially consolidated sediments. No mitigation is required.
- **Lyon and McAleer Creeks, Lake Ballinger.** There would be no impact to these water bodies, because of the great depth of the tunnel beneath land surface. No mitigation is required.

Portal 41 Influent Pump Option

Dewatering impacts for the IPS shaft would be similar although slightly greater than those described for Portal 41, given that it would be completed within the same aquifer and to approximately the same depth. The IPS excavation would be larger than the Portal 41 shaft and would be temporarily shored using slurry wall construction methods with internal bracing. Groundwater inflow volumes for the IPS excavation are expected to be in the 80 to 150 gpm range during the first 6 months of shaft construction, with lesser volumes during the remainder of the two-year construction period. Dewatering impacts at the Route 9 Treatment Plant site would be reduced by implementation of this option, because the depth of shaft construction at the treatment plant site would be substantially reduced.

Connection to the Existing Wastewater System

Connections to existing wastewater facilities would be made at portals of the influent portion of the conveyance system. Existing facilities include the Kenmore Pump Station and one local influent line (connecting at Portal 11); the North Creek Pump Station (connecting at Portal 41); and the Swamp Creek Trunk (connecting at Portal 44).

The Kenmore local sewer connection near Portal 11 would involve pipeline installation at a relatively shallow depth (average 20 feet) at the north end of Lake Washington in areas where groundwater is close to land surface. Short-duration microtunneling construction is planned for this connection and would likely encounter shallow groundwater (possibly the Qal Aquifer). Groundwater inflows of between 10 and 40 gpm are expected for this type of construction method assuming that appropriate tunneling face controls are used. There would be little impact to area aquifers associated with this withdrawal, given the short construction period and the location of withdrawal at the downgradient end of the local flow regime adjacent to the point of discharge into Lake Washington.

The Kenmore Pump Station connection to Portal 11 would be a little deeper (average 40 feet), but groundwater conditions and impacts would be similar.

The Swamp Creek Trunk would extend up the Swamp Creek valley at relatively shallow depth (average 10 feet) in areas where groundwater is close to land surface. Short-duration open-cut construction is planned for this connection and may encounter shallow groundwater (the Qal/Qvr Aquifer). Construction dewatering of between 5 and 10 gpm may be necessary in some areas to maintain a dry excavation. There would be little impact to area aquifers associated with this withdrawal because only short segments of the excavation would be open at any one time and because of the anticipated low discharge rates.

The North Creek Pump Station connection would be 30 to 40 feet deep and constructed with microtunneling methods over a period of a few months. Depending on the final location chosen for Portal 41, the connection could be completely within the Qal Aquifer in the North Creek valley or may extend partially into aquifers within older Vashon and pre-Fraser deposits flanking the valley. Groundwater inflow rates would be in the 10- to 40-gpm range. There would be no significant impact to the aquifers at these flow rates, given the short construction period, although short-term localized water level drawdowns of several tens of feet are possible along the axis of the tunnel at the higher inflow rates.

Surface Water Construction Impacts: Route 9–195th Street Corridor

Primary Portal Siting Areas

Potential construction impacts are described under Impacts and Mitigation Common to All Systems. Potential construction impacts to surface waters at primary portal siting areas along the 195th Street corridor are summarized in Table 6-17. These potential portal impacts include water quality degradation of receiving waters from erosion of excavated soils and accidental spills of petroleum products or other types of construction waste. Candidate portal sites are listed with the nearest receiving water that would receive drainage from the portal site. Figures 7-3 through 7-23 present streams, wetlands, and buffer areas on or adjacent to candidate portal sites for each portal siting area.

Table 6-17. Potential Impacts to Surface Water Resources in the Primary Portal Siting Areas on the Route 9–195th Street Corridor

Portal Siting Area	Long-term Dewatering Rate (cfs)		Receiving Water[c]	Average Monthly Stream Flow (cfs) min - max	Potential Construction Impacts	Potential Operation Impacts
	Peak[a]	Sustained Range[b]				
Potential Impacts Common to all Portals					Water quality degradation of receiving waters from erosion of excavated soils and accidental spills of petroleum products or construction waste	Potential impacts from stormwater runoff because of small (< 5,000 ft^2) increase in impervious surface
11	0.6	0.04 – 0.18	Sammamish River (sites A, B, and C)	117 - 824[d]	Same as Common to All Portals	Same as Common to All Portals; and water quality degradation from emergency overflows
41	0.6	0.04 – 0.22	North Creek (sites A and W)	3.38 - 258[e]	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge during low flow periods	Same as Common to All Portals
	0.6	0.04 – 0.22	Sammamish River tributary (sites C, D, J, and X)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
44	0.6	0.002 – 0.31	Little Swamp Creek (site E)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
	0.6	0.002 – 0.31	Little Swamp Creek tributary (sites C and D)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals

Table 6-17. Potential Impacts to Surface Water Resources in the Primary Portal Siting Areas on the Route 9–195th Street Corridor (cont.)

Portal Siting Area	Long-term Dewatering Rate (cfs)		Receiving Water[c]	Average Monthly Stream Flow (cfs) min - max	Potential Construction Impacts	Potential Operation Impacts
	Peak[a]	Sustained Range[b]				
5	NA[f]	0.002 – 0.01[g]	McAleer Creek (sites B, G, and X)	4.37 – 22.7[g]	Same as Common to All Portals	Same as Common to All Portals
19	0.6	0.02 – 0.29	Tributary to Puget Sound (sites A and C)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
	0.6	0.02 – 0.29	Barnacle Creek (site E)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals

[a] Peak rate during tunnel excavation for up to 2-week period.
[b] Range of sustained maximum rate during portal (0.5 to 1 year) and tunnel (1 to 3 years) excavation.
[c] Receiving water is the nearest surface water body that receives drainage from the candidate portal site.
[d] Ecology website, based on manual measurements 1959-1999 (Ecology, 2002)
[e] Snohomish County web site, based on hourly mean flow data from stream gauge, 1995-2001 (Snohomish County, 2002)
[f] NA = Not Applicable. Dewatering ranges are for portal dewatering only. Portal 5 will not receive tunnel dewatering discharge.
[g] King County hydrologic web site; based on daily mean flow data from stream gage for water years 1992-1994 and 2001 (King County, 2002b)

For waters that would receive dewatering discharge at Portal 44 (Little Swamp Creek and a tributary to Little Swamp Creek) Portal 41 (North Creek and a tributary to Sammamish River), and Portal 19 (Barnacle Creek and a tributary to Puget Sound), potential impacts include water quality and channel erosion impacts. Based on guidelines established by Ecology, discharges exceeding 10 percent of streamflow could cause impacts to the water quality, channel morphology, and aquatic biota of the stream (see Regulatory Environment Common to All Systems). The estimated maximum sustained dewatering rate would be greater than 10 percent of the annual average stream flow (<1 cfs) for receiving water at Portal 41 (Sammamish River tributary), 44 (Little Swamp Creek and its tributary), and 19 (Barnacle Creek and a tributary to Puget Sound). In addition, the peak dewatering discharge rate (0.6 cfs), which is expected to sustain for up to 2 weeks only, would be greater than 10 percent of the minimum monthly stream-flow of North Creek (3.38 cfs) for Portal 41. Thus, impacts from dewatering discharge could occur throughout the year at Portal 44 (Little Swamp Creek and a tributary to Little Swamp Creek), Portal 41 (tributary to Sammamish River) and Portal 19 (Barnacle Creek and a tributary to Puget Sound) and during low-flow periods at Portal 41 (North Creek).

Avoidance of sensitive areas was a factor in the evaluation of candidate portal sites and will be a factor in the selection of preferred candidate sites. If, however, candidate sites are located such that sensitive areas cannot be avoided, streams and wetlands may need to be relocated. Potential impacts associated with relocation of streams could occur at candidate portal sites 19A (a tributary to Puget Sound), and 44C and D (a tributary to Little Swamp Creek). See Chapter 7 for a presentation of potential impacts and mitigation for wetlands and fish habitat.

Decisions about specific dewatering disposal options at portal locations have not been made at this time because the final portal sites have not been selected. Potential dewatering disposal options include discharge to local stormwater systems, discharge to nearby surface water, or discharge to the sanitary sewer. See Appendix 6-F, Groundwater and Stormwater Management of the Candidate Portal Sites, for a discussion of disposal options by candidate site within the portal areas.

Secondary Portal Siting Areas

If secondary portals were used, impacts at secondary portal sites would be less than those at primary portal sites because a secondary portal would be smaller in size (one-half acre or less) and would require a shorter construction period. Dewatering would not occur at any secondary portal; therefore, there would be no potential impacts to surface waters.

Portal 41 Influent Pump Station Option

Construction-related impacts under the Portal 41 influent pump station (IPS) option would be similar to those described, above, for Portal 41. However, because of the additional area required (up to 2 acres) for the IPS, there would be an increased potential for sediment-laden runoff to enter North Creek during rain events. In addition, there would be a higher risk for spills or other leaks of fossil fuel-based materials because of the increased number of trucks and construction equipment at the site during the first 2 years of the construction period. Refer to Chapter 9 for a description of the impacts associated with spills and leaks. BMPs and policies and procedures would be implemented to ensure minimal impact to water quality.

Dewatering impacts would be similar to the types of impacts described for Portal 41, but dewatering volumes at the site would increase by 80 to150 gpm (0.2 to 0.4 cfs) during the first 6 months of the IPS shaft construction, with lesser volumes over the remainder of the 2-year construction period. Numerous options exist for dewatering discharge; the method of discharge will be determined by volume, weather, and stream conditions at the time of construction. Dewatering is discussed in detail in Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites.

Depending upon the proposed construction area, temporary stormwater management may be required.

Connection to the Existing Wastewater System

Connections to existing wastewater facilities would be made at portals on the influent portion of the 195th Street corridor. Existing facilities include the Kenmore Pump Station and a local influent line (connecting at Portal 11); the North Creek Pump Station (connecting at Portal 41); and the Swamp Creek Trunk (connecting at Portal 44). The Kenmore Pump Station and the local influent lines are located near the Sammamish River; the North Creek Pump Station is located near a tributary to the Sammamish River; and the Swamp Creek Trunk connection site is located near Little Swamp Creek. Open-cut or microtunneling construction methods would be used to construct the connecting pipes. The exact alignment of the connecting pipe would not be known until the specific portal site is selected. If a high-quality stream or wetland would be crossed, microtunneling or jack-and-bore construction methods would be used to avoid impacts. Impacts may occur to marginal or low-quality drainages, wetlands, and buffers that are located in open-cut construction areas. These impacts could include filling of wetlands and drainages, temporary water quality degradation from excavation and erosion of soils, and removal of vegetation. Significant adverse impacts to receiving surface or ground water are not anticipated, because construction BMPs and other mitigation measures are expected to reduce potential impacts to a level of non-significance. Refer to Chapter 7 for a discussion of impacts to plants and animals along the conveyance corridor.

Operation Impacts: Route 9–195th Street Corridor

Groundwater Operation Impacts: Route 9–195th Street Corridor

Portal Siting Areas

There are no impacts unique to the 195th Street corridor in terms of long-term operation impacts. See Impacts and Mitigation Common to All Systems for a discussion of operation impacts.

Tunnels

While alternatives differ in terms of system hydraulics, all tunnels will be designed to meet Ecology design standards and thus to limit exfiltration and reduce infiltration to levels that protect the aquifers. Thus, there are no impacts unique to the 195th Street corridor in terms of long-term operation impacts. See Impacts and Mitigation Common to All Systems for a discussion of operation impacts.

Surface Water Operation Impacts: Route 9–195th Street Corridor

Primary Portal Siting Areas

Potential operational impacts are described in the Impacts and Mitigation Common to All Systems section. Potential operation impacts to surface waters at primary portals of the 195th Street corridor are summarized in Table 6-15. All primary portals would have one access manhole approximately 12 feet in diameter. In addition to the access manhole, some of the primary portals would have various permanent surface structures. The undeveloped portions of each primary portal site would be revegetated. The creation of permanent structures with associated impervious surfaces would cause minor increases in stormwater runoff from the portal sites. The addition of dechlorination and odor control facilities at Portal 5 could create additional impervious surface.

Secondary Portal Siting Areas

After construction, secondary portals, if used, would be backfilled and revegetated with only a manhole remaining. The local increase in stormwater would be minimal, and no substantial impact would occur.

Portal 41 Influent Pump Station Option

Operation of the influent pump station (IPS) at Portal 41 would result in additional impervious surface area and corresponding runoff. The additional stormwater runoff would be treated and discharged in compliance with the Ecology Manual (2001), and is not expected to substantially impact surface waters. Refer to Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites, for a complete discussion of stormwater management. Location of the IPS at Portal 41 would result in an increased frequency of risk for emergency overflows compared to locating the IPS at the Route 9 site, because the amount of storage in the conveyance line would be reduced. The potential frequency of overflow could increase from once every 75-100 years if the IPS is at the Route 9 site to once every 50-75 years if the IPS is located at Portal 41. Either option provides a significantly reduced risk over current conditions.

Proposed Mitigation: Route 9–195th Street Corridor

Construction Mitigation: Route 9–195th Street Corridor

Mitigation for construction of the 195th Street conveyance corridor would be as described above under Impacts and Mitigation Common to All Systems.

An IPS at the Route 9 site would require a deep shaft to pump flows from the conveyance system to the treatment plant. Construction of the shaft would require intrusion into the Cross Valley aquifer. Locating the IPS at Portal 41 instead of at the treatment site would avoid potential impacts to this aquifer. Short-term drawdown in the near-surface aquifer would occur if the IPS were located at Portal 41.

Petroleum-contaminated groundwater could be encountered during dewatering activities for open-cut construction between Portal 19 and the outfall. Any contaminated groundwater removed would be treated and disposed of according to all applicable regulations.

No mitigation is anticipated to be necessary for construction of the connections to existing facilities beyond those described for the portal and tunnel construction.

Operation Mitigation: Route 9–195th Street Corridor

Mitigation for operation of the 195th Street conveyance tunnel would be as described above under Impacts and Mitigation Common to All Systems.

6.3.2.3 Conveyance: Route 9–228th Street Corridor

Construction Impacts: Route 9–228th Street Corridor

Groundwater Construction Impacts: Route 9–228th Street Corridor

The 228th Street corridor passes through the Olympic View Water and Sewer District's Deer Creek Spring wellhead protection area. The corridor almost reaches the wellhead protection area for the Cross Valley Water District. It passes well to the north of the Lake

Forest Park Water District's wellhead protection area, but near several larger Group B water systems.

The 228th Street tunnel also crosses near or beneath a number of surface water features (Hall, Lyon, Swamp, North, and Little Bear Creeks and Lake Ballinger) at a relatively greater depth compared to the other alternatives. The 228th Street tunnel would be at its shallowest within 50 feet bgs beneath North Creek, but 100 feet or more bgs below the other creeks and Lake Ballinger.

Deer Creek Spring is the primary source of water for the Olympic View Water and Sewer District. Deer Creek Spring issues from the Qva Aquifer. The District also has a well on the 228th Street corridor, termed the 228th Street well, which is not currently being used, but which may be in the future. The 228th Street corridor passes directly by the 228th Street wellfield and within about 3,500 feet of Deer Creek Spring at approximately 200 feet lower elevation than the spring.

The Lake Forest Park Water District derives most of its supply from four deep wells in the Qu Aquifer. Some supply is also obtained from shallower wells installed in the Qva Aquifer. The 228th Street corridor passes about 11,000 feet north of the District's wellfield (see Figure3-4 in Appendix 6-B, Geology and Groundwater).

Primary and Secondary Portal Siting Areas

The primary portal siting areas associated in the 228th Street corridor are shown on Figure 6-7. Potential primary portal impacts unique to the 228th Street corridor are summarized in Table 6-18. No significant impacts on groundwater and surface quality are anticipated. Each portal siting area has a number of candidate portal sites. The groundwater impacts within a portal siting area would not vary substantially among the individual candidate sites.

Secondary portal sites are considered only to allow ground improvement at depth or ventilation to the tunnel (after the tunnel boring machine has passed). The construction methods used to provide either ground improvement or ventilation involve drilling using cased boreholes, similar to the type of drilling used to perform geotechnical explorations. These methods would not involve mass excavation or human entry. Based on current understanding of the geology, secondary portals are not likely to be used.

Table 6-18. Potential Groundwater-Inflow Construction Impacts at Primary Portal Siting Areas on the Route 9–228th Street Corridor

Portal Siting Area	Water District	Estimated Drawdown (ft)	Discussion
11	Northshore Utility District	8 – 60	Drawdown at 500 feet radial distance expected to be between approximately 2 feet.
41	Bothell	7 - 60	Drawdown at 500 feet radial distance expected to be between 1 and 2 feet.
44	Northshore Utility District	Negligible	No impact. Concrete slurry wall with jet-grouted bottom plug expected to result in < 10 gpm groundwater inflow.
19	Olympic View Water & Sewer District	Negligible	No impact. Interlocking steel sheetpiles and jet-grouted bottom plug expected to result in < 10 gpm groundwater inflow.
26	Alderwood	Negligible	No impact. Ground freezing expected to result in < 10 gpm groundwater inflow. No impact on Qva Aquifer or on nearby Hall Creek.
33	Alderwood	Negligible	No impact. Concrete slurry wall expected to result in < 20 gpm groundwater inflow.
39	Alderwood	Negligible	No impact. Concrete slurry wall expected to result in < 20 gpm groundwater inflow. No impact to Qal or Qvr Aquifers or to North Creek.

Tunnels

At expected groundwater inflow rates, there would be no significant impact to groundwater from tunnel construction for the 228th Street conveyance system (Appendix 6-B, Geology and Groundwater). Estimated cumulative upper-bound-case groundwater level declines are shown in Table 6-19. The 228th Street tunnel would be constructed in a different aquifer (the Qu Aquifer) approximately 200 feet lower in elevation than Deer Creek Spring, the primary source of water for the Olympic View Water and Sewer District. The Qvlc Aquitard and other fine-grained pre-Fraser deposits that occur in this area provide further hydraulic separation between the spring and the tunnel. There is therefore little potential for the 228th Street tunnel to impact the spring.

The Olympic View Water and Sewer District has recently taken steps to develop its 228th Street well under an active Water Right Permit, specifically changing the original completion in the deeper Qu Aquifer to a shallower completion within the Qva Aquifer. The District still maintains a development interest in the deeper zone. The proposed 228th Street tunnel alignment passes immediately adjacent to the well, but the tunnel itself would be vertically separated from both the original deeper completion and the shallower completion by over 100 feet of fine-grained lacustrine deposits (the Qu Aquitard and the Qvlc Aquitard). There should therefore be little potential to impact this well. However, the proximity of the tunnel and well bore poses a significant public perception issue and creates a significantly higher potential for accidental impact. In addition the cumulative upper-bound analysis indicates drawdowns at the 228th Street well due to tunnel construction would be within the ranges described previously, i.e. generally less than 1 foot in the Qua Aquifer and less than 26 feet in the Qu Aquifer. Drawdowns associated with a high face inflow event would be greater, if such an event were to occur in the immediate vicinity of the well. If this alternative is selected, close construction monitoring and coordination with Olympic View Water and Sewer District would be required.

Because the 228th Street corridor passes through the area north of the Lake Forest Park Water District's wellfield at a distance of approximately 11,000 feet at its closest point, the corridor is too distant to impact the wellfield.

Other private water supply wells located within a few hundred feet of the 228th Street corridor could potentially be impacted by groundwater inflows during tunnel construction.

Table 6-19. Estimated Upper-Bound Groundwater Level Declines for the Route 9–228th Street Corridor During Construction

Segment (Launching – Recovery Portal)	Max. Drawdown at Launching Portal (ft)		Max. Drawdown at Recovery Portal (ft)	
	Qva/Qal	Qu	Qva/Qal	Qva/Qal
Portal 19 – Portal 26	0.18	7.9	0.25	12.3
Portal 33 – Portal 26	0.65	18.1	0.78	25.8
Portal 39 – Portal 33	0.56	10.1	0.52	14.1
Portal 39 – Route 9 Site	0.51	9.1	0.55	11.8
Portal 11 – Portal 44	0.30	5.2	0.67	7.3
Portal 44 – Portal 41	0.65	5.3	0.72	6.6
Portal 41 – Route 9 Site	0.62	6.5	0.63	15.5

Potential impacts on streams along the influent portion of the 228th Street corridor—Sammamish River, Swamp Creek, and North Creek—resulting from reductions in groundwater discharge during tunneling are the same as those described previously for the 195th Street corridor. Potential impacts from the effluent portion of the corridor would be as follows:

- **Little Bear Creek.** The 228th Street tunnel would pass about 50 feet below Little Bear Creek within glacial diamicton deposits of variable permeability. These deposits underlie permeable water-bearing recessional outwash deposits. Consequently, leakage into the tunnel could potentially include flow from the outwash deposits and Little Bear Creek. At maximum flow rates, up to 30 gpm of leakage could occur from the tunnel face and heading, with a small added amount through the initial lining. This represents less that 0.1 cfs, which in turn represents about 1 percent of the lowest monthly flow (7.3 cfs) in August. At these rates and considering the short period of time that the tunnel boring machine would be passing beneath the creek, there would be no discernable impact to Little Bear Creek and no mitigation required.

- **North Creek.** The 228th Street effluent tunnel would be approximately 50 feet below the creek elevation and likely within the Qal or Qvr Aquifer. Potential impacts would therefore be similar to those described for the 195th Street tunnel crossing of North Creek.
- **Swamp Creek.** The 228th Street effluent tunnel would cross beneath Swamp Creek at approximately 100 feet below ground surface, within the Qu Aquifers and Aquitards. Highly confined water-bearing zones interlayered with fine grained deposits appear to exist in the area and may hydraulically isolate the tunnel from Swamp Creek. If they do not, the 30 gpm of leakage that might be expected as the tunnel boring machine passes beneath Swamp Creek represents less than 2 percent of the lowest monthly average flow (4.95 cfs). At these rates and considering the short period of time that the tunnel boring machine would be passing beneath the creek, there would be no discernable impact to Swamp Creek and no mitigation required.
- **Lyon Creek.** The 228th Street effluent tunnel would cross beneath Lyon Creek at a depth of more than 150 feet bgs. The vertical separation between the tunnel and the creek and the presence of intervening layers of low-permeability glaciomarine drift effectively isolate surface water in Lyon Creek from groundwater at the tunnel elevation. No mitigation is therefore required.
- **Hall Creek.** The effluent tunnel would cross beneath Hall Creek approximately 200 feet bgs and would be separated from the overlying Qva Aquifer by the Qvlc Aquitard. These geologic conditions effectively isolate the tunnel from the stream. No mitigation is therefore required.

Connection to the Existing Wastewater System

Construction impacts would be similar to those discussed for the 195th Street corridor alternative.

Portal 41 Influent Pump Station Option

The impacts associated with the 228th Street corridor influent pump station option are the same as those described for the 195th Street corridor above.

Surface Water Construction Impacts: Route 9–228th Street Corridor

Primary Portal Siting Areas

Potential construction impacts for the Route 9–228th Street corridor would be similar to those for the Route 9–195th Street corridor, and may include open-cut construction impacts at locations along the influent sections for the conveyance system where connections to existing facilities are being made (as discussed above in the 195th Street corridor impacts section). Potential construction impacts to surface waters at primary portals of the 228th Street corridor are summarized in Table 6-20. Candidate portal sites are listed with the nearest receiving water that would receive drainage. Figures 7-3 through 7-23 in Chapter 7 present streams, wetlands, and buffer areas on or adjacent to candidate portal sites for each portal siting area.

For receiving waters at Portal 44 (Little Swamp Creek and a tributary to Little Swamp Creek), Portal 39 (Palm Creek), Portal 33 (West Fork Swamp Creek and a tributary to West Fork Swamp Creek), and Portal 41 (North Creek and a tributary to the Sammamish River), and Portal 19 (Barnacle Creek and a tributary to Puget Sound), potential impacts include water quality and channel erosion impacts from dewatering discharge. Based on guidelines established by Ecology, discharges exceeding 10 percent of streamflow could cause impacts to the water quality, channel morphology, and aquatic biota of the stream. The estimated maximum sustained dewatering rate would be greater than 10 percent of the annual average stream flow (< 1 cfs) for receiving water at Portal 41 (Sammamish River tributary), 44 (Little Swamp Creek and its tributary), 33 (West Fork Swamp Creek tributary), 39 (Palm Creek) and 19 (Barnacle Creek and a tributary to Puget Sound). Thus, dewatering discharge from these portal sites could impact these receiving water throughout the year. In addition, the peak dewatering discharge rate (0.6 cfs), which is expected to sustain for up to 2 weeks only, would be greater than 10 percent of the minimum monthly stream-flow for receiving water at Portal 41 (North Creek) and 33 (West Fork Swamp Creek) and thus peak discharge may impact these receiving water bodies during low flow periods.

Avoidance of sensitive areas was a factor in the evaluation of candidate portal sites and will be a factor in the selection of preferred candidate sites. If, however, candidate sites are located such that sensitive areas cannot be avoided, streams and wetlands may need to be relocated. Potential impacts associated with relocation of streams could occur at candidate portal sites 19A (a tributary to Puget Sound), 19E (Barnacle Creek and a tributary to Barnacle Creek), 26A and D (Hall Creek), 33D (West Fork Lyon Creek), 39B (Palm Creek), 41J and D (a tributary to the Sammamish River), and 44C and D (a tributary to Little Swamp Creek). See Chapter 7 for a presentation of potential impacts to and mitigation for wetlands and fish habitat. See Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites, for a discussion of dewatering discharge disposal options for candidate sites within the portal areas.

Table 6-20. Potential Impacts to Surface Water Resources in the Primary Portal Siting Areas on the Route 9–228th Street Corridor

Portal Siting Area	Long-term Dewatering Rate (cfs),		Receiving Water[c]	Average Monthly Stream Flow (cfs) min - max	Potential Construction Impacts	Potential Operation Impacts
	Peak[a]	Sustained Range[b]				
Potential Impacts Common to All Portals					Water quality degradation of receiving waters from erosion of excavated soils and accidental spills of petroleum products or construction waste	Potential impacts from stormwater runoff because of small (< 5,000 ft^2) increase in impervious surface
11	0.6	0.04 – 0.18	Sammamish River (sites A, B, and C)	117 - 824[d]	Same as Common to All Portals	Same as Common to All Portals; and water quality degradation from emergency overflows
41	0.6	0.04 – 0.22	North Creek (sites A and W)	3.38 - 258[e]	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge during low-flow periods	Same as Common to All Portals
	0.6	0.04 – 0.22	Sammamish River tributary (sites C, D, J, and X)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
44	0.6	0.002 – 0.31	Little Swamp Creek	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
	0.6	0.002 – 0.31	Little Swamp Creek tributary (sites C and D)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals

Table 6-20. Potential Impacts to Surface Water Resources in the Primary Portal Siting Areas on the Route 9–228th Street Corridor (cont.)

Portal Siting Area	Long-term Dewatering Rate (cfs),		Receiving Water[c]	Average Monthly Stream Flow (cfs) min - max	Potential Construction Impacts	Potential Operation Impacts
	Peak[a]	Sustained Range[b]				
19	0.6	0.02 – 0.29	Tributary to Puget Sound (sites A and C)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
	0.6	0.02 – 0.29	Barnacle Creek (site E)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
26	NA[f]	0.002 – 0.02	Hall Creek (sites A, C, and D)	Annual 5[g]	Same as Common to All Portals	Same as Common to All Portals
33	0.6	0.002 – 0.29	West Fork Swamp Creek (sites C and D)	4.95 - 122[h]	Same as Common to All Portals plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
	0.6	0.002 – 0.29	West Fork Swamp Creek tributary (site A)	Annual < 1 (estimated)	Same as Common to All Portals plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
39	0.6	0.002 – 0.25	Palm Creek (sites B, C, and D)	Annual < 1 (estimated)	Same as Common to All Portals plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals

[a] Peak rate during tunnel excavation for up to 2-week period.
[b] Range of sustained maximum rate during portal (0.5 to 1 year) and tunnel (1.5 to 3 years) excavation.
[c] Receiving water is nearest surface water body that receives drainage from the candidate portal site.
[d] Based on manual measurements 1959– 999 (Ecology, 2003)
[e] Based on hourly mean flow data from stream gauge, 1995–2001 (Snohomish County, 2002)
[f] NA = Not Applicable. Dewatering rates are for portal dewatering only. Portal 26 will not receive tunnel dewatering discharge.
[g] Mountlake Terrace, 1993
[h] Based on daily mean flow data from stream gauge for water years 1992-1994 and 2001 (McAleer Creek) and 1999-2002 (Swamp Creek) (King County, 2002a)

Secondary Portal Siting Areas

Potential construction impacts at secondary portals would be similar to those discussed for the 195th Street corridor.

Connection to the Existing Wastewater System

Construction impacts would be similar to those discussed for the 195th Street corridor.

Portal 41 Influent Pump Station Option

The impacts associated with the 228th Street corridor influent pump station option are the same as those described for the 195th Street corridor above.

Operation Impacts: Route 9–228th Street Corridor

Groundwater Operation Impacts: Route 9–228th Street Corridor

Portal Siting Areas

There are no impacts unique to the 228th Street corridor in terms of long-term operation impacts.

Tunnels

There would be differences among the alternatives in terms of system hydraulics. However, all would be designed to limit exfiltration and to reduce infiltration to levels that are protective of the aquifers. Thus, there are no impacts unique to the 228th Street corridor in terms of long-term operation impacts.

Surface Water Operation Impacts: Route 9–228th Street Corridor

Primary Portals

Potential operation impacts to surface waters at primary portals of the 228th Street corridor are summarized in Table 6-20. These impacts would be similar to those for the 195th Street corridor, including stormwater runoff impacts from a small (less than 5,000-square-foot) increase in the area of impervious surfaces not from the tunnel. The addition of dechlorination and odor control facilities at Portal 26 would create approximately 2,600 square feet of impervious surface.

Secondary Portals

Potential operation impacts would be similar to those for the 195th Street corridor.

Portal 41 Influent Pump Station Option

The impacts associated with the 228th Street corridor influent pump station option are the same as those described for the 195th Street corridor above.

Proposed Mitigation: Route 9–228th Street Corridor

Construction Mitigation: Route 9–228th Street Corridor

Mitigation for the construction of the 228th Street conveyance corridor would be as described above under Impacts and Mitigation Common to All Systems. If it is determined that groundwater would be discharged to Little Swamp Creek or Palm Creek, hydrologic studies would be completed to ensure that the additional flow would not impact the water quality, channel morphology, or aquatic biota of these streams.

In addition, special studies and construction measures would be implemented for the Olympic View Water and Sewer District's 228th Street well.

Operation Mitigation: Route 9–228th Street Corridor

Since there are no operation impacts unique to the 228th Street corridor, there are no unique mitigation measures.

6.3.2.4 Outfall: Route 9

Construction Impacts: Route 9 Outfall

The onshore portion of the outfall construction for the Route 9 System would traverse areas of known or suspected groundwater and soil contamination. See Appendix 6-F, Groundwater and Stormwater Management at the Candidate Portal Sites, for a discussion of dewatering discharge disposal options for Portal 19. Impacts from dewatering operations during outfall construction would be identical to those for Portal 19.

Operation Impacts: Route 9 Outfall

There are no additional operation impacts for alternative outfall Zone 7S beyond those described as common to all systems.

Proposed Mitigation: Route 9 Outfall

Additional mitigation for the alternative outfall Zone 7S could include testing to determine the presence of contaminated dewatering and treatment as necessary.

Underdrains are commonly used beneath large water-holding basins to reduce uplift and lateral loads from groundwater. These drains lower the groundwater for some distance around the structure. Underdrains would be used only where lowering the water table would have no potential adverse impacts, such as changing the character of a wetland or significantly reducing the productivity of a water supply aquifer or where other engineered systems to counteract hydrostatic uplift pressures are more appropriate (e.g., deep foundation piling at the Unocal lower yard area).

6.3.3 Impacts and Mitigation: Unocal System

6.3.3.1 Treatment Plant: Unocal

Construction Impacts: Unocal Treatment Plant

Groundwater Construction Impacts: Unocal Treatment Plant

Potential construction impacts related to groundwater include loss of water in Edmonds Marsh and Willow Creek, spreading of existing contamination, and contamination of groundwater from spills. However, the construction controls placed on this project would reduce the risk of these impacts to low levels.

Some structures located in the upper yard would penetrate local discontinuous perched groundwater zones. Local surface water infiltration is believed to be the source of these perched groundwater zones, and thus a greater quantity of water is expected to be pumped in the wet construction season than in the dry season. During the dry season, these perched groundwater layers could be pumped dry and then would likely be replenished during rainy seasons. The flow rate from construction dewatering of the perched layers is estimated to range from 0 to 100 gpm, with the average around 10 gpm over the construction period. Removal of perched water from the upper yard is anticipated to have a negligible effect on groundwater or surface water outside the plant boundaries.

Structures located in the lower yard of the Unocal site will penetrate into the more permeable regional aquifer. If the structures are to be constructed in the dry, groundwater at the structure locations would have to be lowered by as much as 32 feet for the deepest structure, with a weighted average of about 18 feet for all the structures on the lower bench. Because of the relatively high soil permeability, the use of deep wells alone to lower the water table would result in a radius of influence of approximately 1,700 feet. This drawdown would be potentially detrimental to the Edmonds Marsh, so the structures would be constructed by one of three methods so that drawdown in the marsh is no greater than 0.5 feet and so that the potential for saltwater intrusion is minimized:

1. The excavations would be dewatered with wells, but a temporary groundwater cutoff wall would be constructed around the boundary of the site, limiting the horizontal extent of drawdown to the interior of the cutoff wall. The wall would extend vertically to relatively low permeable soil layers.

2. The excavations would be dewatered with wells, with a temporary groundwater barrier wall constructed around the boundary of the site. The effectiveness of the barrier wall would be supplemented by pumping treated water from the dewatering wells back to the surface of the Edmonds Marsh. This alternative would be considered if low permeability groundwater cutoff layers were not present at a reasonable depth at the groundwater barrier/cutoff wall.

3. The structure excavations would be made “in-the-wet”, inside of tight sheet piling. When the excavations reach full depth, a concrete tremie seal would be poured at the bottom of the excavation, creating a relatively water-tight enclosure; water could be pumped from inside the enclosure with little or no effects on the groundwater outside the enclosure. Design of construction joints would be needed to accommodate the smaller excavation sizes required by this construction method.

If the Unocal site is selected, additional subsurface exploration and analyses would be undertaken to determine the most effective construction method and to outline the construction limitations and monitoring requirements to keep drawdown in the marsh less than 0.5 feet.

Cleanup of existing contamination in the lower yard is planned to start in summer or autumn of 2005. If contaminated groundwater is still present at the start of treatment plant construction, the flows would be treated prior to discharge. There is a remote chance that construction dewatering could increase soil contamination by pulling contaminated groundwater through uncontaminated or less contaminated portions of the site,. The concentrations of contaminants over the site would be assessed during design so that cleanup and the location of dewatering wells could be planned to avoid moving contamination to new areas.

Surface Water Construction Impacts: Unocal Treatment Plant

The Unocal site is adjacent to Puget Sound, Willow Creek, and Shelleberger Creek. Edmonds Marsh, adjacent to and northeast of the site, is discussed in Chapter 7.

Erosion

Construction at the Unocal site would disturb up to 48 acres, a portion of which lies within the stream buffer for Willow Creek.

The general erosion impacts are discussed in the section covering Impacts Common to All Systems. Because of its proximity to the construction area, Willow Creek could receive increased sediment loads, resulting in increased turbidity and sedimentation during construction, even with implementation and monitoring of all erosion and sediment control BMPs. Construction within the Willow Creek buffer exacerbates the risk of sediment or other construction-related pollutants reaching the creek. Additional sediment deposition in Willow Creek could lead to reduced water depth and decreased habitat value. Erosion potential at the site would be greatest during the extensive earthwork needed for site preparation of the retaining wall construction. This phase of the project is expected to last up to 3 years, and would include both the wet and dry seasons. Special erosion control measures would be implemented as described in the mitigation section below.

Dewatering

Additional site-specific investigation will be needed to confirm dewatering volumes and durations at the Unocal site. Although no data are available to indicate a hydrologic connection between groundwater at the Unocal site and Willow Creek, such a connection is possible given their proximity. If the surface-groundwater connection is shown to exist, special mitigation measures would be undertaken to prevent changes in water levels in Willow Creek and Edmonds Marsh, as described under mitigation below.

Dewatering discharge would not be routed to Willow Creek. The discharge would be routed either to the Edmonds Marsh, if needed, or Puget Sound after any required treatment, or into the City of Edmonds sanitary sewer. Because dewatering volumes are likely to exceed the maximum daily allowance for the Edmonds sanitary sewer system, excess dewatering discharge would most likely be routed to Puget Sound.

Water Quality Construction Impacts: Unocal Treatment Plant

Construction of structures at the northern edge of the site would bring equipment within 200 feet of Willow Creek; construction of the stormwater treatment facility, which would be located within the Willow Creek buffer, would bring construction equipment within 100 feet of the creek. Because of this proximity, the stream would be vulnerable if a spill or leak should occur. Any uncontained spills could migrate to the stream, with resultant potential biological and water quality effects. The potential for this to occur would increase with the 72-mgd sub-alternative, because the site footprint would increase. In the event that the 72-mgd sub-alternative is implemented, King County will work to optimize the site layout to reduce potential impacts to Willow Creek. Water quality impacts during construction would be regulated by Ecology under an individual NPDES construction stormwater permit.

Operation Impacts: Unocal Treatment Plant

Groundwater Operation Impacts: Unocal Treatment Plant

Structures founded in the Transitional Beds of the upper yard would have underdrains; the flow of perched water into these underdrains is anticipated to be very small, with negligible effects on groundwater or surface water outside of the site. The purpose of the underdrains is to provide a flow pathway away from the base of the structures. Deep structures in the lower yard would be pile-supported to penetrate through the upper liquefaction-prone soil, as well as to counteract hydrostatic uplift loads. Therefore, underdrains would not be constructed beneath structures in the lower yard. As a result, there would be no long-term impacts to groundwater levels. The buried structures would be a barrier to lateral groundwater flow. However, the area of the buried structures is small relative to the discharge area of the aquifer. At most, the groundwater level would rise by a tiny amount upgradient from the lower yard, resulting in increased flow around the structures. However, the overall regional discharge to Willow Creek and Edmonds Marsh would be unchanged.

Surface Water Operation Impacts: Unocal Treatment Plant

Stormwater Runoff

The use of the Unocal site for the project may involve co-location with the proposed Edmonds Crossing multimodal project. This sub-alternative would result in the largest amount of impervious area at the site (28 acres) and was used to conservatively calculate the required stormwater facilities for the site. The project would increase the amount of impervious surface area, which could increase peak stormwater runoff rates and volumes compared to present conditions. According to Appendix 1A of the Ecology Manual (Ecology, 2001), stormwater discharged to large bodies of water such as Puget Sound must receive basic treatment (as defined by the Ecology Manual) to reduce total suspended solids (TSS), but does not have to be detained and released at a specific rate. Therefore, no stormwater detention is proposed for this site. Stormwater treatment would be required for the 6-month, 24-hour design storm. This would require 2.9 acre-feet of treatment volume for this site.

A wet pond would be used to meet the basic treatment requirements. To allow for gravity flow, the pond would be located in the lowest part of the site, which lies along its northwestern boundary within the existing buffer of Willow Creek in an area that has been previously disturbed. The outlet from the pond would be at an elevation of 15 feet to prevent the inflow of saltwater at the highest tides. Treated stormwater would be discharged to Puget Sound via a new outfall that would discharge at a depth of 50 feet. Further information on the stormwater treatment system at the Unocal site can be found in Appendix 6-D, Permanent Stormwater Management at the Treatment Plant Sites. The wet pond could be designed to release low flows of treated stormwater to Willow Creek and Edmonds Marsh to enhance the habitat or maintain minimum creek flows.

A large stormwater pipe, known as the Edmonds Way Drain, runs beneath the Unocal site. This pipe would be relocated within the site to avoid project facilities.

The proposed stormwater management facilities for the Unocal site are shown in Figure 3-15 (Chapter 3) and are summarized in Table 6-21.

Table 6-21. Volumes, Areas, and Peak Flow Rates of Proposed Stormwater Facilities at the Unocal Site

Receiving water	Puget Sound
Detention pond volume (acre-feet)	Not required for discharge to Puget Sound
Water quality treatment pond volume (acre-feet)	2.9
Treatment pond area (acres)	1
100-year design storm peak flow rate without detention (cfs)	19
100-year design storm peak flow rate with detention (cfs)	Not required for discharge to Puget Sound

At ultimate development, if conventional activated sludge digesters are constructed in the future (refer to Chapter 3), Willow Creek along the northeastern portion of the treatment plant site would need to be relocated.

Emergency Overflows

In extreme and rare cases, emergency overflows would discharge either through the safety relief point in Kenmore or directly through the treatment plant's deep outfall. Overflows at the safety relief point at Kenmore would occur only when the new Kenmore Pump Station systems have failed and the King County emergency flow management system procedures are insufficient to contain flows in the system. Refer to the discussion under Operation Impacts Common to All Systems in this chapter for further discussion of this issue.

Overflows to Puget Sound through the outfall would occur only when the pump station is operating, the plant's primary and backup power supplies have failed, and emergency flow management system procedures are insufficient to contain flows in the system. In such an extreme situation, influent would bypass the treatment plant at the Unocal site and discharge directly to Puget Sound via a safety relief point. Use of the safety relief point would protect Willow Creek, but would temporarily affect Puget Sound. The system would include a safety relief at the influent pump station that would route the influent to the plant's effluent outfall.

Overflows at the treatment plant site would temporarily increase bacteria, nutrients, and toxicants and would decrease dissolved oxygen levels in Puget Sound. Depending on the severity of the emergency event, water quality in the vicinity of the overflow could be in violation of Washington State Water Quality Standards for bacteria for as much as a few days following the event. Releases of suspended solids and associated metals and organic contaminants during an overflow could impact marine sediments and the benthic/ epibenthic community in the immediate vicinity of the outfall diffuser. Impacts to Puget Sound would be minimized by the large amount of dilution and mixing with marine waters that would be associated with discharges from the marine outfall at a depth of about –600 feet MLLW and a distance of 5,200 to 5,750 feet from the shoreline. Receiving water would be monitored during and following an overflow event. Water quality is expected to return to its former conditions once dilution and chemical breakdown have occurred. Refer to Chapter 9 for a discussion of impacts of emergency overflows on human health.

Floods

The treatment plant would be designed to withstand floods that could reasonably be projected to occur within its design lifetime.

The Unocal site is adjacent to the Puget Sound shoreline. Elevations at the site range from +20 to +175 feet MLLW. There are no documented cases of flooding at the Unocal site. The Brightwater Treatment Plant would be designed in accordance with Ecology flood-proofing guidelines. However, these guidelines do not ensure protection against catastrophic events such as a tsunami, which would result in catastrophic impacts throughout the entire region. Because tsunamis are associated with seismic events, they are very difficult to predict. However, because tsunamis that inflict significant damage have not been documented in historical times (since about 1870) in Puget Sound and because only one has been identified in the last 2,000 years (Atwater and Moore, 1992), the recurrence interval may be much longer than 100 years. Willow Creek is not subject to flooding. However, the Edmonds Way Drain, which flows under the Unocal site, has exceeded its capacity during severe storm conditions with resultant flooding of local streets along Admiral Way. Because the Unocal site would not contribute stormwater runoff to the Edmonds Way Drain and all stormwater runoff generated by the treatment plant would be treated and discharged directly to Puget Sound, the plant construction would not increase the flooding potential in this area.

Proposed Mitigation: Unocal Treatment Plant

Construction Mitigation: Unocal Treatment Plant

If the Unocal site is selected, geotechnical borings extending at least 100 feet (or less if suitable cutoff materials can be confirmed at shallower depths) would be drilled and the type of mitigation would be selected.

In order to limit short-term drawdown in the Edmonds Marsh during dewatering for excavations in the lower yard, one of three possible mitigation measures would be implemented:

1. If a suitable low-permeability cutoff material is present within roughly 100 feet of the ground surface, tight sheet piles could be installed along the northern edge of the project site to avoid drawdown of groundwater flow from the Edmonds Marsh. The sheet piles would be removed at the completion of construction in order to restore normal groundwater flow.

2. If a suitable low-permeability cutoff material is not present, the sheet piling would be installed and a portion of the treated dewatering discharge could be pumped back to the Edmonds Marsh in order to keep groundwater levels similar to their current levels.

3. The structures in the lower yard would each be constructed inside of braced sheet piling, excavated in the wet, with a tremie (bottom) seal poured at the bottom. This construction method would require little or no dewatering outside of the sheet piles.

The pumped groundwater from the construction dewatering system would be monitored for petroleum products and other contaminants found at the site. If contaminants are found, the pumped water would be treated to remove the contaminants. Standard remediation methods for treatment would be employed to remove pollutants to a level suitable for discharge.

The groundwater level in the adjacent Edmonds Marsh would be monitored during construction. If groundwater levels in the Marsh decline by more than 0.5 foot, treated dewatering water from the project site would be piped to one or more locations within the marsh sufficient to maintain baseline hydrologic conditions.

Measures beyond those described above in Common Impacts and Mitigation Common to All Systems may be needed to protect surface water resources near the Unocal site. These would include additional erosion control at the plant perimeter near Willow Creek, such as double silt fencing.

Operation Mitigation: Unocal Treatment Plant

Operational mitigation for the Unocal treatment plant is as described under Operation Mitigation Common to All Systems: Treatment Plant. In addition, the following specific measures would be applied.

Willow Creek would be removed from the pipe that conveys the final 1,500 feet of stream to Puget Sound, and the pipe would be replaced by an open stream channel. Refer to Chapter 7 for a discussion of proposed conceptual enhancements.

A water quality pond would be constructed to treat runoff from the treatment plant site. The treated stormwater would be released directly to Puget Sound via an outfall constructed to a depth of 50 feet. Since the stormwater would be released directly to Puget Sound, no detention would be needed.

Potential Mitigation

The culvert conveying Willow Creek under Pine Street and SR-104, upstream of the Unocal site, could be replaced to provide fish passage upstream.

6.3.3.2 Conveyance: Unocal

Construction Impacts: Unocal Conveyance

Groundwater Construction Impacts: Unocal Conveyance

The Unocal corridor (Figure 6-1) passes through the Olympic View Water and Sewer District's Deer Creek Spring wellhead protection area and through the southwestern edge of the Lake Forest Park Water District's wellhead protection area. It also passes close to the wells at Holyrood Cemetery.

The Unocal tunnel also crosses near or beneath a number of surface water features (Willow, McAleer, Lyon, Swamp, and North Creeks, the Sammamish River, and Lake Ballinger) at a relatively shallow depth compared to the other alternatives. The tunnel would be within 50 feet of land surface including and east of Lyon Creek, but 100 or more feet below the other listed creeks mentioned above and Lake Ballinger.

Deer Creek Spring is the primary source of water for the Olympic View Water and Sewer District. Deer Creek Spring issues from the Qva Aquifer. The Unocal conveyance tunnel would pass within about 2,000 feet of Deer Creek Spring, approximately 150 feet lower in elevation, within the Qu Aquifers and Aquitards. The tunnel also passes within about 2,500 feet of the 228th Street well at a downgradient location.

The Lake Forest Park Water District derives most of its water supply from four deep wells installed in the Qu Aquifer. Some supply is also obtained from shallower wells in the assumed Qva Aquifer. The Unocal corridor passes about 2,200 feet southwest of the District's wellfield.

Primary and Secondary Portal Siting Areas

The primary portal siting areas associated with the Unocal influent tunnel are numbered as follows: 14, 11, 7, and 3.The secondary portal siting areas are numbered as follows: 13, 12, 10, and 5.

Potential impacts unique to the Unocal corridor are described for each primary portal in Table 6-22. Impacts at secondary portals, if needed, are expected to be less than the range of impacts at the primary portals.

Table 6-22. Potential Groundwater-Inflow Construction Impacts at Primary Portal Siting Areas on the Unocal Corridor

Portal Siting Area	Water District	Estimated Drawdown (feet) at portal	Discussion
3	Olympic View Water and Sewer District	Negligible	No Impact. Ground freezing expected to result in < 10 gpm groundwater inflow.
7	Shoreline	Negligible	No Impact. Concrete slurry wall expected to result in <20 gpm groundwater inflow.
11	Northshore Utility District	8 – 60	Drawdown at 500 feet radial distance expected to be approximately 2 feet.
14	Woodinville Water	5 – 40	Drawdown at 500 feet radial distance expected to be approximately 2 feet.

Tunnels

At expected groundwater inflow rates, there would be no significant impact to groundwater (Appendix 6-B, Geology and Groundwater). Estimated cumulative upper-bound-case groundwater level declines related to tunnel construction are shown in Table 6-23. The Unocal tunnel would be constructed in a deeper aquifer (the Qu Aquifer) than the aquifer supplying Deer Creek Spring. The Qvlc Aquitard and other fine-grained pre-Fraser deposits that occur in this area provide hydraulic separation between the spring and the tunnel. There is therefore little potential for the Unocal tunnel to impact the spring.

Table 6-23. Estimated Upper-Bound Groundwater Level Declines for the Unocal Corridor

Segment (Launching – Recovery Portal)	Maximum Drawdown at Working Portal (ft)		Maximum Drawdown at Recovery Portal (ft)	
	Qva/Qal	Qu	Qva/Qal	Qu
Unocal Site – Portal 3	0.10	6.2	0.16	11.0
Portal 3 – Portal 7	0.23	10.2	0.20	6.3
Portal 7 – Portal 11	0.50	15.5	0.30	5.7
Portal 11 – Portal 14	0.30	5.8	0.45	6.5

The Unocal corridor is located south and southwest of the Lake Forest Park Water District's wellfield at a distance of about 2,200 feet at its closest point. At this point the Unocal tunnel would lie 50 to 85 feet below the production well screens. Construction of the Unocal tunnel would therefore have no significant effect on Qu Aquifer water levels at the 5 to 50 gpm seepage rates in this tunnel segment.

The two Holyrood Cemetery wells are reportedly located about 600 and 1,600 feet south of the corridor alignment. No significant impact is expected to the two wells because they are screened at least 150 feet below the tunnel.

Potential impacts on streams along the Unocal corridor due to reductions in groundwater discharge would be as follows:

- **Sammamish River.** The easternmost portion of the Unocal corridor generally parallels the Sammamish River. In some areas the tunnel would be constructed at shallow depth within the Sammamish River valley alluvium; in other areas, the tunnel would be deeper as it penetrates highland ridges separating the Swamp Creek, unnamed creek (near Bothell), and North Creek valleys. Expected seepage rates are low along the length of this tunnel (less than 50 gpm or approximately 0.1 cfs) and are unlikely to affect the Sammamish River with lowest monthly flows averaging 117 cfs.
- **North Creek.** The impacts to North Creek would be similar to those previously described for the 195th Street corridor. No mitigation is required.
- **Swamp Creek.** The Unocal corridor crosses beneath Swamp Creek near its confluence with the Sammamish River. The potential for impact to Swamp Creek from tunneling would be similar to that described above for impacts to the Sammamish River. A numerical analysis of cumulative upper-bound seepage conditions was conducted to determine the effect on Swamp Creek. The analysis showed a maximum drawdown of less than 0.7 foot in the Qal Aquifer. This value is within the range of normal seasonal water level fluctuations expected for shallow unconfined aquifers in the area, and is consistent with expectations of little impact. No mitigation is required.
- **Lyon Creek.** The Unocal tunnel would cross beneath Lyon Creek at a depth of approximately 40 feet below the creek, which is at the base of the outwash deposits present in the Lyon Creek valley at this location. There is potential for impacts to streamflow during construction of the tunnel, and design of this segment would require a combination of the following design measures to prevent these impacts:
  - The tunnel vertical profile would be raised or lowered, based on detailed geotechnical explorations, to place the tunnel within fine-grained deposits to the degree possible.
  - Detailed geotechnical explorations would be undertaken to define the hydraulic relationship between tunnel zone and surface water. Tunnel construction specifications would be developed to protect against excessive inflows. Special precautions could include advance grouting to reduce seepage and the application of fullface pressure in the tunnel boring machine to control flows.
- **McAleer Creek, Willow Creek, and Lake Ballinger.** Tunnel construction beneath these water bodies would be within the pre-Fraser deposits. Any leakage

into the tunnel would come from the deep Qu Aquifer, not from the shallow Qva Aquifer or surface water bodies. No mitigation is required.

Connection to the Existing Wastewater System

Connections to existing facilities would be made at two portals in the Unocal corridor. Existing facilities include the Kenmore Pump Station and a local influent line (connecting at Portal Siting Area 11) and the North Creek Pump Station (connecting at Portal Siting Area 14). The impacts associated with these activities were previously described under construction impacts of the 195th Street corridor.

Surface Water Construction Impacts: Unocal Conveyance

Construction impacts for the Unocal corridor are summarized by portal siting area in Table 6-24. The data represent a worst-case scenario by identifying all of the resources within each portal area that could be affected by portal or pump station construction.

Pump Station

A new Kenmore Pump Station at Portal Siting Area 11 along the Unocal corridor would include the construction of a stormwater treatment facility. Treated runoff would be discharged to Lake Washington. Pump station construction at Portal Siting Area 11 would occur over a 2-year period and would affect up to 2 acres. The potential for sedimentation in surface waters (Lake Washington) is lower than that described for the portals because a much smaller volume of spoils would be generated. Depending on the proposed construction area, temporary stormwater management may be required.

Primary Portal Siting Areas

Potential construction impacts for the primary portals on the Unocal corridor are similar to those for the Route 9 corridors and are summarized in Table 6-24. Candidate portal sites are listed with the nearest receiving water that would receive drainage. Figures 7-8 through 7-28 in Chapter 7 present streams, wetlands, and buffer areas on or adjacent to candidate portal sites for each portal siting area.

Table 6-24. Potential Impacts to Surface Water Resources in Primary Portal Siting Areas on the Unocal Corridor

Portal Siting Area	Long-term Dewatering Rate (cfs)		Receiving Water[c]	Average Monthly Stream Flow (cfs) min - max	Potential Construction Impacts	Potential Operation Impacts
	Peak[a]	Sustained Range[b]				
Potential Impacts Common to all Portals					Water quality degradation of receiving waters from erosion of excavated soils and accidental spills of petroleum products or construction waste	Potential impacts from stormwater runoff because of small (< 5,000 ft^2) increase in impervious surface
11	0.6	0.002 – 0.27	Sammamish River (sites A, B, and C)	117 - 824[d]	Same as Common to All Portals	Same as Common to All Portals; water quality degradation from emergency overflows, and potential impacts from stormwater runoff because of increases in impervious surfaces associated with pump station
3	NA[e]	0.04 – 0.11	Puget Sound (sites D, E, and F)	not applicable	Same as Common to All Portals	Same as Common to All Portals
7	0.6	0.002 – 0.25	West Fork Lyon Creek (sites A, B, and C)	Annual < 1 (estimated)	Same as Common to All Portals plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals
14	NA[e]	0.09 – 0.18	Sammamish River tributary (sites A, B, and D)	Annual < 1 (estimated)	Same as Common to All Portals; plus water quality and channel erosion impacts from dewatering discharge	Same as Common to All Portals

[a] Peak rate during tunnel excavation for up to 2-week period.
[b] Range of sustained maximum rate during portal (0.5 to 1 year) and tunnel (1 to 2.5 years) excavation.
[c] Receiving water is nearest surface water body that receives drainage from the candidate portal site.
[d] Based on manual measurements 1959–1999 (Ecology, 2003)
[e] NA = Not Applicable. Dewatering rates are for portal dewatering only. Portals 3 and 14 will not receive tunnel dewatering discharge.

For receiving waters at Portal Siting Area 7 (West Fork Lyon Creek) and Portal Siting Area 14 (tributary of Sammamish River), potential impacts include water quality and stream channel erosion impacts from dewatering discharge. Based on guidelines established by Ecology, discharges exceeding 10 percent of streamflow could cause impacts to the water quality, channel morphology, and aquatic biota of the stream. Both maximum sustained dewatering rate and peak dewatering discharge rate (0.6 cfs) are greater than 10 percent of the average streamflow for Portal Siting Area 7 (less than 1 cfs) and Portal 14 (less than 1 cfs). Thus, impacts from dewatering discharge could occur throughout the year at Portal Siting Area 7 (West Fork Lyon Creek) and Portal Siting Area 14 (tributary of Sammamish River).

Avoidance of sensitive areas was a factor in the evaluation of candidate portal sites and will be a factor in the selection of preferred candidate sites. No required relocation of streams or wetlands has been identified on primary portal siting areas for the Unocal system alternative. See Chapter 7 for a discussion of potential impacts to and mitigation for wetlands and fish habitat.

Secondary Portal Siting Areas

Potential construction impacts for the secondary portals on the Unocal corridor are similar to those discussed for the Route 9 corridors.

Connection to the Existing Wastewater System

Connections to existing facilities would be made at two portals. Existing facilities include the Kenmore Pump Station and two local influent lines (connecting at Portal Siting Area 11) and the North Creek Pump Station (connecting at Portal Siting Area 14). The Kenmore Pump Station and the local influent lines are located near the Sammamish River; the North Creek Pump Station is located near a tributary to the Sammamish River. Construction impacts would be similar to those discussed for the 195th Street corridor.

Operation Impacts: Unocal Conveyance

Groundwater Operation Impacts: Unocal Conveyance

Portal Siting Areas

There are no impacts unique to the Unocal corridor in terms of long-term operation impacts.

Tunnels

Although there would be differences between the conveyance alternatives in terms of system hydraulics, all would be designed to limit exfiltration and to reduce infiltration to levels that are protective of the aquifers. Thus, there are no impacts unique to the Unocal corridor in terms of long-term operation impacts.

Surface Water Operation Impacts: Unocal Conveyance

Potential operation impacts for the Unocal corridor are similar to those for the Route 9 corridors. Potential operation impacts for surface waters at primary portals on the Unocal corridor can be found in Table 6-22.

Primary Portal Siting Areas

Stormwater treatment facilities at the new pump station in Portal Siting Area 11 would be constructed using guidance contained in the Ecology Manual (Ecology, 2001). Even with treatment, stormwater may include constituents that could have a local minor impact on water quality. Parameters of concern include temperature, turbidity, suspended solids, fecal coliform bacteria, and dissolved oxygen. The discharge of treated stormwater could increase pollutant concentrations and loadings in receiving waters (Lake Washington, Sammamish River). However, such impacts are expected to be minor because of implementation of stormwater treatment facilities.

Secondary Portal Siting Areas

Potential operation impacts for the secondary portals on the Unocal corridor are similar to those for the secondary portals in the Route 9 corridors.

Proposed Mitigation: Unocal Conveyance

Mitigation for the construction of the Unocal conveyance system would be as described above under Impacts and Mitigation Common to All Systems. If it is determined that groundwater would be discharged to West Fork Lyon Creek (Portal Siting Area 7) or the Sammamish River tributary (Portal Siting Area 14), hydrologic studies would be completed to ensure that the additional flow would not impact the water quality, channel morphology, or aquatic biota of the stream.

6.3.3.3 Outfall: Unocal

Construction Impacts: Unocal Outfall

The onshore portion of the outfall construction for the Unocal alternative will traverse areas of known or suspected groundwater contamination. Dewater discharge disposal options are the same as described for the Unocal treatment plant.

Operation Impacts: Unocal Outfall

There are no additional operation impacts for alternative outfall Zone 6 beyond those described as common to all systems.

Proposed Mitigation: Unocal Outfall

There are no additional mitigation measures for alternative outfall Zone 6 beyond those described as common to all systems.

6.3.4 Impacts: No Action Alternative

Under the No Action Alternative, increases in the frequency and volume of emergency overflows that discharge untreated wastewater to Lake Washington, the Sammamish River, and Puget Sound; within the local distribution system; and/or homes, are possible as the population in the region increases and the capacity of the existing wastewater system is exceeded. By the 2050, the likelihood of overflows in the project area would be on the order of every 1 to 2 years. The increased discharges of untreated or partly treated wastewater would have an adverse impact on the quality of these water resources by increasing concentrations of bacteria, nutrients, and toxicants and decreasing concentrations of dissolved oxygen. Increases of all constituents of concern could be expected. These impacts would extend throughout the year because of frequent overflows and because some of the pollutants may be retained in sediments. Additional water bodies could be affected as system capacities are stretched beyond their limits. Significant public health impacts could occur, as described in Chapter 9 and in the EIS for the Regional Wastewater Services Plan, which is incorporated by reference into this EIS (King County DNR, 1997). Escalating water quality impairment in local freshwater and marine environments would occur, which would conflict with decades of water quality improvement programs implemented by King County, Snohomish County, and individual jurisdictions in the Brightwater Service Area.

The Cross Valley Water District estimates that the hundreds to thousands of septic tank drainfields situated in the Cross Valley area present a “probable source of contamination” to the groundwater system and a primary source of drinking water for the area (Robinson & Noble, 1999). As treatment plant capacity diminishes in the future under the No Action Alternative, much of the future growth in the area would likely be accommodated by septic systems. As a result, there could be an increase in the number or density of drainfields within protection zones for the aquifers for this and other water districts. This could have a negative impact on drinking water quality because of the threat of potential aquifer contamination that septic tank drainfields pose.

6.3.4.1 Impacts of No Action Alternative at Route 9 Site

Several current tenants at the Route 9 site conduct activities that have the potential to introduce contaminants into the groundwater and surface water. The property occupied by Woody’s Auto Wrecking on the southern portion of the site is listed on Ecology’s Confirmed and Suspected Contaminated Sites List, indicating that investigation under the Model Toxics Control Act may be required. Four underground storage tank sites are within the Route 9 site boundaries. Currently, no investigations or cleanup plans independent of the Brightwater System project are planned. If there is contamination, the No Action Alternative could allow the contamination to continue to flow to the shallow aquifer and discharge to Little Bear Creek.

Much of the ground surface across the Route 9 site is covered with pavement or gravel. Very little of the area where the treatment plant would be constructed is vegetated. Only a small portion of this site currently has stormwater treatment facilities. Untreated runoff from this large commercial-industrial area would continue to flow to Little Bear Creek. Large amounts of sediment and, possibly, hydrocarbons would continue to enter the creek. High stormwater runoff from the site would continue to contribute to stream channel degradation.

6.3.4.2 Impacts of No Action Alternative at Unocal Site

The Unocal site is a state-listed hazardous site, with a Washington Ranking Method rank of 1, the highest ranking for cleanup. The site is being cleaned up by the site owner, Unocal Corporation, with oversight by Ecology under an Agreed Order between the two parties. Some contaminated soil has already been removed from the upper yard. At this time, it is not known the extent of soil removal or groundwater cleanup measures that may be required by Ecology for the lower yard as Unocal Corporation continues to comply with Ecology’s Agreed Order. Ecology is writing a Cleanup Action Plan for the entire site. Cleanup of the lower yard under the current plan is projected to begin in summer 2005 (Edmonds City Council, 2002). If the Brightwater project does not locate at the Unocal site, the cleanup activity will continue on its current schedule.

The proposed Edmonds Crossing multimodal project would occupy much of the Unocal site. If constructed, the lower portion of Willow Creek would be removed from the pipeline in which it currently flows and daylighted to Puget Sound.

6.3.5 Cumulative Impacts

There are numerous ongoing projects within the project vicinity, including residential and commercial development and road widening. Water resource impacts associated with individual projects are likely not substantial because of the numerous mitigation requirements of the various permitting agencies. However, the magnitude of these impacts is increased when all of these projects are considered together. Despite requirements to implement best management practices and to manage stormwater runoff from construction sites, the cumulative effect of these projects would be a net decrease in the quality of water resources throughout the project vicinity during the Brightwater construction period. However, after the construction period, the Brightwater project is not expected to create long-term impacts to local water resources because overflows to Puget Sound and local lakes, streams, and rivers would be avoided or reduced and stormwater would be managed at permanent facilities to improve water quality in local water resources, such as Little Bear Creek or Willow Creek.

The Washington Department of Transportation has plans to widen SR9, north of SR 522, past the Route 9 site. Stormwater runoff from this project would be treated and detained before release to Little Bear Creek. At present, runoff from this portion of the highway is not treated or detained prior to reaching Little Bear Creek. Similar to the Brightwater project, the water quality improvement and the reduction in peak road runoff resulting from the SR-9 widening project would have a net beneficial effect upon the creek. King County and WSDOT have initiated discussion on the feasibility of partially combining the stormwater management systems of the two projects.

The proposed project is located in the Central Basin of Puget Sound, and the McAleer Creek, Lyon Creek, Swamp Creek, and North Creek basins. In addition, the Route 9 site is located in Little Bear Creek basin and two Unocal system portal locations are in the Lake Washington basin. Portions of each of these basins lie within the described Urban Growth Areas (UGAs) of one or more jurisdictions. Consequently, additional development can be expected in the future. Available data indicate that 17 to 20 percent of McAleer basin, 37 percent of Little Bear Creek basin, 52 percent of Swamp Creek basin, and 49 percent of North Creek basin are currently covered by impervious surfaces.

Impervious areas for the Unocal system would include up to 28 acres at the plant site and 16 acres or less at the portal sites, totaling 40 acres or less of total new impervious surface. Impervious areas for the Route 9 systems would include up to 36 acres at the plant site and 24 acres or less at the portal sites, totaling 60 acres or less of total new impervious surface. This increase is a small percentage of the total impervious area for each basin. Development of the Edmonds Crossing multimodal project would add additional impervious area and associated stormwater in the shoreline area immediately west of the Unocal site. While the Brightwater System would provide treatment for stormwater generated at the Unocal site, the multimodal project would provide treatment for the remainder of the site’s stormwater.

Long-term best case groundwater infiltration rates into the conveyance system during operation would be commensurate with other wastewater systems constructed in King and Snohomish Counties. The best case estimated leakage would be near 170 gpm after 30 years for the entire length of the Route 9–195th Street system. This loss of groundwater represents a small percentage (less than 1 percent) of the estimated annual recharge for the area.

Cumulative impacts to Puget Sound surface water quality from the construction and operation of the Brightwater treatment plant and outfall were evaluated to account for existing and possible future discharges and contaminant loadings to Puget Sound. If the proposed Edmonds Crossing Multi-Modal Facility proceeds as described in the Unocal System sub-alternative, additional in-water work that is required for that facility could cumulatively add to impacts to marine resources associated with construction of the Brightwater outfall.

In the examination of potential impacts to surface water quality, King County modeled projected impacts from Brightwater discharge using existing water quality conditions in Puget Sound to examine cumulative impacts. This quantitative assessment is believed to be a reasonable approach because there are no known plans for additional point source discharges in the area and there are concentrated efforts in the region to improve the water quality of Puget Sound. King County and other municipal governments in the area are continuing efforts to increase the quality of their discharges in response to stricter regulatory requirements of the Endangered Species Act, Growth Management Act and other environmental regulations. For example, there are planned improvements to combined sewer overflows; other capital improvement projects will have vastly improved stormwater management infrastructure, which will reduce the loadings to Puget Sound. Both the City of Edmonds and King County have plans to improve the performance of some of the existing outfalls in Puget Sound. Similarly, King County is proposing to use MBR treatment technology for the Brightwater System in an effort to minimize the loadings to Puget Sound. Based on this information, it is expected that Puget Sound water quality will continue to improve over time and no additional water quality standard violations will occur due to discharges from the Brightwater treatment plant.

King County will continue to work with the Department of Ecology and other regulatory agencies to ensure that the long-term health of Puget Sound is maintained. Cumulative impacts associated with implementation of the Brightwater System, however, are significantly lower than those that would occur without implementation of the project.

6.4 Significant Unavoidable Adverse Impacts

Significant unavoidable adverse impacts to surface water resources because of construction or operation of the Brightwater System are not anticipated. Some unavoidable adverse impacts to surface water resources may occur during construction if mitigation measures are not consistently applied or maintained; however, the impacts are not anticipated to be significant because they would be temporary and would be contained as soon as detected. While all efforts will be made to avoid emergency overflows, such events would occur only on very rare occasions. Temporary violations of water quality standards could occur; these impacts would be similar for either of the Route 9 alternatives or the Unocal alternative, but would be of greater magnitude and would occur more frequently under the No Action Alternative than if the Brightwater System is implemented.

Significant unavoidable adverse impacts to surface water resources are not anticipated as a result of construction or operation of the conveyance corridors or the marine outfall.

6.5 Summary of Impacts and Mitigation

Table 6-25 provides a summary of the impacts and mitigation for surface water and groundwater described in this chapter.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems

Brightwater System	System Component	Impacts	Mitigation
Common to All Systems	Treatment Plant	Construction • Impacts are specific to individual plant sites as described below.	Construction • Use Best Management Practices to minimize erosion and sedimentation; provide advanced treatment as needed to control turbidity and remove contaminants. Develop a comprehensive erosion and sediment control (ESC) plan as part of the project's Storm Water Pollution Prevention Plan (SWPPP) approved by Ecology and the local agency. • Conduct a thorough site assessment for contaminants prior to site excavation. Remove/remediate contaminated soils or groundwater. • During construction, treatment plant underdrain systems will include leak detection below the water-holding basins. Pressure testing and construction QA/QC will also help reduce the risk of leaks. Spill containment will also be provided around construction fuel and chemical storage tanks. Water will be recycled at washdown areas. • During treatment plant and conveyance construction, King County will require contractors to prepare and follow hazardous spill prevention plans and hazardous waste contingency plans. Spill containment provisions will be developed and response kits provided. These measures will be identified and described in a detailed Spill Prevention, Containment, and Control Plan (SPCCP) to be developed prior to construction. Spill prevention and cleanup provisions will comply with the Ecology 2001 Stormwater Management Manual for Western Washington. • Segregate the clean dewatering flows (pumped groundwater); treat other dewatering flows to meet applicable water quality standards. Infiltrate onsite, where feasible. • Dewatering discharge will meet all applicable water quality standards in the receiving water. If discharge rates exceed 10 percent of the receiving water body flow, a hydrologic study will be conducted to evaluate potential impacts to water quality, channel morphology, and aquatic biota. • A water supply contingency plan would be developed prior to construction as a contingency measure for potable water supply in case the measures taken to reduce groundwater loss are not entirely successful.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Common to All Systems (cont.)	Treatment Plant (cont.)	Operation • Stormwater runoff from new impervious areas. Potential for chemical spills. • Leakage through cracks in the process basins, joints in the effluent piping, or cracks in the chemical storage tanks could result in leakage of untreated effluent or chemicals to the groundwater. • Potential temporary water quality impacts from emergency overflows in the event of multiple equipment and power failures during storms.	Operation • Low impact development (LID) measures would be designed into the project to minimize runoff. Stormwater treatment and detention meeting the guidelines of the Ecology Manual (Ecology, 2001) would be provided. • Stormwater facilities would be designed to minimize solar heating effects. • During treatment plant operation, spill prevention measures such as leak detection systems, secondary containment, drainage retention, and regular inspection and maintenance will be developed consistent with the UFC and other applicable regulations. Storage tanks will be designed with double walls, spill containment berms, alarms, level indicators, ventilation, and other features to minimize spill risks and impacts. • Treatment plant underdrain systems will include leak detection below the water-holding basins. Pressure testing and construction QA/QC will also help reduce the risk of leaks. Spill containment will also be provided around construction fuel and chemical storage tanks. Water will be recycled at washdown areas. • Follow established response procedures for emergency wastewater overflow events, should they occur.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Common to All Systems (cont.)	Conveyance	<u>Construction</u> • Excavation support methods to be used for the portals are self-sealing where they penetrate aquitards and would essentially prevent flow between aquifers. • Expected groundwater inflows are unlikely to cause any significant groundwater-level impacts; impacts on aquifer levels would be temporary and likely indistinguishable from natural variations. • No significant impact on shallow aquifers, springs, public water supply wells, or private wells installed in these aquifers during construction of tunnels. • Deep private wells within a few hundred to several thousand feet of the corridor could experience a decline in water levels under a worst-case scenario, but design measures would be used to prevent such impacts. • Short-lived effects on deep public or private wells located within a few hundred feet of an inflow point could occur, but design measures would be used to prevent such impacts. • Potential to impact five streams where tunnels would be relatively close to ground surface (see discussion for each alternative below). • Potential for erosion of exposed soils.	<u>Construction</u> • Portal sites would be located as far from high quality water resources as practical. • Baseline studies will be conducted to develop site specific mitigation plans. • A conveyance construction groundwater monitoring plan would be prepared by King County prior to the initiation of tunneling. Surface water monitoring would also be performed by establishing new stations or by using existing water gauging locations. Should a substantial short-term inflow of groundwater occur in a section of tunnel within 100 feet of the ground surface, daily flow monitoring or daily water level monitoring will be carried out on any stream or wetland, respectively, located within one-quarter mile of the tunnel inflow. Monitoring will continue for two weeks following cessation of the inflow event. • Where open trench construction occurs, microtunneling and jack-and-bore construction methods would be used at stream crossings. • Monitoring plans will be developed and implemented as part of the Stormwater Pollution Prevention Plan to avoid and minimize impacts to water resources and evaluate effectiveness of BMPs. • Stormwater treatment facilities would be constructed and used for the duration of construction activities (2 to 5 years) at all portal sites. • Dewatering discharge will meet all applicable water quality standards in the receiving water. If discharge rates exceed 10 percent of the receiving water body flow, a hydrologic study will be conducted to evaluate potential impacts to water quality, channel morphology, and aquatic biota.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Common to All Systems (cont.)	Conveyance (cont.)	• Potential for discharge of dewatering water to surface water bodies or local sewer system. • Low potential for reduction in groundwater quality if existing contaminated materials are disturbed and migrate into surrounding groundwater.	• If a stormwater conveyance system is used for dewatering discharge disposal, the system will be evaluated to ensure that the capacity is not exceeded and the system is not impaired. • A potable water replacement plan would be developed as described for the treatment plant.
		<u>Operation</u> • Small paved areas at portals (<5,000 square feet) would not generate significant quantities of runoff. The remainder of the portal site would be revegetated. • Long-term groundwater leakage into a conveyance line tunnel or portal structure could potentially cause water levels to decline in unconfined aquifers, or water pressure to decline in confined aquifers.	<u>Operation</u> • All below-grade conveyance structures are would be designed to be largely watertight.
	Outfall	<u>Construction</u> • On-land trenching open-cut construction activities during outfall construction could require dewatering. • Potential short-term increase in turbidity during nearshore construction of outfall.	<u>Construction</u> • Trench sheeting would be installed on shore and in water to a depth of –30 feet MLLW. • Fully-closing, clam-shell excavation equipment would be used to minimize the loss of sediments as they are transported from the seafloor to the storage barge. • If allowed by construction permitting agencies (below –30 feet), side-casting (immediately redepositing excavated materials to the side of the trench rather than bringing them to the surface) would minimize the amount of sediments resuspended in the upper water column. • During construction of the outfall, all in-water construction would be subject to spill containment requirements. • On-land construction of outfall pipeline segments would utilize groundwater mitigation measures similar to those described for the treatment plant and conveyance systems.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Common to All Systems (cont.)	Outfall (cont.)	<u>Operation</u> • Small amounts of microbiological and chemical contaminants would be discharged into the marine environment. Estimated concentrations at the edge of the acute and chronic mixing zones would meet all applicable standards or criteria. Outside the regulatory mixing zone, concentrations of these pollutants are anticipated to meet water quality criteria. • Some effluent may move into areas such as Possession Sound that have naturally low oxygen; however, Brightwater System effluent is not expected to contribute to ongoing low oxygen concentrations in these areas. • Any chemicals in treated effluent that are released into the sea surface microlayer would be transported away from shorelines and out of Puget Sound.	<u>Operation</u> • Mitigation for potential effects due to discharge of treated effluent would be built into the design of the treatment plant, outfall, and diffuser. The outfall would be sited to ensure rapid mixing and a high degree of dilution with marine waters. The MBR treatment provided to the effluent would reduce the loadings of key pollutants by more than 75 percent compared to standard secondary treatment. • Performance of the outfall and diffuser will be ensured by regular monitoring and maintenance. A routine water quality monitoring program will be established around the diffuser.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System	Treatment Plant	Construction • The project would disturb 71 acres at the treatment plant site. Sediment and potential contaminants in stormwater runoff may cause water quality impacts to Little Bear Creek. • Possible existing soil or groundwater contamination could impact the water quality of runoff from the site. • Fuel spills or leaks from construction equipment could degrade water quality. • Groundwater dewatering discharge averaging 350 gallons per minute (gpm) (up to a maximum of 550 gpm) may impact Little Bear Creek. • Dewatering would result in drawdown of 2 feet or less in the Shallow Unconfined Aquifer within a distance of about 1,500 feet to the north for a duration of approximately 3 years. This amount of drawdown is well within the normal seasonal fluctuations of the natural groundwater system, and therefore the impact to the groundwater resource is expected to be negligible. • Construction of the deep influent pump station would require removal of about 100 gpm of groundwater from the deeper confined pre-Vashon Aquifer over a duration of 4 to 10 months. Drawdown beyond the immediate vicinity of the structure would be negligible due to the isolated nature of the aquifer. • Despite all planned mitigations during construction dewatering, adverse impacts, however unlikely, could occur to domestic wells offsite.	Construction • Same as mitigation described above under Common to All Systems. • In addition, infiltrate removed groundwater into the Shallow Unconfined Aquifer where feasible. • Segregate the clean dewatering flows (pumped groundwater); treat other dewatering flows to meet applicable water quality standards. Infiltrate onsite, where feasible or discharge directly to Little Bear Creek. • If temperature impacts in Little Bear Creek are detected as a result of discharges of on-site stormwater, additional mitigation could include planting of bioswales early during the construction process, and/or on site infiltration or spray irrigation of stormwater.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System (cont.)	Treatment Plant (cont.)	Operation • Twelve streams and watercourses flow across the project site and would be impacted by the treatment plant. • The project could result in up to 36 acres of impervious area, causing water quality and high flow impacts to Little Bear Creek. • 350 gpm of groundwater flow from facility underdrains would be permanently discharged to onsite constructed wetlands and will either infiltrate to the shallow aquifer or will flow to Little Bear Creek as surface water. • Similar to construction dewatering, permanent groundwater drawdown would be 1 to 3 feet of drawdown within a distance of 1,500 feet to the north of the site. • Although underdrain flow would be drawn from the shallow aquifer that contributes water to the creek, the overall long-term impact on creek flow would be minimal. • Chemical spills, facility washdown water, or runoff from the biosolids loading area may reach and overload the stormwater system, resulting in water quality impact to Little Bear Creek. • Despite design and construction measures for leak-proof structures, leaks may occur from structures to the groundwater.	Operation • Same as mitigation described above under Common to All Systems. • In addition, divert the streams/watercourses around the project site: north to Unnamed Creek or south to Howell Creek. Reroute and restore these two streams to handle the increased flows and to provide fish habitat. Upgrade the Howell Creek culvert under SR-9 to provide sufficient capacity. • The underdrain flow (expected to be of good quality) from the plant would be piped separately downstream of the stormwater facilities to constructed wetlands for re-infiltration and/or discharge to Little Bear Creek. • Little Bear Creek would be monitored for a period of 5 years following construction to assure that water releases from the treatment plant site do not negatively impact the creek. • King County would coordinate with Snohomish County regarding measures to improve habitat in Little Bear Creek. Measures could include acquiring, preserving, and enhancing riparian buffer along the creek.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System (cont.)	Conveyance	<u>Construction</u> • Receiving water bodies (Sammamish River, North Creek, Little Swamp Creek, McAleer Creek, and Puget Sound) could be affected by erosion of excavated soils and accidental spills of petroleum products or construction waste. Construction impacts could last for 1 to 4 years, depending on construction purposes of portal sites. • Dewatering flows at an individual portal would average around 50 gpm but could be up to 250 gpm on a very short-term basis (1 to 2 weeks). • Groundwater drawdown would be minimal. No significant impacts are expected to Olympic View Water and Sewer District area during the construction phase. For Lake Forest Park Water District, the cumulative upper-bound numerical analysis predicts a maximum of 7 feet of drawdown at the wellfield. Additional geotechnical engineering explorations and evaluations of the 195th Street profile would determine the feasibility of placing the tunnel entirely within low-permeability deposits. • Dewatering discharge to North Creek during low flow periods could result in water quality degradation and channel erosion. • Dewatering discharge to Little Swamp Creek and Barnacle Creek and a tributary to the Sammamish River could result in water quality degradation and channel erosion.	<u>Construction</u> • Same as mitigation described above under Common to All Systems.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–195th Street System (cont.)	Conveyance	Operation • Water quality of the Sammamish River could be affected by emergency overflows. • Minor groundwater seepage losses (on the order of 100-200 gpm) into the tunnel.	Operation • Same as mitigation described above under Common to All Systems.
	Outfall Zone 7S	Construction • Potential to traverse areas of contaminated soil or groundwater. • Potential for construction-related spills of petroleum products.	Construction • Same as mitigation described above under Common to All Systems. • Testing to determine the presence of contaminated dewatering and treatment as necessary.
		Operation • Based on the analysis of expected effluent quality, effluent dilution and effluent transport, the operation of the Brightwater System outfall will not significantly impact Puget Sound and its water quality.	Operation • Same as mitigation described above under Common to All Systems.
Route 9–228th Street System	Treatment Plant	Construction • Same as for the Route 9–195th Street System.	Construction • Same as for the Route 9–195th Street System.
		Operation • Same as for the Route 9–195th Street System.	Operation • Same as for the Route 9–195th Street System.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Route 9–228th Street System (cont.)	Conveyance	Construction • Impacts common to potential receiving water bodies (Sammamish River, North Creek, Little Swamp Creek, Hall Creek, Puget Sound, Swamp Creek, and Palm Creek) are the same as impacts listed for the Route 9–195th Street System. • Dewatering discharge to North Creek, Hall Creek, and Swamp Creek during low-flow periods could result in water quality degradation and channel erosion. • Dewatering discharge to Little Swamp Creek, Barnacle Creek, and Palm Creek could result in water quality degradation and channel erosion. • Potential risk to Olympic View Water and Sewer District's 228th Street well. Little potential to impact Deer Creek Spring; no impacts to Lake Forest Park Water District's wellfield. Other private water supply wells located within a few hundred feet of the 228th Street corridor could potentially be impacted by groundwater inflows during tunnel construction.	Construction • Same as for the Route 9–195th Street System. • Implement special studies and construction measures for 228th Street well.
		Operation • Same as for the Route 9–195th Street System.	Operation • Same as for the Route 9–195th Street System.
	Outfall Zone 7S	Construction • Same as for the Route 9–195th Street System.	Construction • Same as for the Route 9–195th Street System.
		Operation • Same as for the Route 9–195th Street System.	Operation • Same as for the Route 9–195th Street System.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Unocal System	Treatment Plant	Construction • The project would disturb 48 acres at the treatment plant site. Sediment and potential contaminants in stormwater runoff may cause water quality impacts to Willow Creek. • Fuel spills or leaks from construction equipment could degrade water quality. • Removal of perched water from the upper yard is anticipated to have a negligible effect on groundwater or surface water outside the plant boundaries. • Dewatering groundwater drawdown would be potentially detrimental to the Edmonds Marsh. • Some isolated areas of groundwater in the lower yard area are reported to be contaminated above regulatory levels. The dewatering flow may contain petroleum contaminants resulting from past uses of the site. • Dewatering discharge would not be routed to Willow Creek but either to the Edmonds Marsh, if needed, or Puget Sound after any required treatment, or into the City of Edmonds sanitary sewer.	Construction • Stormwater quality mitigation would be similar to the Route 9 site; due to the close proximity of the Willow Creek, additional erosion measures, such as double silt fencing, would be employed. • Spill control mitigation would be similar to the Route 9 site. • Treatment plant structures would be constructed by one of three methods (tight sheet piles at northern end of site, sheet piling with dewatering discharge pumped back to marsh, or sheet piling with bottom seal under wet conditions) so that drawdown in Edmonds Marsh is no greater than 0.5 foot and the potential for saltwater intrusion is minimized. • Water levels within the Edmonds Marsh and Willow Creek would be monitored. Should drawdown in the marsh or area creeks unexpectedly occur as a result of plant site dewatering, surface flow would be discharged to the impacted areas in a controlled manner as needed to maintain normal water levels. Water introduced to the marsh area will meet applicable water quality standards. • Treat the dewatering flows as necessary to remove contaminants; project construction may accelerate the cleanup of the site.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Unocal System (cont.)	Treatment Plant (cont.)	<u>Operation</u> • No streams would be diverted around the treatment plant site (except potentially if conventional activated sludge digesters are constructed in the future). • The project could result in up to 28 acres of impervious area, causing water quality and high flow impacts to Willow Creek. • The 72-inch Edmonds Way Drain would be impacted by project facilities. • Chemical spills, facility washdown water, or runoff from the biosolids loading area may reach and overload the stormwater system, resulting in water quality impact to Willow Creek. • Structures in the upper yard would have permanent underdrains to drain perched groundwater that is expected in this area. Flow from these underdrains is expected to be seasonal (fed by infiltration) and of negligible quantity resulting in no impact to the groundwater resource. • There would be no other permanent dewatering.	<u>Operation</u> • The final 1,500 feet of Willow Creek, currently within a pipe, would be daylighted and the stream channel restored. • Similar to the Route 9 site; stormwater quality treatment would be provided; the treated stormwater would be piped directly to Puget Sound; therefore no detention would be provided. • Spill and contaminant control would be the same as for the Route 9 site.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
Unocal System (cont.)	Conveyance	Construction • Impacts to potential receiving water bodies (Sammamish River, Puget Sound, West Fork Lyon Creek, and a tributary to the Sammamish River) are the same as common impacts listed for the Route 9–195th Street System. • Dewatering discharge to North Creek during low-flow periods could result in water quality degradation and channel erosion. • Dewatering discharge to West Fork Lyon Creek and a tributary to the Sammamish River could result in water quality degradation and channel erosion. • Little potential to impact the Deer Creek Spring or Holyrood Cemetery wells. • Potential for impacts to streamflow in Lyon Creek during construction of tunnel.	Construction • Mitigation would be similar to mitigation for the Route 9–195th Street System. • Tunnel construction specifications would be developed to protect against excessive inflows that could affect Lyon Creek.
		Operation • Water quality in the Sammamish River or Puget Sound could be temporarily affected by emergency overflows. • The Sammamish River would receive stormwater runoff from increased impervious surfaces associated with a pump station (unique to the Unocal System) at Portal 11.	Operation • Mitigation would be similar to mitigation for the Route 9–195th Street System. • A permanent stormwater treatment facility would be constructed in association with pump station construction at Portal 11 (unique to the Unocal System).
	Outfall Zone 7S	Construction • Same as for the Route 9–195th Street System.	Construction • Same as for the Route 9–195th Street System.
		Operation • Same as for the Route 9–195th Street System.	Operation • Same as for the Route 9–195th Street System.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
No Action Alternative		• Emergency overflows from the sewage collection system would occur with increasing frequency as sewage flow continued to increase and the capacities of the existing sewage treatment plants was exceeded. Water quality violations would occur with increasing frequency at the overflow point near the mouth of Lake Sammamish and its junction with the north end of Lake Washington. • Without additional sewage treatment capacity, developing areas in south Snohomish and north King counties are more likely to utilize septic systems instead of sewer hookups. The increasing number of septic systems could negatively impact the water quality of aquifers which provide much of the water supply to residents in the area. <u>Route 9 Site</u> • Most of the project site currently has no stormwater treatment or detention. Nearby Little Bear Creek would continue to be impacted by poor quality runoff and high stormwater flows from the site. • Potential soil contamination due to the commercial-industrial nature of the project site would continue to be carried to nearby Little Bear Creek.	• No mitigation is proposed.

Table 6-25. Summary of Potential Water Resource Impacts and Proposed Mitigation for Brightwater Systems (cont.)

Brightwater System	System Component	Impacts	Mitigation
No Action Alternative		<u>Unocal Site</u> • The ongoing cleanup of contaminated soil and groundwater at this former fuel tank site would continue on it current schedule. • The proposed Edmonds Multimodal project would occupy much of the Unocal site, providing stormwater treatment. The lower, piped portion of Willow Creek would be daylighted to Puget Sound.	

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