SECTION 3.3 WATER
(WAC 463-42-322)

3.3.1 INTRODUCTION

This section summarizes existing information on surface water and groundwater resources in the vicinity of the proposed pipeline and evaluates the potential impacts that the project may have. Sources of water supply for construction purposes including hydrostatic testing are discussed in Section 2.5, aquatic discharges are discussed in Section 2.7, and runoff/erosion control is discussed in Section 2.10. The section is organized according to WAC 463-42-322 and provides a discussion of existing conditions, an assessment of potential impacts and mitigation regarding surface water resources, runoff and absorption, floods and floodplains, groundwater resources and a description of public water supplies which may be affected by the project.

The proposed pipeline route originates at a connection to the existing Olympic Pipe Line (OPL) 16" and 20" mainlines a few miles north of Woodinville, Washington (SE 1/4, Section 21, T27N, R5E). It then extends east and south to cross over Snoqualmie Pass before reaching its termination point in Pasco, Washington on the Snake River. The route crosses several watersheds which exhibit different hydrologic, climatologic, and geologic conditions.

In general there are four hydrologic/geomorphologic regions along the route ranging from relatively steep forested terrain at Snoqualmie Pass to the rolling hills of the arid Columbia Plateau. Table 3.3-1 describes the characteristics and general water resource concerns within each of the four regions. The regional boundaries roughly coincide with general surficial geologic boundaries described in the "*Handbook for Forest Roads Maintenance and Spoils Management*" (Washington Department of Natural Resources, 1982), and Flood Zone boundaries described in "*Magnitude and Frequency of Floods in Washington*" (USGS Open-File Report 74-336, 1975).

TABLE 3.3-1
CHARACTERISTIC PHYSIOGRAPHIC REGIONS AND WATER RESOURCE ISSUES ALONG THE PIPELINE

Region and Route Segment	General Description of Region	Water Resource Issues and Concerns
Puget Sound Lowlands: Thrasher Pump Station to Snoqualmie River Crossing USGS Flood Zone III (USGS 1975)	Shallow water table in valleys. Wet, deep, erodible soils. Deeply incised channels with unstable banks in some upland areas. Broad floodplains in larger stream valleys.	Impacts to aquatic habitat resulting from slope and channel erosion, and bank instability are critical concerns in this region. Disturbance to approach slopes, stream banks and stream beds can exacerbate or initiate erosional processes with subsequent impacts to habitat and potential risks to the pipeline. Seasonal construction phasing, monitoring, and drainage control during construction, with aggressive restabilization measures after construction is critical to the success of the project. Incised streams and bank instability must be considered for stream crossing burial depths and wetlands.
Western Cascade Mountains: Snoqualmie River crossing to Snoqualmie Pass USGS Flood Zone II	Wet, thin soils overlying bedrock, except in alluvial valleys. Steep slopes and approaches to streams are landslide-prone. Seasonal wetness and seeps extremely critical to slope stability. Snow-dominated peak flood events.	Steep slopes and thin wet soils are prone to landslides during the wet season. Impacts to aquatic habitat resulting from materials eroded from slopes entering streams is a key concern in this region. Seasonal construction phasing is critical to maintaining slope stability, and to avoiding both severe slope drainage problems and bank destabilization during pipeline and stream crossing construction. Aggressive slope drainage control re-stabilization measures during and after construction are important.
Eastern Cascades and Foothills: Snoqualmie Pass through upper Yakima Valley to the Columbia River crossing USGS Flood Zone VI	Upper mountainous portions of this section near Snoqualmie Pass (above the Yakima River crossing) have steep slopes subject to landslides, particularly during spring and early summer snow melt conditions, or during summer storm events. Soils are typically thin and erodible, with downcutting channels and incised gullies and canyons in the lower foothills.	In upper mountain areas, slope drainage control is critical to maintaining slope stability during construction and operation. At stream crossings in lower foothills within incised canyons, pipeline burial depth must consider downcutting and bank instability.
Columbia Plateau: Columbia River crossing to Pasco USGS Flood Zones X and XII	Dry, erodible soils of variable thickness overlying basalt bedrock. Flat to hilly terrain in the Saddle Mountains. Large landslide areas exist in the northwestern slopes of the Saddle Mountains, including the Corfu landslide site. Steep escarpments and canyons occur in some drainages in the basalt. These canyons formed from ancient flood events and are not significantly downcutting at present. The region experiences very dry conditions in summer, fall, and winter; however, irrigation maintains high water levels in canals during much of the summer.	Large summer thunderstorm events initiate temporary high flows with potential for significant bank and bed erosion. Pipeline burial should span entire valley widths to avoid exposure from channel migration and subsequent bank erosion. In addition, channel and bank restoration at irrigation canals is important in order to prevent disruption or loss of valuable irrigation water due to leakage and channel erosion.

Precipitation in Washington is characterized by two distinct climatic regions. The area west of the Cascade

Range has a temperate maritime climate characterized by dry, moderately warm summers and wet, mild winters. The eastern part of the state has an arid to semi-arid climate with greater extremes in temperature during summer and winter than western Washington. Precipitation along the route ranges from approximately 40 to 80 inches annually in the Puget Sound lowlands to as much as 180" annually in the western Cascades. East of Snoqualmie Pass at the crest of the Cascades, precipitation diminishes markedly. Within the eastern Cascades, precipitation ranges from 160" annually near the summit of Snoqualmie Pass to an average of 10" annually near Kittitas (NOAA, 1995). East of the Cascade foothills in the Columbia Plateau, precipitation remains very low, ranging between 10 and 15" annually. Rainfall and snowmelt are the primary water sources for streams and rivers along the pipeline route.

Key data sources used to obtain the information presented in this report include the United States Geological Survey (USGS) streamflow and water quality data records, USGS topographic maps, and three comprehensive summaries: *Water Resources* prepared by the Pacific Northwest River Basins Commission in April 1970 (PNRBC, 1970), describing the eastern basins, the *Initial Watershed Assessment Water Resources Inventory for the Snohomish River Watershed and the Cedar-Sammamish Watershed*, prepared for the Washington Department of Ecology in 1995, and *Magnitude and Frequency of Floods in Washington* (USGS, 1975). References for groundwater included USGS Water Supply Bulletins entitled *Geology and Ground-Water Resources of Northwestern King County, Ground-Water Resources of Snohomish County, and Ground-Water Survey Odessa-Lind Area, Washington* (1963, 1952, and 1974 respectively) and *Ground-Water Hydrology of the Sagebrush Flat Area and Possible Relations to the Discharge of Rattlesnake Springs, Grant and Douglas Counties, Washington* (USGS, 1980).

The State of Washington manages its water resources through an inventory system which organizes water resources on a watershed basis. The inventory areas, called water resource inventory areas, represent the basins of the major rivers within the boundaries of the state. The State also manages instream flows in the larger rivers and streams in order to preserve flow for aquatic habitat as well as senior water rights. The State Department of Ecology (Ecology) manages water resources in order to preserve water quality for both human and wildlife use (WAC 173-200 and 201A). The State Department of Natural Resources has developed a stream type system which characterizes streams and rivers of the State according to their existing water quality, water uses, and importance to fishery and downstream concerns.

3.3.1.1 Water Resource Inventory Areas (WRIAs)

Seven Water Resources Inventory Areas (WRIA) are located along the proposed pipeline route. These include the Cedar-Sammamish River Basin (WRIA 8), Snohomish River Basin (WRIA 7), Upper Yakima River Basin (WRIA 39), Alkali-Squilchuck Basin (WRIA 40), Lower Crab Creek Basin (WRIA 41), Esquatzel Coulee Basin (WRIA 36), and Lower Snake River Basin (WRIA 33). The location of each WRIA along the pipeline route is shown in Figure 3.3-1. The WRIAs provide a means for State agencies to inventory and identify water resource management issues on a watershed basis. Water quality, instream flow limitations and other water management issues are inventoried on a WRIA basis, and are presented by WRIA in this report. Streamflow and channel characteristics, however, do not necessarily conform to WRIA boundaries and are discussed more generally as a function of hydrologic and geomorphologic conditions.

FIGURE 3.3-1 - WRIA BOUNDARIES

3.3.1.2 Water Rights and Instream Flows

Ecology's Shorelands and Water Resources Program is charged with managing the state's water resources to ensure that the waters of the state are protected and used for the greatest benefit. An important component of water management relies on permitting and enforcement of water rights. The State's authority on these issues is outlined in Chapters 90.03 and 90.44 of the Revised Code of Washington (RCW).

Prior to granting a permit for water use, Ecology must determine that the proposed water use passes the following four statutory tests (Chapter 90.03.290 RCW):

- The use will be beneficial
- The use will be in the public interest
- The water is available
- The use will not impair senior water users

In addition to these statutory tests, when Ecology makes a water use decision it must also consider other water management issues and concerns mandated by State and Federal Laws including non-degradation of water quality WAC 173-200 and 201A), preservation of instream flows to maintain aquatic habitat and other beneficial uses especially where specified by statute (WAC 173-500), and preservation of aquatic habitat for endangered fish stocks and other species.

3.3.1.3 Water Quality Classification

Washington classifies most of the rivers and streams along the pipeline alignment as either a Class AA or Class A stream. The water use and quality criteria of these streams are established by Ecology. Beneficial uses include water supply, fish and shellfish habitat, wildlife habitat, and recreation. Ecology maintains a list of water bodies which fail to meet standards for bacteria, temperature, siltation, oxygen levels, nutrients, and toxic compounds or heavy metals. Streams or rivers that will be crossed by the pipeline and have existing water quality problems are identified in the following discussion.

The Federal Clean Water Act (Section 303[d]) and federal regulations (40 CFR Part 130.7) require Washington State to develop a list of "water quality limited" water bodies to EPA every two years. This 303[d] list contains water body segments in which the water quality does not meet state water quality standards and where technology-based controls are not sufficient to achieve water quality standards. The state is then required to establish maximum daily limits on pollutant discharge to these areas. Fecal coliform and temperature violations generally cause the greatest number of listings for streams in the state.

3.3.1.4 Stream Types

The Washington Department of Natural Resources (DNR) utilizes a stream typing system for waters as set forth in WAC 222-16-030. Various state agencies classify streams, lakes, and ponds within forested areas of the state using type numbers 1, 2, 3, 4, and 5.

- Type 1 waters are defined as all waters within their ordinary high-water mark with "shorelines of the state" designations.

- Type 2 waters are segments of natural waters not classified as Type 1 waters, but have a high use and are important from a water quality standpoint for domestic water supplies, recreation, and fishery habitat.

- Type 3 waters are segments which are not classified as either Type 1 or 2, but have a moderate to slight use and are moderately important for the uses identified for Type 2 waters.

- Type 4 waters are significant tributaries to Type 1, 2, or 3 waters and may be perennial or intermittent.

- Type 5 waters include all other waters in natural water courses with or without well-defined channels, areas of perennial or intermittent seepage, ponds, and natural sinks.

This typing system is used in this section to identify water resource sensitivities as part of the impact assessment and does not include man-made irrigation ditches and canals.

Irrigation ditches exhibit different flow patterns, flow timing, and water quality issues than natural streams, and are evaluated for the purpose of this project according to channel width, depth, and flow quantity. Impact sensitivity is evaluated in the same manner as for natural streams, and therefore, they are grouped within the classification scheme for all other streams based on pertinent characteristics.

3.3.2 SURFACE WATER RESOURCES

3.3.2.1 Existing Conditions

Based on the most recent stream survey completed by Dames & Moore fisheries biologists, there are approximately 293 watercourse crossings along the proposed route. These range from small intermittent streams and drainages, irrigation ditches and canals, to large rivers including the Snoqualmie, Yakima, and Columbia Rivers. The following sections discuss water quality, instream flow, streamflow variability, and stream channel conditions along the route. Specific water resource management issues including water quality, instream flow, and water rights are also presented for each WRIA.

Water Quality

Table 3.3-2 indicates the Washington Department of Ecology water quality class rating for the larger named streams traversed by the proposed pipeline, along with any water quality limiting factors identified for those streams. The smaller unnamed streams traversed by the route alignment are generally considered to have a class A rating unless they are tributary to a class AA water body, in which case they would also have a AA classification. All of the smaller unnamed streams are tributary to larger Class A or AA streams, except those in WRIA 41 draining to Lower Crab Creek, which is classified as Class B water quality.

Class AA water quality is considered extraordinary, capable of supporting all habitat, recreational and water supply uses. Because of the high quality of these waters, disturbances and discharges which may affect water quality may easily cause degradation and detrimental impacts. Class A waters are considered to have excellent quality capable of supporting all habitat, recreational and water supply uses; however, water quality parameters are less pristine than AA waters, and the waters are generally somewhat less sensitive to potential impacts. Class B waters are considered to be of good quality, capable of meeting most water uses, with the exception of drinking water, and because water quality parameters are less pristine, are generally less sensitive to impacts compared to Class A or AA waters.

Water quality limiting factors are water quality parameters that are considered to be sensitive to impacts such that the existing beneficial uses would be compromised (State water quality antidegredation policy, WAC 173-201A-070) if actions resulting in detrimental impacts to those parameters were to occur. Several streams traversed by the pipeline have limiting factors including fecal coliform, temperature, dissolved oxygen, pH and pesticides. Any action which would cause these water quality parameters to decline would generally not be allowed without application of reasonable methods of prevention, mitigation, and/or an over-riding public interest. Short-term modifications to the antidegradation policy are permitted when necessary to accommodate an essential activity or protect the public interest, and/or if the modification will not result in permanent (more than 12 months) detrimental impacts to existing beneficial uses.

Instream Flows

Table 3.3-3 indicates those streams and rivers traversed by the proposed pipeline that have administrative instream flow limitations associated with them. The specified flows listed on the table must be maintained to preserve instream flow uses including downstream senior water rights. Any action which would cause the instream flow requirement to not be met would generally not be allowed without an over-riding public interest and/or mitigation.

TABLE 3.3-2
WATER QUALITY RESTRICTIONS

TABLE 3.3-2 (CONTINUED)
WATER QUALITY RESTRICTIONS
OF NAMED WATER BODIES ALONG THE PIPELINE CORRIDOR

OF NAMED WATER BODIES ALONG THE PIPELINE CORRIDOR

Stream Crossing Name	Crossing Number	Ecology Class Rating[(a)]	Ecology Segment Number[(b)]	Water Quality Limiting Factor (Ecology 1998)
Cedar-Sammamish River - WRIA 8				
Little Bear Creek	1	AA	WA-08-1085	Fecal Coliform, Lead
Snohomish River - WRIA 7				
Anderson Creek	7	A		
Ricci Creek	9	A		
Snoqualmie River Crossing #1	11	A	WA-07-1060	Temperature
Peoples Creek Crossing #1	14	A		
Peoples Creek Crossing #2	15	A		
NF Cherry Creek Tributary Crossing #1	17	A		
NF Cherry Creek Tributary Crossing #2	18	A		
NF Cherry Creek	19	A		
Cherry Creek	20	A	WA-07-1062	
Harris Creek	25	A		
Tolt River	26	AA		
Griffin Creek	28	A		
Tokul Creek Tributary	32	A		
Tokul Creek	34	A	WA-07-1106	Temperature
Snoqualmie River Crossing #2	38	A	WA-07-1100	Temperature
SF Snoqualmie River Crossing #1	42	A		
SF Snoqualmie River Crossing #2	43	A		
Boxley Creek	44	A		
Change Creek	52	AA		
Hall Creek	53	AA		
Mine Creek	57	AA		
Wood Creek	59	AA		
Alice Creek	60	AA		
Rock Creek	66	AA		

TABLE 3.3-2 (CONTINUED)
WATER QUALITY RESTRICTIONS
OF NAMED WATER BODIES ALONG THE PIPELINE CORRIDOR

Stream Crossing Name	Crossing Number	Ecology Class Rating[a]	Ecology Segment Number[b]	Water Quality Limiting Factor (Ecology 1998)
Harris Creek	67	AA		
Carter Creek	72	AA		
Hansen Creek	75	AA		
Humpback Creek	78	AA		
Ollalie Creek	83	AA		
Upper Yakima River - WRIA 39				
Mill Creek	86	AA		
Cold Creek	88	AA		
Roaring Creek	97	AA		
Meadow Creek	99	AA		
Mosquito Creek	103	AA		
Stampede Creek	104	AA		
Cabin Creek	117	AA	WA-39-1075	Temperature
Tucker Creek	124	AA		
Big Creek	127	AA	WA-39-1073	Temperature
Little Creek	129	AA		
Granite Creek	131	AA		
Peterson Creek	130	AA		
Spex Arth Creek	132	AA		
Tillman Creek	133	A		
Thornton Creek	143	A		
Yakima River	147	A	WA-39-1060	Temperature, Dissolved Oxygen
Swauk Creek Crossing	151	A	WA-39-1400	Temperature
Dry Creek	156,157, 160,161	A		
Reecer Creek	166	A		
Currier Creek	177	A		
Wilson Creek	187	A	WA-39-1020	Temperature, Fecal Coliform
Naneum Creek	190,193	A		

TABLE 3.3-2 (CONTINUED)
WATER QUALITY RESTRICTIONS
OF NAMED WATER BODIES ALONG THE PIPELINE CORRIDOR

Stream Crossing Name	Crossing Number	Ecology Class Rating[(a)]	Ecology Segment Number[(b)]	Water Quality Limiting Factor (Ecology 1998)
Coleman Creek	196	A		
Cooke Creek	199	A	WA-39-1034	Dissolved Oxygen, Temperature, Fecal Coliform
Caribou Creek	200	A		
Park Creek	201	A		
Alkali-Squilchuck - WRIA 40				
Johnson Creek	222	A		
Columbia River	223	A		
Lower Crab Creek - WRIA 41				
Lower Crab Creek Crossing	244	B	WA-41-1010	Temperature, pH, Pesticides
Esquatzel Coulee - WRIA 36				
Esquatzel Coulee	283	A		

(a) Chapter 173-201A WAC
(b) Ecology 1998 303[d] proposed list submitted to EPA

TABLE 3.3-3
INSTREAM FLOW LIMITATIONS
OF NAMED WATER BODIES ALONG THE PIPELINE CORRIDOR

Stream Crossing Name	Crossing Number	Control Station Number	Instream Limitation
Cedar-Sammamish River - WRIA 8			
Little Bear Creek	1		Closed to any additional withdrawal
Snohomish River - WRIA 7			
Snoqualmie River Crossing #1	11	12	Minimum low flow is 800 cfs
NF Cherry Creek	19		No diversion when flow drops below 1.0 cfs
Cherry Creek	20	12.1485.00	Normal year flows must be maintained at all times unless a critical condition is declared. A critical year flow represents flows below which substantial damage to instream values will occur. Minimum low flow is 120 cfs.
Harris Creek	25		Closed to any additional withdrawal
Griffin Creek	28		Closed to any additional withdrawal
Snoqualmie River Crossing #2	38	12.1445.00	Minimum low flow is 600 cfs.
Alkali-Squilchuck - WRIA 40			
Columbia River	223		Minimum low flow 10,000 cfs

Streamflow Quantity and Variability

Streamflow quantity and variability in streams crossed by the pipeline are a function of the watershed area contributing to streams and climatic conditions found along the route. Distinct seasonal flow patterns occur within each hydrologic region, as described in Table 3.3-1. Figures 3.3-2 through 3.3-5 show typical seasonal hydrographs for each hydrologic region identified in the table, illustrated using the seasonal monthly hydrographs for representative streams. The hydrographs show the seasonal timing of peak and low flows on a monthly basis.

FIGURE 3.3-2 - Puget Sound Lowlands Hydrograph

FIGURE 3.3-3 - Western Cascades Hydrograph

Figure 4 Figure 3.3-3c and d (Figure 3.3-3 continued)

FIGURE 3.3-4 - Eastern Cascades Hydrograph

FIGURE 3.3-5 - Columbia Plateau Hydrograph

Puget Sound Lowlands

Streams with watersheds located entirely within the Puget Sound lowlands (west of Snoqualmie and North Bend), exhibit peak flows in the late fall and winter in response to heavy precipitation which falls primarily as rain (Figure 3.3-2a). High flows taper off in early spring due to lower amounts of precipitation. Low flows occur during the summer and early fall. Base flows are sustained by groundwater discharge. The streamflow pattern directly reflects the precipitation pattern in this region. Streams with portions of their watersheds in the Puget Sound Lowlands and portions in the Western Cascades generally exhibit peak flows in the fall resulting from rain and in the spring due to snowmelt (Figure 3.3-2b).
Average annual streamflows issuing from watersheds located within the Puget Sound Lowlands typically average 0.02 to 0.03 m^3/s per km^2 of watershed area (flow per unit area). Streams with portions of their watersheds in the Cascades exhibit average annual flows per unit area ranging from 0.04 to 0.05 m^3/s per km^2 of watershed. During the high flow months, typical unit flows can be expected to be on the order of twice the average annual flow (0.05 to 0.1 m^3/s per km^2). Flood peaks are substantially higher than typical high flows depending on the flood return period. During the low flow months typical unit flows can be expected to be on the order of one fifth of the average annual flow (0.005 to 0.01 m^3/s per km^2).

Western Cascades

Streams with headwaters and large portions of their watersheds in the western Cascades typically exhibit two comparably large peak flow periods (Figures 3.3-3a,b,d), one in the fall and early winter in response to high rainfall, and a subsequent period in spring and early summer in response to snowmelt and rain-on-snow events. Low flows occur in August and September, and are sustained by groundwater discharge from large alluvial aquifers in the mountain valleys and from snowmelt late into the summer. In smaller headwater streams issuing from the mountainous watersheds (South Fork Snoqualmie, Figure 3.3-3c), precipitation in the fall and winter falls almost entirely as snow, resulting in peak flows occurring generally only in the spring (resulting from snowmelt). Additionally, in the headwater streams flows can become very small or diminish to zero in the late summer.

Average annual streamflows issuing from watersheds located within the Western Cascades typically average 0.07 to 0.1 m^3/s per km^2 of watershed area, with the annual flow per unit area increasing with increasing watershed elevation. During the high flow months, typical unit flows can be expected to be on the order of 1.5 times the average annual flow (0.1 to 0.15 m^3/s per km^2). Flood peaks are substantially higher than typical high flows, depending on the flood return period (see section 3.3-4). During the low flow months typical unit flows can be expected to be on the order of one quarter to one third of the average annual flow (0.02 to 0.03 m^3/s per km^2). A notable exception to the flow characteristics generally found in this region is Boxley Creek, which is crossed by the pipeline near North Bend. This Creek is fed primarily by seepage from Chester Morse Lake, a condition created when the reservoir was constructed by the Seattle

Water Department. Flow in Boxley Creek shows a much larger annual average flow, with lower high and low flow ranges and variability.

Eastern Cascades

In the eastern Cascades, peak flows occur in the late spring in response to snowmelt. Flows decline through the summer months, and are maintained from snowmelt and groundwater baseflow even though precipitation diminishes significantly during the summer (Figure 3.3-4b). The lowest flows occur from August through October (except where there is storage and flow regulation maintaining higher flows into the summer and fall, which can be seen in the Yakima River, Figure 3.3-4a), remaining relatively low through March as precipitation accumulates in the snowpack. Streamflows per unit area of watershed increase with increasing watershed elevation due to higher precipitation in the upper elevations of the mountains and significantly reduced precipitation in the eastern foothills.

Average annual streamflows issuing from watersheds located within the Eastern Cascades typically average 0.02 to 0.03 m^3/s per km^2 of watershed area. During the high flow months, typical unit flows can be expected to be on the order of two to three times the average annual flow (0.04 to 0.09 m^3/s per km^2). Peak flood flows are substantially higher than typical high flows, depending on the flood return period. During the low flow months typical unit flows can be expected to be on the order of one half to one third of the average annual flow (0.007 to 0.01 m^3/s per km^2).

Columbia River Plateau

Due to the paucity of precipitation across most of the Columbia Plateau (particularly in the vicinity of the proposed pipeline), average flows are generally very low in natural streams and coulees, such as Crab Creek (Figure 3.3-5a). Peak flows occur during early spring (February and March) in response to rain and snowmelt and can result in large flash floods. The lowest flows occur in late fall (October and November) and can be zero or near zero. Low flows generally persist throughout the summer, fall and winter. In irrigation canals and streams with substantial flow contribution from irrigation return flows, such as in Esquatzel Coulee Drainage Canal (Figure 3.3-5b), streamflows in the summer and fall are much higher than in streams recharged from natural sources only. In these drainages, low flows occur in mid-winter, and high flows occur in the spring due to natural precipitation and are subsequently maintained and/or increased due to irrigation throughout the summer and fall.

Average annual streamflows issuing from watersheds located within the Columbia Plateau, and which are not recharged significantly by irrigation, typically have flows per unit area on the order of 0.001 m^3/s per km^2 of watershed area. During the high flow months, typical flows can be expected to be on the order of three times the average annual flow (0.003 m^3/s per km^2). Flood peaks can be much higher than typical high flows, as much as several orders of magnitude depending on the return period. During the low flow months typical flows can be expected to be on the order of one tenth of the average annual flow (0.0001 m^3/s per km^2), and in smaller watersheds may be zero. Irrigation canals and streams that are recharged from irrigation return flow, exhibit higher annual flow depending on the quantity of irrigation within the watershed.

Stream Channel Conditions

Stream channel conditions vary considerably along the pipeline route, and are a function of the climate, watershed and flow conditions, channel slope, channel roughness, bed and bank sediments, and the sediment load of the stream. The stream channel geometry (width, depth and channel shape), channel stability, scour, erosion and sedimentation conditions are all created by interaction of the above factors. In general, channel forms are characteristic of specific geomorphic conditions. The various channel types also present unique construction and operational concerns related to the proposed pipeline which must be considered as part of the design, implementation and impact assessment. Table 3.3-4 indicates the channel types found along the route, the location and geomorphic environments where the channel types are found, and construction and operational concerns associated with each channel type.

One of the primary stream crossing design considerations for the pipeline is scour width and depth. Adequate design of each crossing will require burying the pipeline below the maximum scour depth across the active channel scour width such that the pipeline does not become exposed during large erosional events. Pipeline exposure can lead to physical damage to the pipe with increased risk of spills and leaks. The active channel scour width is defined as the width within which the channel may migrate over time via bank erosion and channel shifting. In general, channels are subject to greater migration within floodplains where there are lower gradients and sediment is accumulating. Channel shifting can also occur in streams that are subject to rapid sediment influx and large flow events.

The depth of scour in a channel is related primarily to stream velocity and bed sediment size. However, stream velocity may vary considerably over short reaches if there are slope and channel geometry changes, or obstructions to flow. Pipeline burial depths will be greater than the expected flood scour depths for each stream to eliminate the potential impacts from scour.

TABLE 3.3-4
PIPELINE STREAM CROSSINGS:
CONSTRUCTION, OPERATIONAL, AND ENVIRONMENTAL ISSUES ASSOCIATED WITH CHANNEL FORMS AND CONSTRUCTION/OPERATIONAL GUIDELINES

Stream Channel Forms	Channel Description	Geomorphic Location and Occurrence Along Pipeline Route	Construction and Operational Issues and Recommendations	Environmental Issues and Potential Impacts
I) Meandering Channel	Low gradient (typically less than 1 to 2 percent) with variable bankfull width (depending on dominant discharge and bed material). These channels have erodible banks exhibiting channel migration across the floodplain valley. Occasionally channel bed is downcutting through erodible rock layers, forming canyons. In general, however, streambeds of meandering channels are depositional environments.	Meandering streams and rivers with low gradient channels are located in valley bottoms or in flat terrain. In the Cascades and the Puget Sound lowland areas, meandering rivers typically occur in the larger floodplains and valleys and consist of the mainstem rivers as well as medium and minor tributary reaches which flow through the floodplain. East of the Cascades, meandering rivers occur on the flat Columbia River plateau and frequently are downcutting, forming canyons.	Scour depths on outside bends of meandering channels can be deep. Channel meanders migrate across the entire floodplain valley over time, causing severe and ongoing bank erosion. In some channels, where canyons are forming, rate of channel downcutting can be significant. Maintaining bank integrity during and after pipeline construction is important to minimize the impact on bank erosion and meander processes. Pipe burial must be deep enough or bed and bank protection measures put in place, to avoid exposure from scour and erosion across the full width of the historical meander pattern to avoid potential exposure from scour and erosion.	Meandering channels in floodplains, both large and small, typically provide significant aquatic habitat and support fisheries. These channels also are located in areas of greater human development. Channel and bank stabilization after construction is very important, as unstable banks will erode damaging valuable habitat. Temporary sediment production during construction generally is not as significant due to lower stream flow velocities (with more rapid settling of the sediment load) and higher background suspended sediment concentrations (because the channels are receiving waters for upstream sediment sources).
II) Braided and Alluvial Fan Channels	Low to moderate gradient (typically up to 2 to 3 percent) depending on discharge and bed material, with multiple channels of highly variable width. These channels carry substantial sediment loads and form in depositional environments.	Braided and alluvial fan channels typically form in tributaries to mainstem rivers where steep channels transition to valley bottoms. However, larger valley bottom channels of low gradient can be braided when accompanied by large sediment loads and bed material of relatively large size. Braided and alluvial fan channels are typically found in the Cascades where there is	Crossings will be wide due to channel shifting and migration of the channel thalweg across wide active floodplains and alluvial fans. Deep scour and erosion are not critical concerns in these depositional settings. Debris buildups or washouts could occur at road crossings.	Natural channel shifting and sediment deposition are of concern during construction and with regard to pipeline burial width across the active channel. Operational impacts could include pipeline exposure and exacerbation of bank erosion if the pipeline is not buried deep enough within the active channel width within which

Stream Channel Forms	Channel Description	Geomorphic Location and Occurrence Along Pipeline Route	Construction and Operational Issues and Recommendations	Environmental Issues and Potential Impacts
		an abundance of large sediment loads and steep slopes meet larger river valleys such as in the upper reach tributaries of the Snoqualmie and Yakima Rivers. Channels shift frequently and sediments in these are continually being reworked by the flow.		channel shifting occurs.
III) Steep Confined Channels	Steep gradients are typically greater than 3 percent. Bankfull channel widths are typically less than 50'. Channels are incised and confined by their banks. Bed and bank material is more or less erodible, composed of fine grained to cobble size and larger, and sometimes bedrock that has been incised by weathering.	Steep incised channels form in mountainous terrain such as the Cascades or in the steep approaches to canyons as found in the Columbia plateau in Eastern Washington. These channels are tributary to larger streams located in the valley bottoms and often serve as conduits for sediment and debris from landslides and erosion in the upper reaches of watersheds.	These channels are stable in position; however, burial depth must consider rates of ongoing incision. Large scour events resulting from failure of debris dams in the upstream channel must also be considered in the depth of pipe burial.	Steep channels typically do not provide significant aquatic or spawning habitat. However, these channels are significant to preserving downstream water quality because they are conduits for upstream sediment and debris inputs. Potential impacts from construction and operation result from impacts to sediment throughput such as debris dams and bed/bank destabilization, which can exacerbate rates of downcutting.
IV) Steep Unconfined Channels	Steep gradients are typically greater than 3 percent. Bankfull channel widths are typically less than 50'. Channel banks are low with minor or no incision. Bank material is more or less erodible, composed of gravels to cobble and boulders. Channel beds are usually composed of large size material or bedrock which is relatively resistant to erosion. Because of the low banks, channels are subject to shifting.	These channels are located in steep mountainous terrain in the Cascades where relatively resistant bedrock is present with thin soils and overburden cover. They are tributary to larger valley bottom streams, draining upland portions of watersheds.	Channels can easily shift from their banks and cause erosion to the surrounding soils as a result of floods, debris flows, and destabilization of bed and banks. Erosion due to shifting stream channels could result in pipeline exposure. Stabilization of bed and banks and maintenance of bed and bank integrity during and after construction is important to prevent shifting processes from eroding soils covering the pipeline. Pipeline burial depth and bank stabilization at the stream crossing must be sufficient to allow for natural channel shifting. Due to the resistant nature of the underlying bedrock and thin soils and overburden,	These streams provide conduits for sediment and debris flow to downstream areas. Because water flow can be easily disrupted by channel shifting and dissipation of energy onto the surrounding forest floor, maintaining channel bed and bank integrity during construction and operation will minimize potential impacts to downstream areas and surrounding forest soils.

Stream Channel Forms	Channel Description	Geomorphic Location and Occurrence Along Pipeline Route	Construction and Operational Issues and Recommendations	Environmental Issues and Potential Impacts
			stabilization of the stream bed and banks may be necessary to protect the pipe.	
IV) Minor Insignificant Channels	Bankfull width is 2' or less. Channel gradients and channel conditions are widely variable depending on the geomorphic environment. Channels are typically intermittent, dry in the summer months and carrying storm runoff to larger streams during the winter and spring.	These channels occur throughout the various geomorphic regions along the alignment. They are too small to be significant conduits for sediment and debris, and flow/velocities are not great enough to create distinct stream and riparian habitat.	There are no unique concerns regarding construction or operation of pipelines of roads at these stream crossings. Adequate burial depth and maintaining channel integrity are critical.	There are no unique environmental issues related to these streams. No significant impacts are anticipated if BMPs are followed providing adequate drainage control, stabilization measures, and minimal channel disturbance.

Specific Water Resource and Management Issues by WRIA

The proposed project will not require issuance of any new water rights and, therefore, will not compete with existing or senior water right holders in any of the WRIAs. However, the project may have short-term indirect impacts (although these are not anticipated, see Section 3.3.2.2) to senior water rights. The following discussion presents ongoing water management conditions in each WRIA traversed by the pipeline. WRIAs are defined by the State to provide a mechanism for inventorying and addressing water management issues and strategies on a watershed basis.

Cedar-Sammamish River Basin (WRIA 8)

The Cedar-Sammamish Watershed Water Resources Inventory Area (WRIA 8) is located in King and Snohomish Counties and is comprised of five major subbasins which converge into Lake Washington. The pipeline will originate within the North Lake Washington Subbasin in the 15.30 square mile Little Bear Creek drainage system. Little Bear Creek is the only drainage system that will be crossed by the pipeline in WRIA 8. The Little Bear Creek drainage system, within the Puget Lowland Province, is relatively long and narrow with low relief. The system drains into the Sammamish River to Lake Washington. Mean annual precipitation along this segment of the route is 38" with about 75 percent of the precipitation occurring from October through March.

The pipeline route bisects the western edge of the Little Bear drainage at an elevation of 400', and crosses the creek 1000' north of Maltby Road at an elevation of 200'. Five unnamed tributaries to Little Bear Creek will also be crossed (Tables 3.3-6 and 3.4-8). The area contributing to streamflow at the Little Bear Creek crossing is approximately 10 square miles. Flow in Little Bear Creek is not monitored on a regular basis; however, average annual discharge at the mouth of the creek is estimated to be approximately 20 cfs (USGS, 1984).

Instream flow regulations which limit surface-water withdrawals in the Cedar-Sammamish Basin WRIA are published in the Washington Administrative Code (WAC) Chapter 173-508, titled "Instream Resources Protection Program - Cedar-Sammamish Basin, Water Resource Inventory Area (WRIA 8)." All but one stream or lake contributing to the Lake Washington drainage above the Chittenden Locks are closed to further consumptive appropriations. The exception is the Cedar River drainage which has limitations regulating instream flows. The closure of additional water diversion includes Little Bear Creek as presented in Table 3.3-3.

Eighteen water rights have been issued for areas adjacent to the pipeline right of way. Sources of these permits are either creeks or wells. The Cross Valley Water District is the largest user with 4 wells located less than a mile from the right of way near the community of Maltby. Other beneficial water uses include domestic water supply, irrigation and stock watering, and fish propagation.

Little Bear Creek is listed as a Class AA stream according to criteria set by the Washington Administrative Code (WAC) 173-201A. Currently, Little Bear Creek fails state water quality standards for fecal coliform bacteria (Ecology, 1995) (Table 3.3-2). The pipeline project will not contribute to increases in fecal coliform levels.

Snohomish River Basin (WRIA 7)

The Snohomish River Watershed Water Resources Inventory Area (WRIA 7) is located in north-central Puget Sound and includes portions of King and Snohomish counties. Two distinct physiographic provinces occur within the WRIA. The Puget Lowland Province is characterized by topographic upland plateaus dissected by broad river valleys found in the western portion of the WRIA. This province is a low area mostly less than 1,000' MSL with plateaus typically ranging in elevation from 200 to 600' mean sea level (MSL). A transition to the foothills of the Cascade Mountains forms the eastern edge of the province. On the eastern and southeastern portion of WRIA 7 the Cascade Mountains Province is characterized by rugged mountainous terrain with dissected bedrock. Summit elevations are typically 6,000 to 7,000' MSL with mountain slopes between 2,000 and 4,000' MSL (Ecology, 1995).

Mean annual precipitation throughout the WRIA is 86.7," but varies spatially from 25" in the northwestern WRIA to 180" in the eastern portion (Ecology, 1995). Precipitation is typically of light to moderate intensity and continuous over extended periods during the wet season (November through April).

The Snohomish River carries the combined flow of the Snoqualmie and Skykomish Rivers. Major tributaries to the Snoqualmie include Cherry Creek, Harris Creek, the Tolt River, Griffin Creek, Patterson Creek, Raging River, Tokul Creek, and the South, Middle, and North Forks of the Snoqualmie River. The pipeline will cross 88 waterways in WRIA 7 including two bridge crossings of the Snoqualmie River and two bridge crossings of the South Fork Snoqualmie River. Other named creeks and rivers crossed by the pipeline include Anderson Creek, Ricci Creek, Peoples Creek, Cherry Creek, Harris Creek, Tolt River, Griffin Creek, Tokul Creek, and Meadowbrook Slough. Thirteen named tributaries to the South Fork Snoqualmie River will also be crossed by the pipeline. Meadowbrook Slough and Change Creek are bridge crossings. Rockdale Creek will be avoided. The pipeline at Wood and Alice Creeks is routed over culverts 20 to 30' below the level of the pipeline on the Iron Horse Trail. The pipeline crosses many unnamed streams over or under culverts (Tables 3.3-6 and 3.4-8).

Instream flow regulations which limit surface-water withdrawals in the Snohomish WRIA are published in the Washington Administrative Code (WAC) Chapter 173-507, titled "Instream Resources Protection Program - Snohomish River Basin, Water Resource Inventory Area (WRIA 7)." Surface water source limitations for 40 streams or lakes in the WRIA are presented in the WAC. Of these, 20 creeks and streams are closed to diversions when their flows drop below single specified levels. In addition six creeks, one stream, and the Raging River are closed to all surface-water diversion. Creeks, streams, and rivers crossed by the pipeline which have these restrictions include Griffin Creek, Harris Creek, and a tributary to Cherry Creek (Table 3.3-3).

There have been 149 water rights issued in WRIA 7 adjacent to the pipeline. Sources of these permits are creeks, springs, and wells. Beneficial water uses include domestic and municipal water supply, irrigation and stock watering, and fish propagation. Permitees include the cities of Seattle, Carnation, Snoqualmie, and North Bend.

In addition, a portion of the South Fork Tolt River upstream of the proposed pipeline route has been developed as a source of municipal water supply for the greater Seattle metropolitan area. The South Fork Tolt Reservoir project is operated by the Seattle Water Department to provide municipal water supply, primarily for north Seattle and other communities located on the east side of Lake Washington. The Reservoir system provides 56,200 acre-feet of storage and is diverted for public use outside of the Snohomish River Basin.

All tributary streams within the WRIA are designated as Class A except the South Fork Snoqualmie River from the west boundary of Twin Falls State Park to its headwaters which is designated as Class AA.

Water body segments crossed by the pipeline and located in the Snohomish WRIA which were identified in Ecology's May 13, 1994 303(d) list submitted to the EPA are presented in Table 3.3-2. In most cases, failure to meet fecal coliform standards is the primary reason for waterbody segment listing. Those segments or creeks crossed by the pipeline in the Snohomish River WRIA which fail water quality standards include the Snoqualmie River, Cherry Creek, and Tokul Creek. The pipeline project will not contribute to increased fecal coliform levels or other limiting water quality criteria.

Upper Yakima River Basin (WRIA 39)

The Upper Yakima River Basin is within the Eastern Cascades and is characterized by rugged mountainous terrain with dissected bedrock. Summit elevations are typically 6,000 to 7,000' MSL with mountain slopes between 2,000 and 4,000' MSL (Ecology, 1995). Climate in this basin is influenced by topography, elevation, and prevailing winds.

The Yakima Basin is subject to both the moderating influence of the prevailing westerly winds and to the climatic characteristics of the interior. The area has a winter wet season and a summer dry season. Summer storms are characterized by heavy showers and occasional cloudbursts. Frequent weather changes occur during the winter in response to Pacific weather systems and occasional invasion of arctic air masses from Canada. Annual precipitation ranges from less than 10" to greater than 100" in the Cascades. Approximately two-thirds of the annual precipitation falls between October and March.

Runoff of the Yakima River Basin is variable. The mountainous portions of the basin produce runoff somewhat similar to streams west of the Cascade Mountains. The U.S. Bureau of Reclamation (BOR) has constructed several dams and many irrigation canals in the Yakima Valley.

The pipeline route borders the western perimeter of Keechelus Lake. This lake was formed when the BOR constructed a dam at the lower end of a natural lake. Keechelus Lake has 157,800 acre-feet of active storage. Another BOR facility, the Kittitas Main Canal, starts from the Easton Diversion Dam and flows generally southeast along the south side of Yakima River. The North Branch Canal starts at the end of Main Canal and borders the northern edge of the Kittitas valley irrigation area. The pipeline will cross both of these canals. These irrigation projects have altered the natural flow regime of the Yakima River and its tributaries through storage, diversions, and return flow.

The pipeline crosses a total of 122 waterways in WRIA 39. The pipeline will cross 25 named creeks and rivers which contribute flow to the Yakima River. In addition, the river will also be crossed at a point downstream of the town of Cle Elum. Major tributaries to the Yakima River include the Cle Elum River, Teanaway River, Taneum Creek, Swauk Creek, Reecer Creek, Naneum Creek, and Caribou Creek.

Currently the Yakima River Basin does not have instream flow regulations which limit surface-water withdrawals; however, water rights and instream flows are currently under adjudication due to competing water use issues. Ecology has issued 453 water right permits for water within the proposed pipeline right of way. The permits have been issued for the beneficial water uses of domestic and municipal water supply, irrigation and stock watering, and fish resources. Municipal permit holders include Kittitas County PUD and the City of Cle Elum. All named creeks crossed by the pipeline are sources for existing water withdrawal permits.

The Yakima River from its headwaters to the Cle Elum River is designated a Class AA stream by Ecology (WAC 173-201A). Tributaries to the Yakima River which are crossed by the pipeline that have a Class AA designation are Roaring Creek, Meadow Creek, Mosquito Creek, Stampede Creek, Cabin Creek, Big Creek, Little Creek, Tucker Creek, and Spex Arth.

Water segments in WRIA 39 crossed by the pipeline which are listed on the 303 [d] list as "water quality limited" by the state include the Yakima River, Wilson Creek, Naneum Creek, Cooke Creek, Big Creek, and Swauk Creek (Table 3.3-2). Water quality parameters exceeding state standards include temperature, fecal coliform, and dissolved oxygen. The pipeline project will not affect or exacerbate any of these water quality constituents.

Alkali-Squilchuck Basin (WRIA 40)

The Alkali-Squilchuck Basin is situated on the Columbia Plateau. Elevations on the Columbia Plateau range from less than 1,000' above sea level to about 2,500' along the margins. Average annual precipitation is less than 10" in this semi-arid region. The Columbia and Snake River have sources in the mountains to the east and north, while streams originating on the Columbia Plateau are generally small and intermittent. In the Alkali-Squilchuck basin, the pipeline will cross Johnson Creek approximately 3,000' upstream from the creek's confluence with the Columbia River, immediately upstream of Wanapum Dam. No flow information is available for Johnson Creek, an intermittent stream. Johnson Creek is an unclassified surface water designated as Class A according to Section 173-201A.

Currently, 6 water right permits have been issued for water appropriation in areas adjacent to the pipeline right of way. The main source of these withdrawals is groundwater. The beneficial water uses are listed as domestic water supply and irrigation.

<u>Lower Crab Creek Basin (WRIA 41)</u>

The Lower Crab Creek Basin lies in the northern half of the Columbia Plateau Province. Crab Creek is the primary watercourse in this WRIA. The pipeline will cross the creek near Corfu in Adams County. Crab Creek is a spring-fed stream with a continuous flow of 50 to 75 cfs. Crab Creek originates in Moses Lake which is principally supplied by Rocky Ford Creek. Lower Crab Creek flows southwesterly from Moses Lake to its confluence with the Columbia River below Wanapum Dam and near the community of Beverly. Flow in Lower Crab Creek is largely regulated by managers of the Potholes Reservoir. Many diversions upstream from the confluence are for irrigation, and a major portion of the perennial flow is irrigation return flow, including transbasin diversions. Diversionary canals crossed by the pipeline include the Royal Branch Canal, Wahluke Lateral, and Potholes Canal.

The number of water rights issued in WRIA 41 which are adjacent to the pipeline right of way is 61. The main source of these withdrawals is groundwater; however, 6 permits have been issued for spring or creek withdrawal. Beneficial water uses include domestic and municipal water supply, irrigation, stock watering, and commercial /industrial uses. The municipal suppliers are Royal City and Grant County PUD.

Crab Creek and its tributaries are designated as a Class B stream by Ecology (WAC 173-201A). The portion of Lower Crab Creek crossed by the pipeline is listed on the 303 [d] list as "water quality limited" 303[d] list (Table 3.3-2). Parameters which fail to meet state standards are temperature, pH, and pesticides. The pipeline project will not affect or exacerbate the water limiting quality concerns in Crab Creek.

<u>Esquatzel Coulee Basin (WRIA 36)</u>

The 551 square mile Esquatzel Coulee Basin is situated in the Columbia Plateau region. The pipeline route crosses the Esquatzel Coulee drainage basin near Eltopia in Franklin County. Water is diverted from the coulee into the Esquatzel Diversion Channel near Pasco. Most of the diversion channel flow is irrigation return flow from the Columbia River Project. The high flow period for the Esquatzel Coulee and Diversion Channel occurs July through October due to irrigation demands. The pipeline will cross the coulee 1200' southeast of Glade North Road at an elevation of approximately 500'.

The Esquatzel Coulee Basin does not currently have instream flow regulations which limit surface-water withdrawals. Ecology has issued 135 water rights within the area adjacent to the pipeline right of way. The primary source of water for these permits is from wells. Basin City is the only municipal supplier with wells close to the pipeline corridor. Other beneficial water uses include domestic water supply, irrigation and stock watering, and fish propagation.

Esquatzel Coulee and Diversion Channel is listed as a Class A stream according to criteria set by WAC 173-201A. Esquatzel Coulee is not listed on the state water quality 303[d] list of water bodies that are in excess of state water quality standards (Ecology, 1995).

Lower Snake River Basin (WRIA 33)

The Lower Snake River Basin lies within the Columbia Plateau. The Snake River is deeply entrenched below the general level of the plateau. Normal annual precipitation ranges from less than 6" near the Snake River confluence with the Columbia River to slightly more than 20" due to orographic influences.

The pipeline will terminate at the Northwest Terminalling facility located in Pasco near the confluence of the Snake and Columbia Rivers. No water bodies are crossed by the pipeline in this WRIA.

Currently 26 water rights have been issued for areas adjacent to the pipeline right of way. Sources of these permitted water supplies are either wells or the Snake River. The primary beneficial water use is irrigation with some domestic, commercial, and fire protection uses. The primary permit holders are private corporations.

3.3.2.2 Surface Water Impact Assessment

Potential impacts to surface waters resulting from the proposed project can generally be characterized as those directly affecting instream processes and those that affect the banks and surrounding approach slopes and watersheds that drain to water bodies. Potential impacts to surface waters crossed by the project include:

- Channel and bank disturbance with subsequent habitat loss,
- Erosion and sedimentation with subsequent impacts to water quality and habitat,

- Flow interruption of surface water through emplacement of improper drainage structures,
- Pipe exposure from scour due to high flow events,
- Localized water quality degradation from construction activities, and
- Possible leaks and spills from pipeline operation.

Because of the large number of stream crossings and miles of pipeline trenching, potential impacts to surface waters from construction activities are of the most concern. However, the potential for impact to watercourses during operation associated with a leak or accidental release of product, should this occur, could also have significant detrimental impacts. The pipeline will be hydrostatically tested, as described in Section 2.5 Water Supply System) prior to introducing any product. The purpose of the hydrostatic Testing is to confirm the integrity of the materials and pipeline, and therefore minimize the potential for leaks and spills from the pipeline.

Potential surface water impacts from the project are manifested at stream crossings (or crossings of other water bodies such as wetlands and sloughs) where the pipeline intersects the resource. Runoff and drainage from the pipeline alignment will generally reach a watercourse, and direct impacts from construction and operation to the aquatic environment may occur within the watercourse at the point of crossing or downstream. Water courses also serve as the transport mechanism by which water quality impacts are transmitted further downstream. Because of these factors, pipeline stream crossings are the most critical and sensitive to impacts. Thus, the surface water impact assessment will focus on the stream crossings and on the banks and approach slopes to the stream crossings.

Construction Related Impacts

During construction of the pipeline, impacts to surface waters can occur as a result of ground disturbance, disturbance in stream channels, alteration of drainage pathways, discharge of excess water and hydrostatic test water, and spills and contamination from construction equipment and fuel storage. The effects of ground and channel disturbance, and alteration of drainage can result in one or more of the following:

- increased erosion and sedimentation,
- destabilization of stream banks and slopes,
- and destruction of aquatic habitat both directly at the point of disturbance in a channel and indirectly due to downstream sedimentation.

Discharge of excess water during drilling operations, trench dewatering during construction, and discharge of hydrostatic test water can all impact surface waters by affecting water quality and quantity in receiving waters. The potential impacts from discharge of these waters can include one of the following:

- short term introduction of water quality contaminants,

- short term introduction of sediments.

Accidental leaks and spills resulting from equipment operation and fuel storage along the route during construction can also affect water quality if it drains to watercourses. Potential water quality impacts would be temporary, and will not alter general water quality conditions.

Pipeline Stream Crossings

During the construction phase, the primary impact will be effects of increased erosion and sedimentation. Disturbance of the streambanks and stream channels can occur with increased sediment loading and resultant habitat destruction. The extent of increased turbidity will depend on both the existing channel condition and the selected construction methodology. Typically the effects will be short lived and will disappear once construction ceases and restoration measures are employed. Construction techniques are described in detail in Section 2.10 (Surface Runoff) and 2.14 (Construction Methodology) and include open cut methods such as dry trenching, flume and trench, or divert and trench.

The construction method used most often to bury the pipeline into the bed of a watercourse will be one of the open cut methods. Since the methods involve the excavation of a trench in the river bed, varying amounts of sediment can be released into the water column depending on the sediment size composition in the area to be crossed (including stream banks) and the control mechanisms. Both the presence of suspended sediment in the water column and the eventual deposition of fine sediments downstream may be injurious to aquatic life.

Wet trenching is employed in streams with low velocity (generally less than 0.1 m/s) and/or there are no water quality and aquatic habitat concerns immediately downstream. Typically, these are small DNR type 4 and 5 streams (including intermittent or dry streams) which do not have enough erosive power and are not large enough to significantly impact downstream water quality, and low gradient channels, sloughs and oxbows. A field assessment will be made by the construction manager (with oversight by Ecology) at each crossing to determine low sensitivity and/or low velocity at the time of construction. Preliminary sensitivity ratings have been developed based on survey information which can be used as an initial guideline and are presented on Table 3.3-6. These ratings will be refined as additional information is gathered as part of the design phase of the project. Once the determination is made, wet trenching will proceed, or the alternate dry trenching method will be employed.

Dry trenching uses flow control methods to route flow past the open cut. Flow is re-introduced to the channel after the pipeline is backfilled and the bed and banks are stabilized. Dry trenching can dam and divert flow completely out of the channel, for example into a dry adjacent channel or through a temporary flume, pipe or sluice, or can dam a part of the channel, concentrating flow in other parts of the channel and creating a backwater behind the temporary dam which can be trenched but which will not allow velocities high enough to cause erosion (less than 0.1 m/s). This latter approach will complete the trenching in two stages, one from each bank.

The stream diversion will be designed and operated such that it does not cause erosion and scour of the stream channel and will be screened to preclude fish entry. Excavating will be conducted to avoid cave-ins and sloughing of the trench sides and river banks. The original gradient of the stream will be maintained following backfill and no spoils banks or other objects will be left in the channel. All areas disturbed by the construction will be stabilized by mulching, re-seeding, or rip-rap placement, and excess spoils will be disposed of such that they do not re-enter the stream.

The modified open cut utilizes various measures to divert or control the water during the construction of the crossing. Special equipment and personnel are utilized to incorporate the designs for controlling mobilized sediment. The flume diversion is generally used to bypass stream waters through the construction area using a pipe placed in the streambed parallel to the streambank and centered where the pipeline would cross. This method is used in small watercourses with defined banks, defined channels and a solid fine textured substrate. This method is also employed when sedimentation and fish passage are of concern.

Another modified open cut method is the diversion method. This requires that the flow be diverted into a new temporary channel while the pipeline is installed across the old channel. This method is generally used for streams too large to flume, at braided channels, and when sedimentation and fish passage are of concern. It is best used when the new channel is clear of fines so that little sedimentation will occur.
The trench crossing the stream will be excavated using trackhoes operating from the stream banks. The pipeline crossing and alignment will be as nearly perpendicular to the stream as possible. Alterations to and disturbances of the stream bed, stream bank, and bank vegetation will be limited to the amount necessary to construct the project. The pipeline will be installed at a sufficient depth so that subsequent disturbance of the streambed is avoided. The depth will be below the maximum potential scour depth in the channel. Scour depths are estimated as described above, and consider bed material size.

Other stream crossing methodologies include:

- Horizontal Directional Drilling
- Bridged Crossing

Directional drilling is employed where excavation methods are impractical, such as where the stream is located on shallow bedrock, where the stream is too large for trenching, and where bank and bed instability are of particular concern based on geotechnical analyses. Drilling methods do not disturb the bed and banks of the stream, and therefore will have considerably less potential impact than trenching; however, drilling fluid runoff and runoff from site disturbance on the drilling pads near the banks can impact the stream if it is not controlled adequately. In some situations, the drilling fluid (mud) has been known to fracture the stream bed and escape into the water.

Bridged crossings will be used where an existing bridge of sufficient size and strength is located at the site of the proposed crossing. Bridge crossings will have minimal impact to streams, as no instream or bank construction will be necessary.

Stream crossing methods at each of the 293 waterways traversed by the pipeline are listed on Table 3.3-6 along with channel data and sensitivity ratings. The total number of waterway crossings includes 61 irrigation canals and 34 minor waterways with no defined channels. Surface water bodies most vulnerable to construction impacts include steep channels with banks and beds composed of easily erodible unconsolidated sediments. Fine-grained sands and silts are generally the more susceptible to erosive forces than larger particles. Sediments can be entrained and subsequently deposited in sensitive downstream reaches. Silts and clays can remain in suspension and result in turbid conditions in all downstream water bodies.

Pipeline construction will include temporary erosion control measures (see Section 2.10 Surface Water Runoff) which will minimize erosion and sedimentation impacts to surface waters. Disturbances to the channel from excavation will temporarily impact stream bank and bed integrity, increasing vulnerability to erosion and releasing entrapped fine grained sediments. These effects, however, will generally be localized, and will diminish in the downstream direction. The distance over which attenuation will take place will be determined by channel gradients and flow velocities. In addition, if these channel disturbances are made prior to a major flood event, channel erosion would likely be accelerated if bank and bed integrity is not restored.

Bottom dwelling organisms can be impacted by direct removal as the streambed is trenched. They can also become entrapped or entrained in the intake of the pipe used to divert water around the construction area. The placement of temporary dams and the operation of machinery in the stream can alter the substrate, causing local turbidity and sedimentation and displacement of these smaller organisms.

When equipment is operated in streams or refueling of equipment takes place within a floodplain, petroleum products could enter the water. Accidental petroleum spills during construction operations could affect aquatic organisms, either causing mortalities or causing fish and their food organisms to avoid contaminated areas. Aromatics in diesel and gasoline are particularly toxic until evaporated. Heavier oils can coat streambeds and interfere with production of food organisms consumed by fish. Spills into smaller tributaries could impact resident populations, especially while incubating embryos are present. It is also possible that some stream crossings will require blasting of bedrock, which, due to acoustic shock, could be harmful to fish that are in the immediate vicinity of the explosion if water were present in the stream. At this time, no in-water blasting is proposed. However, active construction in the stream will scare most fish out of the area prior to detonation.

The open cut crossings of streams will require the streambank to be graded to a slope that would allow passage of construction equipment and installation of erosion control devices. This will require the removal of riparian and streamside vegetation in the immediate vicinity (a 30-foot width).

Removal of riparian vegetation could result in a number of potential impacts. The removal of cover could increase local run-off causing greater erosion, turbidity, and suspended solids in streams and other water bodies. Stream temperatures in localized areas could also increase due to removal of streamside vegetation. Sublethal increases in temperature can indirectly affect survival and cumulative effects can reduce the quantity and quality of rearing habitat in downstream waters. However, the above impacts will be temporary and minimized as much as possible. Tree removal in riparian areas has been avoided in most cases, and all riparian areas will be revegetated shortly after construction (Section 3.4).

Impacts to Senior Water Rights

Temporary water quality impacts from erosion may impact senior surface water rights downstream, if the introduced sediment impairs the use. This possibility is greatest in areas where surface water is used for irrigation, in which case sediment-laden water could damage pumps. Additionally, during hydrostatic testing of the pipeline, water withdrawals from the Snoqualmie River may infringe on instream flow requirements if the water is withdrawn during low flow periods. Neither of these two impacts is expected; however, because construction and hydrostatic testing will occur during a time window when these conflicts are not possible (see Fisheries section for construction timing window).

Kittitas Terminal

Prior to construction activities at the Kittitas Terminal, an onsite stormwater collection system will be completed to direct runoff to a retention/detention facility designed to the 25 year storm event. Construction will compact the soil and create areas impervious to surface infiltration, which will result in larger volumes of surface runoff. This runoff will be collected in the onsite stormwater collection system and directed to a retention/detention facility.

Operation Related Impacts

Impacts to surface waters may result from operation of the proposed pipeline system in response to one or more of the following conditions:

- ongoing construction related problems that were inadequately addressed by stabilization measures including on-going erosion due to stream bank and bed instability initiated by construction, erosion from stream approach slopes if slope stabilization and revegetation are inadequate, slope erosion and mass wasting if drainage problems are initiated and/or exacerbated by clearing and construction,

- initiation of slope erosion, bank erosion and mass wasting if drainage in the trench or on slopes is inadequately controlled such that water is concentrated and/or results in changes in soil saturation, and

- water quality impacts if a leak or spill occurs in the pipeline and flows to a stream coarse or other water body.

Drainage problems at the Kittitas Terminal may also result in water quality problems if runoff is not adequately collected and routed to the retention/detention facility. Storm water discharge at the Terminal is discussed in section 2.7 Aquatic Discharges, and spill prevention and control is discussed in detail in Section 2.9 Spill Prevention and Control.

If the pipeline were exposed by scour at river and stream crossings potential damage to the pipeline might occur. However, the burial depth at river and stream crossings will be sufficient to prevent exposure. In addition, the pipe will be concrete coated to reduce the potential buoyancy.

Impacts to Senior Water Rights

Temporary impacts to senior water rights could occur if a spill or leak of petroleum product from the pipeline entered a stream or river and impaired the beneficial use of the resource. In the event of a spill, which is considered to be unlikely and a very rare possibility, all downstream surface water right holders will be notified (see Appendix B for a list of water rights in each WRIA) of the spill and an assessment made as to the degree and quantity of impaired use. OPL will develop a plan, in coordination with state and local agencies, municipalities and communities, to compensate for impaired water uses if a spill occurs. The plan will be developed on a WRIA basis as part of the project implementation. This is of particular concern in WRIA 39, Upper Yakima River, due to ongoing adjudication in their region.

Impact Sensitivity

Impacts to surface waters resulting from project construction and operations will largely be observed at stream crossings and downstream of stream crossings because it is at these crossing points where the project and surface waters interact. For this reason, impact sensitivity can largely be assessed as a function of the stream channel and aquatic habitat conditions found at and downstream of the crossings. Key hydrologic and channel factors associated with streams and other surface water bodies which significantly affect the sensitivity and degree of impacts from construction and operation of the pipeline include channel size, habitat quality, stream bed and bank erodibility, channel slope, steepness of bank and approach slopes at the stream crossings, the amount and intensity of rainfall, and the occurrence of high runoff and streamflows.

The above factors have been used to develop a hydrologic sensitivity rating for pipeline stream crossings. The rating is based on readily obtainable channel information, and is reproducible and representative of the range of conditions found along the proposed route. The hydrologic sensitivity rating is the sum of the indices for Bankfull Channel Width, Channel Gradient, Bed and Bank Erodibility, and DNR Stream Type. Indices used in the calculation of hydrologic sensitivity are described in Table 3.3-5. Hydrologic sensitivity ratings for the streams crossed by the proposed pipeline are presented on Table 3.3-6 along with the channel data used to develop the rating, channel depth, observed low flows (August 1996), and stream crossing construction method.

The stream channel characteristics used to develop the hydrologic sensitivity ratings include channel width, channel gradient (within the crossing corridor), and erodibility. Each of these characteristics influence a channel's capacity to erode and transport significant amounts of sediment to downstream areas. The DNR stream type is a measure of the human and habitat value of the stream, at the crossing and downstream of the crossing (see DNR stream type system). This measure is also used in the hydrologic sensitivity ratings to account for the different values and uses which may be more or less sensitive to change at each stream.

TABLE 3.3-5
RELATIVE HYDROLOGIC/GEOMORPHOLOGIC SENSITIVITY RATING INDICES

Index Parameters	Parameter Description and Justification	Index Rating Values	Relative Rating Value Description
Bankfull Channel Width	The channel width is an indicator of channel size and discharge, channel form and habitat function. These factors are important considerations concerning construction, operation and contribution to downstream areas.	1 = Width less than 50' 2 = Width 50 - 100' 3 = Width >100'	Bankfull channel widths are broken into three width categories which correspond to channel conditions found in the project area. Smaller tributary streams generally have widths less than 50', large tributaries to the mainstem rivers have widths less than 100', and the large drainages including the Snoqualmie and Yakima Rivers have channel widths in excess of 100'.
Channel Gradient	The channel gradient is an indicator of stream velocities and erosive tractive forces, as well as the channel form. Steep gradient streams typically are found in mountainous areas or are associated with the headwalls of canyons, and are sediment and debris conduits.	1 = Gradient < 2% 2 = Gradient 2-4% 3 = Gradient > 4%	Channel gradient index values correspond to channel conditions found in the project area. Channels in steep terrain that act primarily as conduits for sediment and debris generally have gradients larger than 4%. Alluvial fan channels and braided channels typically have gradients of less than 4% but greater than 2%, and streams located in floodplains generally have gradients less than 2%.
Bed and Bank Erodibility	The erodibility of the bed and banks of a stream channel is a direct indicator of potential sediment delivery to downstream areas, and potential channel disruption from construction and operation of the pipeline and access roads.	1 = low erodibility 2 = moderate erodibility 3 = high erodibility	The erodibility index is defined by the dominant substrate, with coarse materials including cobbles and large gravels as the lowest erodibility, small gravels and sand as moderate erodibility and fines (fine sand/silt and clay) as the highest erodibility.
DNR Stream Type	The DNR stream typing system is an index to the beneficial uses or potential beneficial uses and importance of waterways in Washington State. The stream typing criteria include stream value for public and domestic water supply, use and preservation of fish and wildlife habitat, and preservation of water quality.	DNR type 5 = 1 DNR type 4 = 2 DNR type 3 = 2 DNR type 2 = 3 DNR type 1 = 3	The DNR stream types, 1 through 5 are used inversely as the index values. DNR stream type 1 are shorelines of the state, and therefore are the larger streams supporting fisheries, recreational and water supply uses. Because of the importance of type 1 waters, the index rating is 5 (the most sensitive to impact). The DNR type system not only indexes the beneficial use categories of the stream reach in question, but also characterizes cumulative impacts in a downstream direction. The least sensitive stream type is 5, indicating that these streams have little if any significance to downstream water quality and beneficial uses, and are generally intermittent without well defined channels. The type 5 stream, therefore is indexed with the lowest impact rating value of 1.

TABLE 3.3-6 - Hydrologic Data Summary

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

TABLE 3.3-6 - Hydrologic Data Summary (continued)

3.3.2.3 Surface Water Mitigation

The primary means to minimize impacts during both construction and operation of the project is to follow BMPs as outlined in Section 2.10 for surface water and erosion control, and to use the appropriate stream crossing construction trenching method as field conditions warrant (See Section 2.14 Construction Methodology). Several of the most sensitive streams as indicated by the sensitivity rating) will be bridged or drilled, thus significantly reducing the potential for impacts at these crossings. These streams include both crossings of the Snoqualmie River, both crossings on South Fork Snoqualmie River, and the Columbia River. Bridges will be used where a bridge of adequate size and strength is available. Several of the irrigation canals will be jack-and-bored due to their existing structure (concrete lining).

It is assumed that for the majority of stream crossings, effective application of drainage and erosion control BMPs during construction, and appropriate construction methods (see Appendix) will result in minimal impacts. The key mitigation strategy and BMPs that will insure minimal impacts are the following:

- Minimizing the amount of disturbance.
- Seasonal construction phasing, thus avoiding time periods when significant erosion can occur.
- Effective monitoring of BMPs during construction to detect problems before they become significant, especially at the most sensitive crossings, followed by appropriate actions to modify the BMPs if monitoring indicates that problems are developing.

The key design and construction features and post-construction BMPs and activities which will insure minimal impacts during operation include the following:

- Adequate pipeline burial depth and width at each crossing, considering the full active channel width and active downcutting of the bed in incised channels.
- Stream bank and bed stabilization after construction.
- Aggressive slope stabilization and re-vegetation after construction.
- Inclusion of block valves at spacings sufficient to prevent large petroleum products releases, placement of trench plugs in the pipeline trench on each bank of a crossing (to prevent leakage from entering a stream via the trench fill).
- Effective long term monitoring of erosion conditions to prevent potential pipeline exposure.

- Effective corrosion protection at crossings (and in areas of shallow ground water) to preserve the integrity of the pipeline.

- Effective long term monitoring for leaks and spills to provide adequate lead time for prevention and cleanup actions.

At the most sensitive stream crossings including all those with sensitivity ratings greater than one standard deviation from the mean for all of the crossings (41 stream crossings), more frequent and focused monitoring will be accomplished during construction and operation. The monitoring schedule will be developed in coordination with the Department of Ecology.

During the design phase of the project, crossing design plans and drawings will be developed for the most sensitive stream crossings (greater than two standard deviations from the mean) including specifications for construction method, temporary drainage and erosion control measures (such as specific placement of erosion control and sediment detention structures, and construction/operation monitoring plans. Additionally, these plans will be adapted by the field construction managers for application to all of the crossings.

The following specific BMPs should be followed at all stream crossings.

<u>Staging Areas</u>

- Staging areas will be located at least 50 feet away from streambank where topographic conditions permit.
- The streambed preparation area will typically be 60 feet by 100 feet on both sides of the stream crossing.
- No hazardous materials, chemicals, fuels, and lubricating oils will be stored within floodplain.
- All equipment will be refueled at least 100 feet from the streambank.
- Additional training will be provided and absorption material will be kept in staging areas for cleanup of small releases.

<u>Spoil Placement and Control</u>

- The upper 6" to 12" of topsoil will be removed and protected throughout construction with erosion control devices.
- Spoil flow, or runoff of spoil will be prevented from going off of right-of-way.
- All spoil material from water body crossings will be placed in the right of way at least ten feet away from the ordinary high water line.

- The materials removed from the trench below the topsoil level may also be stockpiled in adjacent upland areas. However, it will not be placed on top of, or mixed with, the topsoil material previously removed.

Seasonal Phasing and Time Windows for Construction

- Construction of stream crossings will occur during low flow periods but prior to anadramous fish migration.

Watercourse Crossing Procedures

- Equipment crossings of sensitive perennial streams (see Table 3.3-6) will be accomplished with the use of pads with culverts, clean rockfill and culverts, or a portable bridge.
- The crossing through the stream will be reduced to 30 feet wide or less.
- Stream crossings will be constructed as perpendicular to axis of stream channel as engineering and routing conditions permit.
- Before trench excavation begins, vegetation and topsoil in the riparian zone will be removed and stockpiled for later use.
- Material removed for trench construction will be stockpiled on the ground outside the sensitive area and contained within an earthen berm.
- Once the trench has been excavated, preconstructed lengths of pipe will be pulled through the stream ditch underneath the bypass pipe.
- If the stream width warrants it, concrete coated pipe will be installed to prevent the pipe from floating up through the surface after water is returned to the streambed.
- Clean gravel will be used for upper one foot of fill over backfill trench within stream channels.
- Downstream flow rates will be maintained at all times.
- For crossings of ecologically sensitive fish habitat, streams will be routed across a trench using a flume pipe or pump around system using the "dry ditch" technique.
- Instream construction in minor streams will be completed within 48 hours if possible.
- If blasting is required, fish will be captured and relocated to other appropriate stream areas prior to blasting activities.
- Floating silt fences will be used if appropriate.

Temporary Erosion and Sediment Control

- See Section 2.10 Surface-Water Runoff for a listing of erosion and sediment control devices.
- Temporary erosion and sediment control devices will be inspected daily and repaired as

needed.

- Sediment filter devices will be installed and maintained at all streambanks.

Bank Stabilization and Revegetation

- The streambank will be returned to original contour when possible.
- Revegetation will be performed immediately after construction using vegetation that quickly establishes and native plants such as willows and alder for long-term stabilization.
- Log deflectors will be used where practicable to create sediment deposition and allow the reestablishment of vegetation to stabilize banks.
- The use of rip-rap will be limited to areas where flow conditions preempt vegetative stabilization.

Operations

- All river crossings will be restored after construction and will have ongoing maintenance as required to prevent erosion
- Frequent inspections of the pipeline by air will provide detection of any potential problems due to erosion or other construction activity in the area.
- Water crossings will be surveyed for bottom contours to ensure adequate soil depth over the pipeline is maintained.

Senior Water Rights

As previously mentioned, a spill or leak during pipeline operation may impact downstream senior water rights by impairing use because of degraded water quality. If a spill should occur of sufficient quantity to impair downstream water use, OPL will compensate for the impairment according to a plan developed in coordination with state and local authorities, and communities in each WRIA.

Permits

Pipeline construction will require permits for temporary stormwater discharge (see Section 2.10 Surface-Water Runoff and Erosion Control) and hydrostatic testing, as well as hydraulic permits (see Section 3.4.4 Plants and Animals - Fisheries) for stream crossings. The project will comply with Aquatic Conservation Strategy Plans (see Section 3.4.4 Plants and Animals - Fisheries).

3.3.3 RUNOFF AND ABSORPTION

Runoff and absorption/infiltration conditions are a function of the climatic conditions (particularly the amount and intensity of rainfall and accumulation of snow), the soil permeability, solid thickness, land surface cover, and ground slope. In general, areas of highest runoff and lowest absorption occur where soils are thin, slopes are steep and cover is sparse. High runoff areas are the most sensitive to potential impacts from the project construction, because the high runoff contributes to higher erosion, particularly where soils are more erodible. Areas of greater capacity for absorption and lower runoff occur where soils are thick and permeable, and slopes are mild. High absorption areas are the most sensitive to potential operational impacts resulting from leaks and spills from the pipeline, and also coincide with areas of groundwater recharge.

3.3.3.1 Existing Conditions

Along the pipeline route, areas of high runoff are expected in the mountainous areas of the western and eastern Cascades. However, runoff will be greatest in the western Cascades because of climatic conditions, with higher rainfall and greater snow accumulation compared to the eastern Cascades. Due to thin soils in the mountain areas, high runoff is also often associated with saturated soil conditions. Where soils are erodible or disturbed, or where trees are harvested (reducing the stabilizing effect of tree roots), this combination creates conditions where landslides and mass wasting are prevalent. In larger river valleys and intermontane regions, areas of mild slope and thick soil accumulations occur within the generally steep terrain of the Cascades. In these areas, runoff is reduced and absorption can be high, creating significant groundwater reservoirs and wetlands.

The areas of greatest absorption are in the Puget Sound Lowlands and the Columbia Plateau due to the generally low relief and thick soil assemblages. In the Puget Sound Lowlands, higher precipitation with less intensity contributes to the highest absorption found along the route alignment, along with the most significant groundwater reservoirs. Additionally, permeable glacial soils are prevalent in many areas of the Puget Sound Lowland, further increasing the potential for absorption in this region. However, the glacial soils which dominate this region are often highly erodible, thus even though surface runoff rates are not as high as in the Cascades (because of lower precipitation, less intensity and miler slopes), erosion is a significant problem in drainages and on slopes that have been cleared of vegetation.

Within the Columbia Plateau, low rainfall results in much lower rates of absorption and groundwater recharge, although in the flatter areas, very little runoff is generated, as it is immediately absorbed by the soils. Throughout much of the region soils are highly erodible, and in some area exhibit relatively low permeability (loess deposits and lacustrine soils). In these areas, particularly where slopes are steeper such as in ravines and hilly terrain, precipitation of relatively high intensity (although of low annual total) can result in very high runoff rates with subsequent high rates of soil erosion. Under these conditions, runoff associated with individual storms and as compared to annual precipitation totals can be the highest along the route.

3.3.3.2 Runoff and Absorption Impact Assessment

Potential impacts to runoff and absorption processes resulting from the project will vary depending on the region, as described above. However, clearing and ground disturbance in all areas along the pipeline route will impact runoff and absorption similarly, with resultant increases in runoff with erosion and decreases in absorption/infiltration. The relative impacts of clearing and ground disturbance will be most keenly observed in the Puget Sound Lowland region and in the Western Cascades, due to the much higher rates of precipitation and importance of vegetation to soil stability. In the eastern Cascades clearing and ground disturbance will impact runoff, erosion and absorption similarly; however, due to lower amount of precipitation, the impacts will generally be less. In the Columbia Plateau, clearing and grading will have a comparatively lower impact, due to less vegetation and less precipitation. Additionally, the conditions that result in high erosion and runoff (i.e. high intensity rainfall, erosive soils and steeper terrain) will tend to be susceptible to high runoff and erosion irrespective of the disturbance created by the project. This is due to less overall change in conditions resulting from the disturbance as soils are generally more exposed with less ground cover in this region compared to other regions.

Impacts related to increased runoff and erosion can be locally significant to streams and water bodies if not minimized and mitigated, particularly in the short term during and immediately after construction. Increases in runoff will not impact overall streamflow rates and peak flows; however, because over the watershed, the area of disturbance is small. Impacts related to reductions in absorption, including reduction in groundwater recharge and soil moisture, will likely have little or no impact due to the small area of disturbance relative to the areal extent of recharge areas. Recharge and soil moisture conditions are maintained by infiltration over broad areas, and the linear pipeline feature would not cover enough area to be considered significant to these processes. However, in areas of high absorption, leaks and spills from the pipeline could have significant impacts if the product leak or spill were large enough to spread to the water table.

3.3.3.3 Runoff and Absorption Mitigation Measures

Minimizing impacts and mitigation for impacts to runoff and absorption resulting from the project construction and operation revolve around the following general BMP and mitigation strategies:

- Adequate drainage and erosion control during construction;
- Minimizing disturbance area;
- Avoiding construction during periods of high precipitation (seasonal construction phasing);
- Adequate re-vegetation and slope stabilization after construction; and
- Effective monitoring of BMPs during construction and spill monitoring during operation.

BMPs and mitigation details have been previously described in section 2.10 and 3.3 above. Application of

BMPs and mitigation strategies will emphasize the concerns and focus related to each region discussed above.

3.3.4 FLOODS AND FLOODPLAINS

Flood magnitudes and the development of floodplains in streams and rivers along the pipeline route vary depending on climatic, watershed and topographic conditions. Flood magnitudes increase with increasing watershed area, and are larger in proportion to the contributing watershed area in areas of greater precipitation. The amount of vegetative cover, forested area and lake are in a watershed also affects flood magnitude. In watersheds with similar contributing areas, where there is less ground cover and no lakes flood magnitudes are larger. This is because of less storage in the watershed and higher runoff rates. In steeper terrain, particularly those areas where channels are actively downcutting and incised, floods are contained within the incised channel, whereas in flatter terrain in areas of sediment deposition, floods are not contained within the channel banks and form broad floodplains.

Floods with a relatively frequent return period, i.e. high probability of occurrence, form the stream channel characteristics and are referred to as channel forming discharges. Floods with return periods of 2 to 5 years are generally considered to represent these discharges, which are frequent enough and large enough to shape the width, depth and banks of channel via scour and erosion processes. Larger floods with a larger return period such as the 100-year flood are conveyed within the channel and in the floodplain as overbank flow. These larger events, therefore affect and are affected by the floodplain characteristics.

The magnitude of the more frequent channel forming floods compared to the larger floods which are conveyed through the floodplain indicates the relative difference between the cross-sectional area and width of the bankfull channel and the cross-sectional area and width necessary to convey the larger flood within the active floodplain. As previously mentioned, however, within incised channels floodplains do not generally occur. Additionally, near the mouths of streams and where channel gradients flatten abruptly, floodplain widths may be much wider than the active channel. In these areas, channel meandering may also be evident.

Flood and floodplain gaging and delineation data is generally available only on the larger streams in the project area, including the Snoqualmie River and its major tributaries, Yakima River, Columbia River and Crab Creek. Flood flow data at stream crossings for gaged streams can be obtained from the U.S. Geological Survey and adjusted by the ratio of the watershed area upstream of the gaged site to the watershed area upstream of the stream crossing, or predicted using statistical methods developed by the U.S. Geological Survey (USGS Open File report 74-336). Table 3.3-7 indicates streams and rivers with mapped 100-year floodplains. The floodplain boundaries within the pipeline corridor have been mapped on the project Atlas.

TABLE 3.3-7
FLOODPLAIN CHARACTERISTICS
OF WATERBODIES ALONG THE PIPELINE CORRIDOR

Crossing Name	Location	Flood Hazard[a]
Little Bear Creek	SW ¼, SEC 22, T27N, R5E	Zone A[b]: 100-year flood - 177 feet
Snoqualmie River	N ½, SEC 25 and N ½ SEC 26, T27N, R6E	Zone A10: 100-year flood - 3,525 feet
North Fork Cherry Creek	W ½, SEC 9, T26N, R7E	Zone A[b]: 100-year flood - 531 feet
Meadowbrook Slough	W ½, SEC 33, T24N, R8E	Zone A[b]: 100-year base flood - 1,954 feet
Tolt River	SW ¼, SEC 14, T25N, R7E	Zone A[b]: 100-year base flood - 257 feet
Snoqualmie River	S ½, SE ¼, SEC 29, T24N, R8E NE ¼, SEC 32, T24N, R8E SW ¼, SEC 33, T24N, R8E	Zone A12: 100-year flood - 3,230 feet
South Fork Snoqualmie River	SEC 4, T23N, R8E NE ¼, SEC 9, T23N, R8E S ½, SEC 10, T23N, R8E NE ¼ SEC 15, T23N, R8E SEC 14, T23N, R8E	Zone A12: 100-year flood - 7,758 feet
Keechelus Lake	SEC 27, 34, 35, T22N, R11E SEC 2, 11, 13, T21N, R11E	Zone A[c]: 100-year flood - 6,668 feet
Cabin Creek	N ½, SEC 9, T20N, R13E	Zone A[b]: 100-year flood - 1,298 feet
Big Creek	SE ¼, SEC 29, T20N, R14E	Zone A[b]: 100-year flood - 535 feet
Little Creek	S ½, SEC 33, T20N, R14E	Zone A[b]: 100-year flood - 787 feet
Yakima River	S ½, SEC 11, T19N, R16E	Zone A[b]: 100-year flood - 836 feet
Swauk Creek	N ½, SEC 17, T19N, R17E	Zone A[b]: 100-year flood - 467 feet
Currier Creek	SEC 35, T19N, R18E	Zone A[b]: 100-year flood - 390 feet
Wilson Creek	NE ¼, SEC 19, T18N, R19E	Zone A[b]: 100-year flood - 147 feet
Naneum Creek	NE ¼, SEC 29, T18N, R19E	Zone A[b]: 100-year flood - 128 feet
Coleman Creek	NE ¼, SEC 4, T17N, R19E	Zone A[b]: 100-year flood - 851 feet
Cooke Creek	NW ¼, SEC 11, T17N, R19E	Zone A[b]: 100-year flood - 862 feet
Caribou Creek	SE ¼, SEC 11, T17N, R19E	Zone A[b]: 100-year flood - 129 feet
Park Creek	SE ¼, SEC 8, T17N, R20E	Zone A[b]: 100-year flood - 434 feet
Columbia River	N ½, SEC 20, T16N, R23E	Zone A[b]: 100-year flood - 998 feet
Lower Crab Creek	SEC 33, T16N, R27E	Zone A[b]: 100-year flood - 272 feet
Esquatzel Coulee	NE ¼, SEC 25, T10N, R29E	Zone A[b]: 100-year flood - 2,365 feet

(a) Data from FEMA flood insurance maps.
(b) Zone A - Area of 100-year flood. Flood hazard level not defined; approximate elevation of Flood Hazard Area.
(c) Flood insurance maps indicate potential for some portions of the JWT to be subject to flooding.

3.3.4.1 Existing Conditions

Puget Sound Lowlands

Floods originating from watersheds located within the Puget Lowland region occur in the late fall and early winter (November to January) resulting from large rainfall events. Typically, the largest floods are the result of heavy rainfall over a short duration that is preceded by a rainy period that has saturated the ground. In this region, the 100-year floods are typically 20 times or more larger than the average annual flows, and 2 to 3 times larger than the channel forming discharge. Many of the streams in this region are deeply incised, especially in the upper reaches and therefore do not exhibit well developed floodplains. In the lower gradient areas (less than 2 percent channel gradient) the 100-year floodplain cross-section and width is likely to be at least three times larger than the bankfull channel cross-section and width, as indicated by the difference in magnitude between the 100-year flood and the channel forming flood. Near the mouth of streams where the channel gradient becomes very flat and velocities decrease significantly, floodplain widths may be more than 3 times the bankfull width. Many of the streams and rivers in this region have floodplains that have been mapped because of development (Table 3.3-7).

Western Cascades

Most of the major floods in this region have occurred between November and February. Storms which cause flooding are usually associated with long duration steady rains coupled with warm temperatures and snowmelt, called rain-on-snow events. Generally, flooding of this type occurs over large areas, such that flooding occurs in many tributaries at or near the same time. The 100-year floods are generally 30 to 40 times larger than the average annual flow, and 2 to 3 times larger than the channel forming discharge. Many streams in this region are deeply incised except in the larger intermontane valleys, and therefore do not exhibit well developed floodplains. However, in the larger valleys, the 100-year floodplain cross-section and width is likely to be at least three times larger than the bankfull channel cross-section and width, as indicated by the difference between the magnitude of the 100-year flood and the channel forming flood. Streams or rivers with designated flood plains are listed in Table 3.3-7.

Eastern Cascades

Most of the major floods in this region occur in the late fall and early winter as a result of rain-on-snow events; however, large floods can also occur in the spring in response to rapid snowmelt. The 100-year floods are generally 10 to 15 times larger than the average annual flow, and 1.5 to 3 times larger than the channel forming discharge. Many streams in this region are deeply incised except in the larger intermontane valleys, and therefore do not exhibit well developed floodplains. However, in the larger valleys, the 100-year floodplain cross-section and width is likely to be at least two to three times larger than the bankfull channel cross-section and width, as indicated by the difference between the magnitude of the 100-year flood and the channel forming flood. Streams or rivers with designated flood plains are listed in Table 3.3-7.

Columbia Plateau

Most of the major floods in this region occur in the late fall and winter as a result of short duration heavy rainfall. The 100-year floods are generally more than 100 times larger than the average annual flow, and 3 to 8 times larger than the channel forming discharge. Large floods generally exhibit greater variability and are larger relative to average flows and bankfull discharges because of the climatic conditions. Many streams in this region are deeply incised within canyons and coulees, and therefore do not exhibit well developed floodplains. However, in the larger valleys and near stream mouths, the 100-year floodplain cross-section and width is likely to be at least three or more times greater than the bankfull channel cross-section and width, as indicated by the difference between the magnitude of the 100-year flood and the channel forming flood. Streams or rivers with designated flood plains are listed in Table 3.3-7.

3.3.4.2 Floods and Floodplains Impact Assessment

The pipeline construction will not impact flood magnitudes and floodplains because of the relatively small area impacted within a given watershed, and because there will be no physical obstructions to flow. Additionally, construction will occur during periods of low flow, thus avoiding flood conditions altogether. Impacts to the flooding and floodplains during operation are also expected to be minimal and non-significant, since the pipeline will be buried and pipeline facilities will be small in area and located outside of designated floodplains. However, consideration of floodplain issues are important for protection of pipeline and minimizing potential effects which could contribute to pipeline leaks, spills and other damage.

During large floods, sections of pipeline across the width of the floodplain may be subject to buoyant forces within the trench due to saturation. The buoyancy could stress the pipeline and lead to fractures and subsequent leaks and spills. Additionally, physical damage to valves and other facilities located within a floodplain could occur from floating debris. To minimize these potential impacts to the pipeline, all pipeline facilities and above ground valves will be located outside of floodplain boundaries.

Within stream valleys with no designated floodplain, field determination of the floodplain width will be completed at each stream crossing either as part of the design phase at the most sensitive steam crossings or during the construction phase. The expected floodplain width, as characterized above for each hydrologic region will be used in conjunction with field identification of high water marks and extent of floodplain channels to delineate the floodplain. The pipeline will be buried below maximum scour depth across the full width of the floodplains, and will be encased in concrete pipe to protect against scour and flotation.

3.3.4.3 Floods and Floodplains Mitigation Measures

- To minimize potential impacts to the pipeline from flooding, all pipeline facilities and above ground valves will be located outside of floodplain boundaries.
- The pipeline will be buried below maximum scour depth across the full width of the floodplains, and will be weight-coated with concrete or river weights to protect against scour and flotation.

3.3.5 GROUND WATER RESOURCES

Ground water conditions along the proposed alignment are highly variable depending on the geologic and climatologic conditions. The occurrence and depth to ground water is primarily a function of climatic conditions along the route, and the permeability of overlying soils and geologic strata. In the driest areas, ground water generally occurs at greater depths due to low seasonal recharge, and occurs at shallower depths in areas of higher precipitation. The exception to this is ground waters in association with large bodies of surface water such as in low-lying basins with lakes and river valleys. In these areas, the ground water and surface water interact maintaining base water levels.

Along the pipeline route, ground waters are recharged (replenished) primarily by direct infiltration of precipitation or by flood waters that inundate floodplains. In the drier areas of eastern Washington, infiltration from flooding streams and rivers may be the primary source of ground water recharge. Recharge typically occurs during wet periods when precipitation exceeds evaporation and evapotranspiration, and when rivers and streams are at peak stage. Recharge to ground water from direct infiltration of precipitation occurs at varying rates depending on the permeability of soil and overlying geologic materials. Recharge may also be from small streams and water bodies which lose water to the underlying sediment.

In general, ground water flows from areas of recharge to areas of discharge. In areas of recharge by precipitation, ground water flows vertically downward until it reaches the water table (or piezometric surface), where it then flows in the direction of topographic relief toward surface water drains and reservoirs such as streams, rivers and lakes. Typically, areas of recharge are located at higher elevations, and areas of discharge are at lower elevations. Ground water provides baseflow to streams and rivers in discharge areas, sustaining instream flow during dry periods. Recharge to ground water occurs over large upland areas and through soils overlying the water table via infiltration of rainwater and snowmelt. The rate of recharge is dependent on the permeability of the soils and geologic formations as well as the quantity of water available for infiltration. Discharge occurs where the ground water table intersects the land surface, or where artesian conditions exist. Artesian conditions occur where overlying geologic deposits have a very low permeability and sufficient recharge is available at higher elevations to create an upward pressure head.

Localized recharge and discharge conditions can exhibit a trend reversal in floodplains of large streams and rivers fed by watersheds that are larger and more climatically variable than the prevailing conditions in the floodplain reach. Under these conditions, during periods of high river flow water supplied further upstream, will create high surface water elevations relative to local ground water elevations, and flood waters will recharge ground water via infiltration through the streambanks and floodplain soils. During dry periods, the more typical recharge/discharge relationship will re-establish itself, with ground water discharging back toward the river or stream.

Ground water flow velocity is dependent on the hydraulic gradient, i.e., the slope of the water table (or piezometric surface) and the permeability of the geologic materials through which ground water flows. In high permeability sands and gravels vertical infiltration rates in recharge areas can be as high as 100 to 500 feet per day, given a hydraulic gradient of 1 and a permeability of 10 to 100 feet per day. In low permeability soils, such as glacial tills and fine grained sediments (silts and clays) vertical infiltration rates can often be less than 1 foot per day. Horizontal flow rates are typically much lower due to lower hydraulic gradients even in the most permeable materials.

Ground water occurs in virtually all geologic formations, however under many conditions is relatively unavailable for human use because it is contained within low permeability geologic materials or is located at excessive depths. Ground water contained in geologic formations near enough to the surface and with sufficient permeability to be accessible to pumpage in quantities suitable for human uses comprise aquifers. Aquifers along the route alignment occur in various geologic formations including recent alluvial deposits near large rivers and streams, glacial drift deposited during previous glacial periods, fractured bedrock of the Cascades, layered basalt formations and pre-glacial sedimentary formations. A general description of aquifer types along the pipeline route are presented below and in Table 3.3-8 along with issues of concern regarding the project for each aquifer type.

TABLE 3.3-8
AQUIFER TYPES AND ASSOCIATED ISSUES OF CONCERN

Region	Characteristics	Issues and Concerns	Monitoring/ Mitigation
Alluvium	Typically shallow water table associated with surface water bodies and floodplains. Well yields moderate to high supporting public and domestic supplies. Variable sediment types. Provides baseflow to streams and rivers. Limited extent.	Shallow water table subject to contamination with risk of spread and entering surface water bodies and wells. Dewatering during construction may be necessary. Pipeline corrosion will be prevented.	Pipeline design features to minimize risk of leak (e.g., welded high-strength coated pipe, cathodic protection, block valves). Computerized leak detection system, regular visual inspections, internal inspections, and regular maintenance.
Glacio Fluvial	Variable water table depths. Multilayered aquifer, confined	Risk of contamination in shallows zones with subsequent	Pipeline design features to minimize risk of leak (e.g.,

TABLE 3.3-8 (CONTINUED)
AQUIFER TYPES AND ASSOCIATED ISSUES OF CONCERN

Region	Characteristics	Issues and Concerns	Monitoring/ Mitigation
	and unconfined conditions. Well yields can be substantial, supporting public and domestic supplies. Limited extent. Provides baseflows to rivers and streams.	spreading to water table and surface water. Dewatering may be necessary during construction in areas of shallow groundwater.	welded high-strength coated pipe, cathodic protection, block valves). Computerized leak detection system, regular visual inspections, internal inspections, and regular maintenance.
Cascade Bedrock	Deep water table, often associated with fracture zones. Very limited in extent. Generally does not support water supplies.	Lower risk of contamination from spills; however, groundwater cleanup is impractical. Trench could serve as preferential pathway.	Flow barriers will be located in the trench at stream crossings and trench backfill will be of similar or lower permeability as the surrounding soils.
Loess/Dune Deposits	Variable water table depths; however, typically deep. Poor well yields generally do not support water supplies. Limited aquifer extent. Slow groundwater movement.	Lower risk of contamination from spills; however, groundwater cleanup is impractical. Trench could serve as preferential pathway.	Flow barriers will be located in the trench at stream crossings and trench backfill will be of similar or lower permeability as the surrounding soils.
Outburst Flood Deposits	Water table generally shallow, although can be deeper in upland areas. Aquifers are associated with streams and rivers providing baseflows. Large yield supporting public and domestic supplies. Rapid transport. Limited extent.	Risk of contamination in shallow zones with subsequent spreading to water table and surface water. Dewatering may be necessary during construction in areas of shallow groundwater.	Pipeline design features to minimize risk of leak (e.g., welded high-strength coated pipe, cathodic protection, block valves). Computerized leak detection system, regular visual inspections, internal inspections, and regular maintenance.
Lacustrine Deposits	Water table depth variable. Low yields to wells.	Risk of contamination in shallow zones. Pipeline corrosion could also result in shallow zones. Trench may serve as preferential pathway. Dewatering during construction may be necessary.	Pipeline design features to minimize risk of leak (e.g., welded high-strength coated pipe, cathodic protection, block valves). Computerized leak detection system, regular visual inspections, internal inspections, and regular maintenance.
Columbia River Basalts	Aquifers typically deep, exhibiting confined (artesian) conditions. Aquifers are regionally extensive. Groundwater transport rapid. Groundwater supports public, domestic, and irrigation wells. Well yields can be high.	Risk of contamination through well bore holes is possible. If such an event occurred, spread can be considerable.	Conduct surveys to determine proximity of wells to pipeline alignment.
Sole-Source Aquifers (Cross-Valley Aquifer)	Aquifer is located in a glacio-fluvial sand deposit, underlying glacial till ranging in thickness from 25 to 100 feet. The aquifer is recharged via infiltration through the capping till layers.	Risk of contamination.	Pipeline design features to minimize risk of leak (e.g., welded high-strength coated pipe, cathodic protection, block valves). Computerized leak detection system, regular visual inspections, internal inspections, and regular maintenance. If studies show additional measures are necessary, such measures may include extra pipe wall thickness,

TABLE 3.3-8 (CONTINUED)
AQUIFER TYPES AND ASSOCIATED ISSUES OF CONCERN

Region	Characteristics	Issues and Concerns	Monitoring/ Mitigation
			additional localized cathodic protection, additional pipe joint inspection prior to coating, and additional block valve.

Alluvium

Generally, alluvial aquifers are unconsolidated sand, gravel, silt and clay deposited by streams along lowland floodplains. Alluvial deposits of sufficient extent to comprise an aquifer occur in association with the larger rivers in Washington within and adjacent to existing floodplains and valleys. Alluvial aquifers occur primarily in the coarse grained deposits, including sands and gravels, although they also occur in alluvium composed of interbedded fine grained silts and clays and coarser grained sands and gravels.

Alluvial aquifers are recharged by precipitation and seepage from associated rivers and tributaries. Wells generally obtain water at shallow depths and are used for all purposes. Deep alluvial aquifers can be capped by low permeability silt/clay floodplain deposits, effectively confining the aquifer and reducing recharge rates from overlying aquifers and from precipitation.

Glacial Fluvial Deposits

Glacial fluvial deposits include unconsolidated sand, gravel, silt and clay. These sediments were deposited either directly by glacial ice (advance) or by meltwater streams (recessional) draining from the retreating continental and alpine glaciers that covered the Puget Sound lowland and the Cascade Mountains. In Washington, glacial deposits of sufficient size and permeability to comprise aquifers occur primarily in the Puget Sound lowland area, and northward west of the Cascade Mountains. The most recent glaciation (in the Pleistocene) is responsible for most of the surficial geologic features in the Puget Sound area and is referred to as Vashon Drift. The glacial deposits in the Vashon Drift are interbedded with inter-glacial alluvial deposits, ,and form a thick sequence of over 1000 feet throughout much of the Puget Sound Basin. Sand and gravel units in the drift form the principal aquifers.

Outburst floods from glacier dammed lakes occurred during glacial periods in both western and eastern Washington. These deposits often include extensive and highly permeable gravel and cobble aquifers, particularly in eastern Washington resulting from the Spokane outburst floods which occurred near the end of the last Pleistocene glaciation.

These aquifers receive recharge by direct precipitation primarily, and form some of the most productive aquifers in Washington State. In association with many of these aquifers, however, are overlying and interbedded low permeability glacial deposits including till and silt beds. These low permeability materials can be thick and often prevent significant rates of recharge via infiltration. Thus many of the glacial aquifers are relatively isolated, confined and in some cases slow to recharge. Glacial aquifers supply water for all uses.

Cascade Mountain Bedrock

The Cascade Mountains lie in a north-south orientation through east-central Washington and Oregon. The Cascades are typically made up of Tertiary igneous, sedimentary and metamorphic bedrock. Igneous bedrock within the range is both intrusive and extrusive, as evidenced by the chain of volcanoes throughout the range. The Cascades form a hydrogeologic divide between the eastern Columbia basin and the western Puget Sound Basin. The divide is cut by the Columbia River. Ground water within the Cascade Mountain bedrock occurs within weathered and faulted/fractured zones which create sufficient permeability to allow ground water withdrawals, or within thin soils overlying the bedrock.

Recharge to water bearing rocks and soils is from direct precipitation often in the form of snowmelt. Ground water resources are generally limited and utilized for small scale domestic or public purposes.

Basalt

Basalt aquifers include lava flows and sedimentary interbeds of Miocene age. Basalt rocks several thousand feet thick cover most of the Columbia Plateau in Eastern Washington. Groundwater in basalt aquifers occurs mostly in fracture, rubble zones, and interbeds of sand and gravel between lava flows. The groundwater moves laterally along interflow zones and to a lesser extent vertically between flows often through well boreholes. Water movement is controlled locally by fractures and joints and regionally by folds and faults in the basalt.

Recharge of the basalt aquifers is primarily by direct precipitation. In some areas, leakage from streams and seepage from irrigation waters supplies also contributes significant recharge to the basalt aquifers.

Other Sedimentary Deposits

Some sedimentary deposits other than alluvial and glacial deposits also comprise aquifers in Washington. The deposits are divided into two types; fluvial-lacustrine which formed in river and lakebed environments, and eolian which were deposited by wind. The fluvial lacustrine sediments include partially consolidated Tertiary clays, silts, sands and gravels. These are often found on terraces above existing river and stream valleys, and underlie the river valleys which cut through them. Included in these deposits are the Ellensburg and Ringold Formations in eastern Washington.

Eolian deposits include often thick sequences of peri-glacial loess (silt and fine sand) deposited during the retreat of the most recent Pleistocene glaciation throughout eastern Washington. The loess may be 250 feet thick in some areas. Other deposits under this type consist of recent active sand stabilized dunes of fine to medium sand.

Ground water resources in these fine-grained and semi-consolidated formations are recharged from direct precipitation, and are typically limited. Wells drilled in these formation often use ground water from underlying or contacting aquifers, or from perched layers of sufficient permeability to yield water to wells for domestic, irrigation and stock watering purposes.

3.3.5.1 Existing Conditions

The following discussion of general ground water conditions along the pipeline route focuses on the four hydrologic regions previously described for streams and floodplains. However, characteristic ground water regimes including alluvial, glacio-fluvial, outburst flood, bedrock, lacustrine and loess deposits described in Table 3.3-8 may occur in any of the regions to some extent. Basalt aquifers occur in the foothills of the eastern Cascades and the Columbia Plateau region along the pipeline alignment. The principal aquifers in each region are discussed along with specific ground water conditions found along the route. Hydrogeologic regimes, as identified in Table 3.3-8 found along the pipeline route are mapped on Figure 3.3-6.

FIGURE 3.3-6 - Hydrogeologic Regimes

Puget Sound Lowlands

The primary aquifers in this province are located in glacial drift on the plains west of the Snoqualmie Valley, alluvium along the Snoqualmie River floodplain, and bedrock in the Cascade Mountains. The occurrences of ground water west of the Snoqualmie River are found in the Interlake Drift Plain between Lake Washington and Lake Sammamish, and the Eastern Drift Plain located west of the Snoqualmie River in the Snohomish River valley. In the drift plains, aquifers within stratified Vashon age glacial deposits or underlying pre-Vashon glacio-fluvial deposits occur almost everywhere except in the larger stream valleys where alluvial deposits pre-dominate and along the margins of the plain.

The aquifers are generally capped by thick deposits of glacial till throughout the region. The till is generally low permeability and devoid of significant ground water resources, although perched lenses of sand and gravel in the till formation may constitute small isolated aquifer zones.

Ground water development is extensive in the eastern and southern portions of the region. Most wells, especially those of higher yield used for public supplies, tap aquifers located in one or both of the drift plain deposits, although shallow dug wells utilize the limited perched ground water in sand lenses within the overlying glacial till. The main aquifer in the Snoqualmie River valley is located in the unconsolidated alluvial deposits associated with the river and the floodplain. Water quality in the alluvial aquifers generally is poorer, often high in iron compared to the water quality of the glacio-fluvial aquifers.

Cross Valley Sole Source Aquifer

The Safe Drinking Water Act, Public Law 93-523, was signed into law on December 16, 1974. Section 1424(e) of the Act provides that the EPA administrator can designate an aquifer as a sole source aquifer if it is the sole or principal drinking water source for an area and which, if contaminated, would create a significant hazard to public health. Federal grant monies or other federal financial assistance cannot be committed to a project which the EPA Administrator determines may contaminate the sole source aquifer.

In 1987 the EPA designated the Cross Valley Sole Source Aquifer, an area of approximately 36 square miles in south central Snohomish County. This aquifer is the only sole source aquifer crossed by the proposed pipeline alignment. The aquifer area is bounded on the east and north sides by bedrock, which is at or near land surface on the steep bluffs above the Snohomish and Snoqualmie Rivers, on the west by the North Creek Valley, and on the south by approximately the King/Snohomish County Line (See Figure 3.3-7).

Figure 8 Figure 3.3-7 Cross Valley Aquifer

This aquifer is located within a regionally extensive and heterogeneous sand and gravel layer ranging in thickness from less than 25 feet to greater than 100 feet. The sand and gravel formation is a Vashon age glacial deposit often referred to as the Esperance sand. The formation is capped by as much as 100 feet of low permeability glacial till, averaging 50 feet in thickness in most places (Newcomb, 1952 and Liszak, 1993). The capping till is absent in stream and river valleys where it has been eroded by fluvial action. In these areas, the aquifer is overlain by more permeable alluvial deposits of limited extent.

The aquifer is recharged by direct precipitation which infiltrates through the capping till layer, or through alluvial materials where rivers have cut into the overlying till. Recharge is slow through the till layer, with infiltration rates often less than one foot per day. Infiltration is much more rapid through the alluvial deposits. Additionally, because the till layer has been eroded in the larger river valleys, there is hydraulic communication between the major rivers and streams and the aquifer. Although ground water is contained in small perched sand layers within the overlying till layers, these sand lenses are not considered part of the sole source aquifer. Under natural conditions, groundwater discharge from the aquifer system probably passes toward the Bear Creek and potentially the North Creek drainages (Robinson & Noble, 1989).

The existing OPL mainline product pipeline runs north-south for 5 miles through the western portion of the designated sole source aquifer area. For the proposed Cross Cascade Pipeline Project a pump station will be constructed near Maltby Road in the southwest corner of the designated aquifer area and the pipeline would run directly east from the pump station across the southern portion of the aquifer and exit the aquifer area at MP 8. Based on the Soil Survey of Snohomish County Area Washington (USDA SCS 1978), approximately 83% (6.5 miles) of the pipeline alignment which crosses the aquifer is underlain by till soils with dense till occurring below 6 feet, and 13% is underlain by poorly drained soils located in depressions and in low lying areas adjacent to streams and rivers. Approximately 4% of the alignment (approximately 0.3 miles or 1,700 feet) crosses well drained permeable soils that are directly underlain by portions of the aquifer. These soils are mapped by the SCS as Everett soils (identified by the number 17 in the Soil Survey for Snohomish County), and they occur within the first several miles of the alignment in the Bear Creek drainage.

Although slow recharge does occur through the low permeability till layers, more rapid and greater volume per unit area of recharge will occur through the more permeable Everett soils. Thus, these soils constitute an important area for recharge and direct hydraulic connection to the underlying Cross-Valley aquifer.

In 1993 the Department of Ecology investigated a protest on the issuance of a water right from the aquifer (Liszak, 1993). The investigation found that wells in the area generally have a surface elevation ranging from 420 feet to 480 feet MSL. Although not all wells have been mapped nor data from the wells evaluated, it appears there are two main aquifer zones: a deep aquifer zone between 200 to 145 feet MSL and a shallow zone between 306 to 236 feet MSL. Most of the wells evaluated were in the shallower zone.

Documentation from 1987 (See Appendix B, Support Document for the EPA Designation of the Cross Valley Aquifer as a Sole Source Aquifer, EPA, 1987) determined that the Cross Valley Water Association had over 2,600 service connections serving an estimated population of 8,000 people. There were approximately 3,300 people obtaining water from individual wells, springs and small community well supplies. Total groundwater use within the sole source aquifer was estimated at 60.5 million cubic feet in 1986. In 1987, the Cross Valley Aquifer provided almost 78 percent of the drinking water used in the aquifer area. EPA found that the water quality from the shallow aquifer zone was of good quality, but the deeper wells were high in hydrogen sulfide gas and iron.

Western Cascades

Along the proposed alignment, aquifers in this region occur in the bedrock and in alluvial valleys of the larger tributaries to the Snoqualmie River. The bedrock aquifer, although heterogeneous is interconnected and regionally extensive by fractures and faults. Yields to wells in the bedrock formations is a function of the amount of fracturing, and generally speaking the deepest wells which encounter the most fracture zones yield the highest volumes. Ground water flow in these aquifers follows the topographic relief. Recharge occurs where weathered bedrock is exposed at outcrops, generally at higher elevations, and to a more limited extent through the forest soils on slopes and lower elevations. Discharge from the aquifer occurs to streams and rivers at lower elevations providing baseflow, and also to the smaller alluvial aquifers which fill the major stream valleys.

Alluvial aquifers occur in the valleys of the larger streams where alluvial sediment has accumulated to sufficient thickness. Generally, this will occur when stream channel gradients are below 2 percent. These aquifers are limited in extent, restricted to the valley width, and are typically shallow in the Cascade Mountains. The aquifers are associated with a stream or river and are recharged by precipitation, from underlying bedrock aquifers and from flood waters in the associated stream. The aquifers discharge directly to the associated stream or river, providing baseflow.

Ground water uses in the Cascade Mountains east of North Bend are limited to small individual domestic supplies and several small public supplies for campgrounds and ski resorts. The source of these ground water supplies is most typically bedrock, although ground water in alluvial aquifers is used in the larger stream valleys.

Eastern Cascades

In the Eastern Cascade region along the proposed alignment, bedrock and small alluvial aquifers occur in the mountainous area similar to the Western Cascades. However, in the foothills of the mountains east of the Columbia River, basalt aquifers, aquifers in terrace deposits and larger alluvial aquifers occur. The primary aquifers in this region include alluvium within the Yakima River floodplain, sedimentary deposits in the Kittitas Valley area, and basalt in the high elevations on the east slopes of the Cascade Mountains.

Groundwater is extensively developed in the valleys of the Yakima River and its tributaries from alluvial and glacial deposits that are as much as 500 feet thick. These deposits are hydraulically connected to the Yakima River and its tributaries, and are recharged by precipitation as well as infiltration from streamflow and irrigation return flows. Recharge to the alluvial aquifer is from direct precipitation over the aquifer and from surrounding terraces, and from flood waters of the Yakima River and tributaries. The aquifer discharges to the Yakima River and through leakage to underlying rocks. Both ground water and surface water rights in the Yakima Valley are being litigated, and the interconnected nature of the river with the alluvial aquifer in its valley render these rights inseparable in some cases.

Ground water obtained from sedimentary rocks on the terraces above the Yakima River and Columbia River is generally of low yield and used for domestic, stock watering and irrigation. Recharge is from direct precipitation, and discharge is to deeper rock units and to the alluvial aquifer in the Yakima valley.

Volcanic rocks in the Cascade mountains yield little or no water to wells, although the Columbia River basalt, which underlies most of the province, is a substantial water-bearing unit. The thick series of basalt flows which underlies a huge area, has a wide range of both permeability and yield. The basalt continues southward beneath the Columbia River into Oregon. Studies show that structural warping of the rocks has caused subsurface damming of the groundwater which results in several essentially separate groundwater basins.

The chemical quality of most of the groundwater is good, ranging from soft to moderately hard. Total dissolved solids are greatest in the sand and gravel along the Yakima River near Yakima, probably caused by the irrigation return flows which are responsible for high sulfate and nitrate content and greater hardness.

Columbia Plateau

In the Columbia Plateau region along the alignment, groundwater is generally available in large quantities from the basalt bedrock, except near the edges of the basalt where it thins out against older bedrock. Multiple basalt aquifers provide complexity to the groundwater situation and are generally known as the Columbia River Group. The thickness of the basalt is highly irregular near the older rocks but increases to the southwest and is more than 10,000 feet near Pasco. The basalt surface is thinly mantled by loess, but in areas to the north, east, and southeast, much of the plateau was scoured by enormous floods of glacial melt water exposing wide belts of basalt within the channeled scabland.

The basalt is recharged mainly by water from precipitation which increases gradually from about 6" near Pasco to about 10" at Potholes Reservoir. Recharge is by direct infiltration and by seepage from the channels of intermittent streams. Thin rocky soils of scabland probably are more conducive to recharge than are the fine loess soils elsewhere. In the western part of the plateau, a substantial amount of recharge is derived from the East Low Canal and land irrigated under the Columbia Irrigation Project.

Groundwater movement is generally to the southwest. Ground water flow rates within the highly permeable weatershed zones between the basalt flows can be rapid in response to pumping, although is generally slow under prevailing natural conditions due to low hydraulic gradients. The soil, sand, and gravel that overlie the basalt do not yield appreciable quantities of water to wells. Some water probably percolates downward, during the months of greatest precipitation or snowmelt, through these deposits to the locally permeable upper part of the underlying basalt. The quality of the groundwater is generally good, ranging from soft to hard, although the water has high concentrations of dissolved iron in some locations.

Ground water from the basalts is heavily used for irrigation, particularly in the Pasco area. In some areas water levels are declining due to pumping,and well boreholes have interconnected the various layered basalt aquifers. These boreholes allow for ground water in upper layers to flow into deeper layers, co-mingling waters of different water quality, and providing a potential conduit for contaminant migration.

Impact Sensitivity

The sensitivity of groundwater to potential impacts along the pipeline route depends on the ground water conditions and the uses of the aquifers crossed by the pipeline. Generally, ground water is susceptible to contamination if the pipeline were to leak or rupture. Impacts may also be incurred if the trench were to act as a preferential pathway for ground water movement, however these impacts would be minor with regard to the ground water resource, but could have more significant impacts to a receiving stream or other surface water body (see Surface Water section).

A sensitivity and potential impact rating has been developed to assess which aquifers are the most critical and where additional protective measures and monitoring are needed to prevent and/or minimize impacts. Table 3.3-9 below describes the ground water information and criteria used to develop the rating system. The rating system ranks the sensitivity of ground water regimes to potential impacts from the project, primarily leaks or spills. The impact rating considers the value of the aquifer resource, the permeability and separation distance of the geologic materials which underlie the pipeline and overlie the aquifer.

Table 3.3-10 provides the milepost segment for separate ground water regimes (or aquifer types) found along the route, as defined in Table 3.3-8, along with a description of the ground water uses in each segment, typical depth to ground water and the impact sensitivity rating for each segment. The impact sensitivity rating for each ground water regime segment along the route is a relative indicator of the value and environmental sensitivity of segment to a potential leak or spill from the pipeline. The mean impact sensitivity rating for the all segments along the route is 7.8, with a standard deviation of 1.6. Ratings of 10 or greater can be considered significantly more sensitive than the mean or typical conditions found along the alignment. These more sensitive aquifer segments are those used for public supplies and/or are susceptible to relatively rapid spread of product if a spill were to occur, and underlie 73 miles of the pipeline, or approximately 32 percent of the route. The majority of the sensitive segments occur in the Puget Sound lowland region, west of the Snoqualmie Tunnel.

TABLE 3.3-9
GROUNDWATER SENSITIVITY AND POTENTIAL IMPACT RATING CRITERIA

Index Parameters	Parameter Description and Justification	Index Rating Values	Relative Rating Value Description
Groundwater Regime	The groundwater regime that the pipeline segment is located in is an indicator of the resource value (i.e., potential yield to wells and connection to surface water resources), and potential to transport contamination if a pipeline leak should occur.	1 = Groundwater Regimes 3,4 and 6 2 = Groundwater Regimes 2 and 5 3 = Groundwater Regimes 1 and 7 4 = Groundwater Regime 8.	The lowest sensitivity rating for regimes 3,4 and 6 reflects the low permeability, transport potential and potential well yield that these groundwater zones exhibit. Groundwater regimes 2 and 5 exhibit potentially high well yields but may not be directly associated with surface water bodies, and are typically heterogeneous, limiting transport potential. Groundwater regimes 1 and 7 exhibit the largest potential for potential contaminant transport, and impact to surface waters (via irrigation pumping from regime 7 [Basalt] and direct baseflow from regime 1 [alluvium]). The greatest sensitivity is assigned to regime 8, sole source aquifer, due to the importance of protecting the aquifer.
Groundwater Use	The groundwater use index characterizes the current value of the resource to human users within the groundwater regime along the pipeline segment.	0 = unknown minor uses 1 = domestic, limited public, irrigation and industrial 2 = public. The rating value is the sum of each of the use index values assigned to each segment.	Public supply use is given the largest sensitivity rating due to the potential impacts to a large number of users. Domestic, irrigation and industrial uses are assigned a lesser sensitivity rating value because they are not subject to a public distribution system and in the case of irrigation and industrial, not a source of drinking water.
Depth to Groundwater	The depth to groundwater, or separation distance, is the vertical distance from the pipeline to the aquifer beneath the pipeline segment. The aquifer is considered to be the uppermost groundwater zone that can provide usable quantities of groundwater to wells and which supplies baseflow to streams. This parameter does not include near surface soil water or extremely limited perched groundwater zones.	1 = >100 feet below surface 2 = 50 - 100 feet below surface 3= 0 - 50 feet below surface.	The index values for depth to groundwater are somewhat arbitrary, and are selected to represent the range of aquifer depths that occur along the alignment. Additionally, in sediments with permeabilities generally sufficient to yield water to a public supply well (100 gpm or greater), leaked petroleum product could migrate up to fifty feet within a 24 hour period, assumed as a reasonable response time if a leak should occur.
Separation Sediments	The characteristics of the sediment that separate and occur between the pipeline	1= glacial till, loess, competent bedrock, clay or other confining material.	The lowest permeability capping materials are rated lowest sensitivity, and the highest permeability

Index Parameters	Parameter Description and Justification	Index Rating Values	Relative Rating Value Description
	and the upper most aquifer are critical to assessing the risk of potential contamination from the pipeline if a leak were to occur. Low permeability sediments would minimize downward migration of leaked petroleum product, containing a spill within the immediate vicinity of the pipeline, and permeable sediments would allow for relatively quick percolation of leaked petroleum product to the upper most aquifer.	2 = low permeability or heterogeneous transmissible sediments including fine to medium sand and well graded sands, silts and gravels. 3 = permeable poorly graded sediments including sands and gravels and highly fractured bedrock.	materials are rated the highest sensitivity. The selected sediment categories are representative of the range of materials found along the alignment.

TABLE 3.3-10
GROUNDWATER CONDITIONS ALONG PIPELINE ROUTE

Pipeline Segment (Milepost)	Groundwater Regime(1)	Known Groundwater Uses Downgradient of Alignment(2)	Estimated Water Table Depth Below Surface (feet)	Sensitivity/ Impact Rating (Scale of 4-12)	Specific Recommendations/Comments
0 - 8.15	2 & 8	PUB, IRR, DOM	~100	10	Cross Valley Sole-Source Aquifer, mp 0-6, Coordinate spill response w/ Cross Valley Aquifer Association
8.15 - 9.3	1	DOM	~20	9	Low yield/poor water quality
9.3 - 11.9	2	limited DOM	~100	7	
11.9 - 16	3	limited DOM	20-50	7	
16 - 33.7	2	PUB, DOM, IRR	10-50	10	City of Carnation
33.7 - 41.05	1	IND, PUB, IRR, DOM	10 - 15	11	Coordinate spill response w/ cities of Snoqualmie and North Bend
41.05 - 56.2	1 & 2	DOM, limited PUB	10 - 15	10	Tinkham & other state park campgrounds present
56.2 - 59	3	DOM, possible limited PUB	Variable, generally >100	5	Commercial and Ski areas present @ mp 58
59 - 64	1 & 2	possible limited DOM	40	9	
64 - 73.35	2	possible limited DOM	~90	7	
73.35 - 75.8	3	DOM, limited PUB	Variable, generally >100	5	Town of Easton, Easton Lake State Park @ mp 74-75
75.8 - 77.8	1	unk, possible limited DOM	~70	8	
77.8 - 98.9	2	DOM, IRR	100->300	6	Indian John rest area @ mp 93
98.9 - 112.4	1	DOM, IRR	20-60	10	
112.4 - 114.9	7	DOM, possible IRR	~100	9	Impact rating assumes basalt bedrock is permeable from the surface to water table
114.9 - 126.4	7	IRR, DOM, PUB	60-100	10	Overlain by 50+ feet alluvium, City of Ellensburg

TABLE 3.3-10 (CONTINUED)
GROUNDWATER CONDITIONS ALONG PIPELINE ROUTE

Pipeline Segment (Milepost)	Groundwater Regime(1)	Known Groundwater Uses Downgradient of Alignment(2)	Estimated Water Table Depth Below Surface (feet)	Sensitivity/ Impact Rating (Scale of 4-12)	Specific Recommendations/Comments
126.4 - 129.4	7	Unk, possible limited DOM	~100	8	
129.4 - 131.4	7	Unk, possible limited DOM	Variable, generally >100	7	Overlain by 50+ feet alluvium
131,4 - 147.4	7	Unk, possible limited DOM	~100	8	
147.4 - 153.4	7	DOM	300	8	Overlain by 50+ feet outburst flood deposits, may be shallow sources within deposits
153.4 - 163.9	7	DOM, IRR	400	8	Overlain by 50+ feet lacustrine deposits
163.9 - 171.4	7	IRR, IND, DOM	200	8	
171.4 - 177.4	7	IRR, DOM	100	9	Overlain by ~50 feet outburst flood deposits, may be shallow sources within deposits
177.3 - 181.9	7	Unk	200	6	Overlain by up to 50 feet of alluvial deposits (landslide)
181.9 - 183.4	7	IRR, DOM	400	6	Overlain by <50 feet loess
183.4 - 187.9	7	IRR, DOM	400	6	Overlain by ~50 feet lacustrine deposits
187.9 - 190.9	7	IRR, DOM	500	6	Overlain by loess and lacustrine deposits, >100 feet
190.9 - 191.9	7	IRR	500	6	Overlain by ~50 feet lacustrine deposits
191.9 - 193.9	7	IRR	300	6	Overlain by >100 feet loess and lacustrine deposits
193.9 - 199.4	7	IRR, DOM	300	8	Overlain by ~100 feet outburst flood and lacustrine deposits
199.4 - 202.9	7	IND, IRR	100	9	
202.9 - 206.9	7	IRR, DOM	200	8	Overlain by ~100 feet outburst flood and lacustrine deposits

TABLE 3.3-10 (CONTINUED)
GROUNDWATER CONDITIONS ALONG PIPELINE ROUTE

Pipeline Segment (Milepost)	Groundwater Regime(1)	Known Groundwater Uses Downgradient of Alignment(2)	Estimated Water Table Depth Below Surface (feet)	Sensitivity/ Impact Rating (Scale of 4-12)	Specific Recommendations/Comments
206.9 - 208.4	7	IRR, DOM	300	7	Overlain by ~100 feet outburst flood deposits, may be shallow sources within deposits
208.4 - 213.4	7	IRR, DOM, IND	250	6	Overlain by ~100 feet lacustrine deposits
213.4 - 219.9	7	IRR, DOM	200	6	Overlain by >100 feet loess
219.9 - 221.4	7	IRR, DOM	100	9	Overlain by >100 feet outburst flood deposits, may be shallow sources within deposits
221.4 - 228.9	7	IRR, IND, DOM, PUB	100	9	Overlain by >100 feet loess, City of Pasco
228.9 - 230.7	7	IRR, IND, DOM	50	10	Overlain by <100 feet outburst flood deposits, may be shallow sources within deposits

(1)
1 - Alluvium
2 - Glacio-Fluvial Deposits
3 - Cascade Mountain Bedrock
4 - Loess/Dune Deposits
5 - Outburst Flood Deposits
6 - Lacustrine Deposits
7 - Columbia River Basalts
8- Sole Source Aquifer

(2)
PUB - Public Supply
IRR - Irrigation
DOM - Domestic
IND - Industrial
Unk - Unknown

3.3.5.2 Groundwater Impacts Assessment

Impacts to ground water resources from construction and operation of the pipeline can occur as a result of small spills and excavation of contaminated soils during construction, dewatering during construction, interruption of ground water flow paths, potential leaks and spills and damage to the pipeline by corrosion. Potential impacts during construction other than the effects of localized dewatering, spills are considered to be low and limited due to the short duration of construction relative to the slow movement of ground water, relatively slow rate of corrosion, and the limited use and therefore limited potential for spills from fuel storage and equipment operation. Thus, the potential for significant impacts will occur primarily during the operation phase of the project.

Excavation

Some localized impacts to groundwater quality adjacent to and downgradient of the excavation may occur due to accidental spills of fuel and other products during equipment operation and pipeline construction and from disturbance of fine sediments during trenching. Minor spills will be cleaned up by construction crews as part of their operating guidelines. These potential impacts would be expected to be short-term and localized, dissipating rapidly from natural processes, including dilution, dispersion, and advection in groundwater, and absorption and physical filtration processes in the soil.

During trenching, there is the possibility of encountering historically contaminated soil as well as buried structures such as wells and underground storage tanks. In these circumstances, proper disposal procedures will be implemented based on the type and quantity of contaminants, and the piping will be rerouted to avoid abandoned wells discovered during the construction process. State regulation requires reporting of both circumstances. In the case of encountering contaminated soils, compliance with RCW 70.105 WAC 173-340 (The Model Toxics Control Act) is required. Chapter 173-160 WAC, Minimum Standards for Construction and Maintenance of Wells, which includes procedures for proper well abandonment, should be followed during orphan well abandonment.

Dewatering

Shallow groundwater may be encountered during trenching along stretches of the alignment. Laterally extensive shallow aquifers with seasonal groundwater levels within trenching depths are likely to be found in alluvial sediments and near major drainages. Locations where shallow aquifers occur include the Upper Yakima, the floodplain areas of the Snoqualmie Valley, and the first 8 miles of the pipeline route. In these areas, trench dewatering may be necessary during construction.

Perched groundwater zones may be encountered at various places along the route including the plateau areas of Puget Sound, the Upper Yakima Basin, Kittitas Valley, and Lower Crab Creek areas and other areas associated with lakes, ponds, wetlands, and small drainages. In these areas, localized dewatering may be necessary where the trenching encounters perched groundwater zones. In addition, depending upon the relative depths of the pipeline excavation and the base of local perching layers, the perching layers may be breached by the pipeline trench with the resulting potential for localized downward drainage into underlying sediments.

Where shallow groundwater is encountered in coarse sediments, the dewatering operation will likely require pumping and discharge of relatively large volumes of water. The dewatering process will depress the water table in the immediate vicinity of the excavation, causing a temporary alteration in the local groundwater potentiometric surface. After the excavation is backfilled, water levels will recover. The discharge of groundwater to local drainages during construction dewatering will require a temporary dewatering permit.

Interruption of Ground Water Flow

The presence of the pipeline facilities could impact groundwater movement and water levels at the Kittitas Terminal Facility by reducing infiltration in areas where compacted soils or impermeable liners are placed and where stormwater collection systems are operated. The reduced infiltration at the facility could also reduce groundwater discharge to surface waters which may be hydraulically connected to the groundwater beneath the facility. However, there is little evidence of shallow groundwater near the facility therefore these impacts would be minor. The compacted soil will have the beneficial effect of reducing the infiltration of petroleum product or other fluids into subsurface soils and groundwater.

Trench backfill, in most cases, will consist of excavated native soils. In areas where the native soils are consolidated, such as compacted till, the more loosely compacted backfill could result in a preferential groundwater pathway along the pipeline trench. However, in most cases groundwater discharge of the trench in these soils would be limited due to the low permeability. In addition, the backfill will consolidate over time and reduce potential impacts further.

In areas where low permeability soils occur at or near the surface, the trenching may cut through low permeability soils and intercept higher permeability materials underneath. This could allow water to more quickly drain into underlying soils allowing for preferential infiltration . In these areas, identified as part of the advance geotechnical evaluation along the route, the backfill will be compacted to match the native overlying soils, and if necessary, the bottom of the trench will be lined with a low permeability material.

Corrosion

Corrosion of an unprotected steel pipeline could occur, particularly if fluctuating ground water levels periodically inundate the pipe or if the pipe is submerged in corrosive waters or soils. The pipeline will utilize external coating and cathodic protection to prevent corrosion. In order to ensure the long term efficacy of these measures, the entire pipeline will be surveyed annually to identify potential deterioration of the coating, the performance of the cathodic protection system will be monitored monthly, and an internal inspection tool (smart pig) will be used approximately every five years to detect changes in pipe wall thickness or the presence of pipe wall deformation.

Leaks and Spills

The potential for leaks and spills from the pipeline during operation is a function of the integrity of the pipe and pipeline facilities. The pipeline and all main product piping in the facilities will be hydrostatically tested with water to insure integrity prior to introduction of product into the pipeline. In OPL's experience, the greatest potential for leaks and spills is at block valves, pump stations, and delivery facility sites where mechanical failures can occur. To prevent accidental spills at pump stations from reaching surface or groundwater, OPL will provide leak containment around the equipment areas. Valves and pump stations will be kept to a minimum in the most sensitive pipeline segments, as described in Table 3.3-10.

It is much less likely that a spill or leak will occur along the pipeline unless the pipeline is physically damaged by third party actions exposing the pipeline, corrosion or the effects of water forces at stream crossings. Pipeline markers, ditch shields, deeper burials, concrete coating, thicker-walled pipes and cathodic protection to prevent corrosion are some of the measures used to prevent damage to the pipeline.

Water Rights

Existing and senior groundwater right holders may be impacted by the proposed project operation if a spill or leak were to occur, and the product reached the groundwater table, migrating to a downgradient well or spring. The pipeline also crosses the Cross Valley Aquifer, see discussion below.

As with potential impacts to senior water rights, OPL will develop as part of the project implementation, a compensation plan worked out with the communities, state and local agencies as a WRIA basis. Other than the Cross Valley Aquifer, there are no other sole source aquifers along the pipeline route.

Cross-Valley Aquifer

There is one designated sole source aquifer in the study area. The Cross Valley Sole Source Aquifer is located in south Snohomish County and is crossed by the pipeline from MP 0 to MP 8. The construction and operation of the proposed pipeline will meet or exceed industry standards, minimizing any potential impact on the Cross Valley Aquifer. There are no restrictions limiting uses or construction practices over the aquifer. OPL will construct one pump station (Thrasher) over the sole source aquifer. There will be no block valves located on the pipeline over the aquifer except at the Thrasher Pump Station. The pump station will be electronically equipped to detect leaks and leak containment will be provided.

A specific monitoring plan with increased line monitoring and ground water monitoring will be developed to insure adequate response time and effectiveness if a spill should occur.

The pipeline alignment across the aquifer is underlain by low permeability tills in most places. In these areas a leak or spill would generally be contained to within the upper six feet of soil. Leaked petroleum products would flow laterally within the more permeable trench backfill and upper soils preferentially. Downward migration toward the aquifer would be very slow due to the low permeability soils allowing time for clean-up before potential contaminants reach the aquifer. If a leak were to occur in poorly drained soils with high water tables, the leaked petroleum products would float on the water table and downward migration restricted, again allowing for detection and clean-up before petroleum products could reach the aquifer.

As previously discussed, well drained soils with hydraulic connection to the aquifer occur in limited sections (a distance of approximately 1700 feet) along the alignment. Prior to construction, OPL will further identify through field inspection the physical limits of these areas and will adjust the final pipeline alignment to either avoid these areas entirely or to the maximum extent practical. If necessary, additional measures will be employed to further ensure that no leaks occur in these areas. Such measures may include extra pipe wall thickness, additional localized cathodic protection (i.e., sacrificial anodes in the pipe ditch) and additional pipe joint inspection prior to coating. The additional inspections may include a longitudinal weld inspection, full body magnetic particle inspection, and/or an ultra-sonic bevel inspection. Depending upon the final alignment in these areas and the corresponding profile of the pipeline, an additional block valve may be installed just east of the area with well drained soils.

3.3.5.3 Groundwater Mitigation Measures

The project incorporates measures to avoid or minimize harm to groundwater. Erosion control measures will be used in all areas where soils are exposed to the elements during project construction requiring drainage basins or settling ponds which could become a pathway to groundwater. The measures to minimize potential groundwater contamination will include one or more of the following:

- Clearing and grading will be limited to the minimum necessary for the pipeline construction.
- Surface water will be diverted from all excavations using temporary and permanent runoff diversion structures.
- Sediment retention ponds will be constructed as deemed necessary to prevent siltation of surface water drainages.
- Surface protection techniques such as mulching will be done as necessary.
- Disturbed soils will be graded and seeded after the pipeline construction has been

completed.

- Until vegetation is established, settling basins will be maintained to help remove sediments from stormwater runoff before it discharges into natural watercourses.
- During trenching, there is the possibility of encountering historically contaminated soil as well as buried structures such as wells and underground storage tanks. In these circumstances, proper disposal procedures will be implemented, and the piping will be rerouted to avoid abandoned wells or contaminated soils discovered during the construction process.
- In areas where groundwater conditions could necessitate dewatering in large volumes, rerouting of the pipeline would be considered.
- To prevent localized impacts to groundwater quality adjacent to and downgradient of excavation, minor spills will be cleaned up by construction crews as part of their operating guidelines.
- In areas where low permeability soils occur at or near the surface, the backfill will be compacted to match the native overlying soils, and if necessary, the bottom of the trench will be lined with a low permeability material.
- The pipeline will utilize cathodic coating and cathodic protection to prevent corrosion. The entire pipeline will be inspected for corrosion on a regular (annual) basis and the most sensitive areas will be inspected more frequently.
- To prevent accidental spills at pump stations from reaching surface or groundwater, OPL provides leak containment is provided at each pump station site. Valves and pump stations will be kept to a minimum in the most sensitive pipeline segments.
- Deeper burials, concrete coating, thicker-walled pipes and cathodic protection to prevent corrosion are measures used to prevent damage to the pipeline.
- To protect existing and senior water right holders, OPL will develop, as part of the project implementation, a compensation plan worked out with the communities, state and local agencies as a WRIA basis to be implemented in the event of an accidental release.
- There will be no block valves located on the pipeline over sole source aquifers except at the Thrasher Pump Station. The pump station will be electronically equipped to detect leaks and leak containment will be provided.
- In sensitive areas with confirmed well-drained soils, impermeable soils will be employed that will prevent petroleum products from escaping the trench, and will direct the petroleum products toward a lower sensitivity area for capture and clean-up.

Preventing corrosion and impacts from potential leaks and spills from the pipeline is a function of initial design, and also a function of effective monitoring.

- Monitoring for pipeline integrity and corrosion, and monitoring the mechanical conditions of valves and pump stations on a regular basis will insure low probability of failure and leakage.

- Routine pipeline inspections and pressure sensing in the pipe will provide early detection of spills if they should occur.
- Early spill detection prevents significant quantity of petroleum products leakage and allows for rapid cleanup before significant spread of product.
- In addition to line monitoring, use of a “smart pig” to detect areas of pipeline weakness will be used on a periodic basis.
- In the most sensitive pipeline segments, increased line monitoring will be employed relative to other less sensitive sections of the pipe.
- A specific monitoring plan with increased line monitoring and ground water monitoring will be developed for the Cross Valley Aquifer area to insure adequate response time and effectiveness if a spill should occur.

See also Section 2.9 Spill Prevention and Control, for a detailed discussion of spill prevention and response measures to protect resources such as groundwater.

Measures which address local areas where slope instability may impact the pipeline are discussed in Section 3.1 Earth.

3.3.6 PUBLIC WATER SUPPLIES

Public water supplies serving towns along the route utilize both surface and ground water resources. The pipeline project will rely on public supplies for water during construction and operation. In general, the project will not impact the quantity or quality of public water supplies. Public water needed by the project for hydrostatic testing and for potable supplies will be available (see section 2.5 with no adverse impacts. Impacts to public water supplies from construction are not anticipated due to the short duration and localized effects of potential impacts to surface waters and ground waters. Potential impacts to water quality from a large spill are possible, however, in surface and ground water supplies that are downgradient of the pipeline.

3.3.6.1 Existing Conditions

Municipal and other public water supplies located downgradient of the route are conceivably at risk from a potential petroleum spill from the pipeline. None of the public sources along the alignment have instituted ground water or watershed protection programs, wellhead protection programs or other source protection programs. Water supply sources for towns and other purveyors that are located less than 5 miles downgradient of the pipeline are considered at potential risk for planning purposes and shown on the Atlas. Actual risk is dependent on the geologic and watershed and channel conditions in each area (see section 3.3-2 and 3.3-5). Municipal and other public water supplies located near the proposed pipeline route, other than small supplies for campgrounds and resorts, include the following:

The Cross-Valley Aquifer Association

This is a ground water source which obtains water from the Cross-Valley sole source aquifer. Five public wells (Well #s 1, 5, 6, 9 and 10) are located less than 0.5 miles downgradient of the pipeline. The well locations are shown on the Atlas. The wells are downgradient of pipeline Atlas segments 2 and 3. An aquifer monitoring and protection plan which will include these wells, will be developed.

City of Carnation

The city of Carnation obtains its public water supplies from ground water wells and springs in the vicinity of the town. One spring is located less than one mile downgradient of the alignment and one well is located less than two miles downgradient (Atlas segments 10 and 11). The well and spring location are shown on the Atlas. The spring and well are associated with the alluvial aquifer located within the Snoqualmie River valley.

City of Snoqualmie

The city of Snoqualmie obtains its water from springs and ground water wells. The primary source is Canyon Springs, which is located upgradient of the pipeline and therefore not at risk from the project, however back-up wells are located less than 1 mile downgradient of the alignment (Atlas segment 14). The well location is shown on the Atlas. The back-up wells tap the alluvial aquifer associated with the Snoqualmie River.

City of North Bend

The city of North Bend obtains its water from springs and ground water wells. The spring source is upgradient of the pipeline alignment, however a well site in North Bend Community Park is less than one mile downgradient of the alignment (Atlas segment 16). Well locations are shown on the Atlas. The well taps the alluvial aquifer associated with the Snoqualmie River. A new wellhead has been located approximately 145 feet from the pipeline route by the city of North Bend. See Figure 3.3-8.

Figure 3.3-8 Proximity of North Bend Wellhead to Pipeline

City of Cle Elum

The city of Cle Elum obtains its water from the Yakima River. The intake location for the water supply is shown on Atlas segment 38. Petroleum leaks any where along the pipeline upgradient of the intake that is within the Yakima River watershed could conceivably impact water quality at the intake. Thus, if an petroleum products leak at a stream crossing were to occur anywhere along Atlas segments 25 through 38, the Cle Elum water supply could be impacted.

City of Ellensburg

The city of Ellensburg obtains its supply from six ground water wells located within City limits, all located greater than three miles downgradient of the pipeline alignment. Well locations are shown on the Atlas, and are downgradient of sections 40 and 50. The wells tap into the alluvial aquifer associated with the Yakima River.

City of Kittitas

The city of Kittitas obtains its water from wells located within City limits, all of which are upgradient of the alignment and therefore not at risk from the project.

The routine needs at the Kittitas Terminal are comparable to the needs of three single family homes. There is a requirement for 100,000 gallons of water to be available at the site for fire response. This could be supplied by either an on-site water storage tank or through a water supply line of sufficient size and pressure capacity to provide an adequate flowrate.

To meet the operational water needs of the Kittitas Terminal, a connection will be made to the City's water line along Badger Pocket Road and minor upgrades made to meet the needs of OPL or other portions of the City's water system.

A similar situation exists for meeting the sewer needs of the Kittitas Terminal. There are two options:

(1) A septic system can be installed; or
(2) A lift station and a sewer line connecting the Terminal site to the City's system can be installed.

The City has verbally indicated a willingness to provide water and sewer service to the Terminal, and a City study has shown that the City has adequate capacity to provide both services. OPL is currently in negotiations with the City and County with the goal of obtaining an interlocal agreement concerning provision of public services and cost reimbursements. The final approach adopted for both water and sewer, and the potential routing of new water or sewer lines, will depend upon the outcome of the negotiations with the City and County.

Kittitas County PUD

The Kittitas County PUD operates wells near Wanapum Dam and obtains water from the Yakima River. The wells are located more than five miles downgradient of the pipeline alignment. The Yakima River intake is downgradient of the pipeline, and therefore at risk of a spill reaching the river.

Port of Royal Slope

The Port of Royal Slope will provide water to the pipeline from a currently unused capped industrial well located adjacent to the pipeline alignment. Since the well is currently unused, there is not considered to be a public water supply risk from the pipeline.

City of Pasco

The City of Pasco obtains its water from wells located within the City limits, as shown on the Atlas. All of the wells are located within 3 miles downgradient of the pipeline segments 96, 97 and 98. The wells tap into basalts and alluvial deposits of the Columbia River.

East Columbia Basin Irrigation District

The pipeline will cross several irrigation canals operated and maintained by the East Columbia Basin Irrigation District. The district will require OPL to be liable for damage or alteration to any canal structures, to prepare erosion control plans for each crossing, that the crossing will not impair flow in the irrigation canals, and that the pipeline be constructed off-season when irrigation is not being conducted.

3.3.6.2 Public Water Supplies Impacts Assessment

Potential impacts to public water supplies from both ground water and surface water sources are the same as those described for surface and ground water sources in general. No significant impacts to public water supplies are expected from construction and normal operation of the pipeline. However, in the event of a significant petroleum spill, significant impacts to water quality could occur, interrupting public water supply. These potential impacts will be prevented and/or minimized by pipeline monitoring, maintenance and integrity testing, and implementation of appropriate design features previously discussed for sensitive ground water and surface water sections.

OPL will discuss and incorporate its construction, operation and monitoring plans with each municipal/public supply purveyors management and protection plans.

3.3.6.3 Public Water Supplies Mitigation Measures

- To prevent and minimize potential impacts to public water supplies, OPL will perform pipeline monitoring for the entire pipeline, maintenance and integrity testing along the pipeline, and implementation of appropriate design features for sensitive ground water and surface water sections.
- OPL will discuss and incorporate its construction, operation and monitoring plans with each municipal/public supply purveyors management and protection plans.
- In the event that a spill occurred, and occurred in an area that caused impact a public water supply, OPL would provide alternative water supplies and compensation to the water users until the water supply is restored.

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