Final Feasibility Study

Former Maintenance and Fueling Facility
Skykomish, Washington

Volume One: Text, Tables and Figures

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Executive Summary

The following is a summary of the key findings and conclusions presented in this Final Feasibility Study (Final FS) for the BNSF Railway Company's Former Maintenance and Fueling Facility in Skykomish, Washington.

Procedural Posture

A Draft Feasibility Study (Draft FS), which was integrated with a Draft Environmental Impact Statement (Draft EIS), was issued on September 3, 2003 for a 60-day public comment period. A Draft Final FS was submitted to Department of Ecology (Ecology) on July 26, 2004 that incorporated revisions to the Draft FS portion based on public and agency comments received in the Fall of 2003. A Final EIS will be issued by Ecology before a Cleanup Action Plan (CAP) is issued by the agency. Ecology will carefully consider public comment during preparation of the Final EIS and CAP.

After considering comments that BNSF and the agency received on the Draft FS and Draft EIS, BNSF developed a preliminary preferred alternative and included that in the Draft Final FS (RETEC, July 26, 2004). BNSF presented it's preliminary preferred alternative to Ecology and the community, collected additional information from technology vendors, revised it's preliminary preferred alternative and prepared a detailed description and analysis of the revised preferred alternative (*Preferred Remedial Alternative (Revised) Technical Memorandum,* December 3, 2004). This Final FS incorporates BNSF's revised preferred alternative and responds to Ecology's comments on that alternative.

Ecology will evaluate all the alternatives presented in this document and select a final cleanup action by balancing several factors, including the restoration time frame, degree of permanence (including cost), and adverse impacts to the community and natural environment. In general, more aggressive technologies cost more, work faster, and are more permanent, but they have greater adverse impacts on the community and natural environment. BNSF believes that its revised preferred alternative, as presented in this document, achieves a reasonable balance between regulatory requirements and the goals and concerns expressed by the community.

Site Background

The former railway maintenance and fueling facility in the east King County town of Skykomish is now owned and operated by BNSF Railway Company (BNSF). Historical activities since the facility opened in the late 1890s included refueling and maintaining locomotives and operating an electrical substation for electric engines. These activities released contaminants to the surrounding environment. BNSF has accepted responsibility for cleaning this historical contamination at the site consistent with the Model Toxics Control Act (MTCA) and the State Environmental Policy Act (SEPA).

Fuel was stored in above and underground storage tanks at the site until 1974, when BNSF discontinued most fuel handling activities at its Skykomish facility. The BNSF facility is currently used as a base of operations for track maintenance and snow removal crews.

Railroad Avenue separates BNSF property from the main commercial district of the town. Maloney Creek flows south of BNSF property and west to the South Fork of the Skykomish River. The site encompasses an area of about 40 acres and includes BNSF property and adjacent property. The approximate boundaries of the study area are as follows: the South Fork Skykomish River to the north, approximately the Old Cascade Highway to the south, Maloney Creek to the west, and Skykomish city limits to the east.

In early 1991, Washington Department of Ecology (Ecology) designated the former maintenance and fueling facility as a high priority cleanup site. Later that year, BNSF indicated a desire to initiate a Remedial Investigation/Feasibility Study (RI/FS) in accordance with MTCA. At that time, formal negotiations for a legal agreement (called an Agreed Order) were initiated. Negotiations were completed in mid-1993. Following a public comment period, the Agreed Order, which includes detailed work plans for the RI/FS process and early interim cleanup work, was signed by Ecology and BNSF. BNSF and Ecology signed a separate agreed order in 2001 for additional interim cleanup work near the South Fork Skykomish River and the levee west of Fifth Street.

Historic and Cultural Resources

Much of the Town of Skykomish has been designated in the National Register of Historic Places, including 13 historic buildings and the Skykomish Bridge. Several of the cleanup alternatives require moving historic buildings temporarily to allow for excavation beneath them. The buildings would then be returned to their original sites in such a way that the rail-oriented configuration of lots and buildings, streetscape and location of buildings relative to the street are maintained. Potential impacts to historic resources may result from temporary relocation, such as loss of landscape features, movement or settling of buildings, and some changes of surface grade. These impacts are discussed in the Draft FS and Draft EIS and will be further addressed, including any necessary mitigation measures, in the Final EIS consistent with SEPA.

Site Contaminants

Investigations performed by BNSF in cooperation with Ecology since 1993 have revealed petroleum contamination in soil, groundwater, the River and the former Maloney Creek that exceeds state standards. The contamination has migrated beyond the railroad property and has been found underneath homes and businesses in Skykomish and in “seeps” on the banks of the South Fork

Skykomish River. In addition, the investigation found lead and arsenic in soils to a depth of approximately six inches.

Based on available data, the site contamination consists of the following:

- **Soils –** Surface soils on the railyard contain petroleum (diesel and bunker C), lead and arsenic above state cleanup standards. Lead and arsenic was also found above cleanup standards in surface soils off BNSF property, but the source of these contaminants is unknown. In some areas of the site, including areas off the railyard, subsurface soils contain petroleum and its components (e.g., polynuclear aromatic hydrocarbons or PAHs) to an approximate 15-foot depth. PCBs have also been detected within the railyard at low concentrations, and are a continued source of concern for the public.

- **Groundwater –** Mixtures of both floating and dissolved diesel and bunker C are present in groundwater beneath the site at levels greater than allowed under state law.

- **Surface Water –** Diesel and bunker C from upland areas are seeping into the river after being transported underground by groundwater.

- **Sediments –** Diesel and bunker C from upland areas are present in sediments along the riverbank at seep locations and below the former Maloney Creek channel.

Cleanup Process

BNSF and Ecology have been working with the local community to ensure all exposure pathways are evaluated and the site is cleaned up. One theme from comments received is that the cleanup should be completed as quickly as possible while preserving historic structures/buildings and public facilities and minimizing disruption of residents and businesses. The contaminants are known to be toxic above certain concentrations, and some components are known human carcinogens. The material seeping into the South Fork Skykomish River and floating on the groundwater north of the railyard are primary concerns because these are areas in which significant exposure is more likely. Although the seep contamination poses little immediate risk to human health, cleanup is necessary to minimize any long-term risk and improve the overall environmental health of the Town of Skykomish and the South Fork Skykomish River. Cleanup actions will include activities to stop contaminants from seeping into the River.

BNSF is currently working with Ecology towards implementing a cleanup action on the levee and in the South Fork Skykomish River in 2006. This action would consist of excavating and replacing the flood control levee, excavating contaminated sediment and the underlying sand and gravel adjacent to the levee and in the Skykomish River, and installing an air sparging system within the levee to treat groundwater discharging into the river. Additional details are presented in Section 10.2.

Additional Interim Action to Address Seeps to the River in 2001

BNSF enhanced its product recovery system to stop contaminants from seeping into the South Fork Skykomish River at the levee through an Interim Action during 2001. An Interim Action is any action that partially addresses the final cleanup of a site. The Interim Action in 2001 resulted in construction of an underground barrier wall west from the bridge along West River Road to stop seeps from reaching the River. Monitoring wells were installed behind (upgradient of) the wall and at the ends of the wall to determine where contaminants accumulate. Temporary recovery operations are conducted from these wells. During the second phase, the wells that contained the most petroleum product were converted into product recovery wells that currently skim petroleum from groundwater. Additional wells were later installed.

Remedial Investigation, Feasibility Study, and Environmental Impact Statement Reports

BNSF submitted a Remedial Investigation Report (RI) to Ecology in 1996, a Draft Feasibility Study in 1999, and a Supplemental RI Report in 2002. These studies provide baseline data about soil, groundwater, surface water, air and river sediments throughout the site that are being used to develop cleanup options that are physically, economically, socially and scientifically feasible.

Based on the findings of these studies, BNSF prepared a Preliminary Draft Feasibility Study to evaluate cleanup alternatives and the potential impacts of those alternatives on the Skykomish site. That document was integrated with a Draft Environmental Impact Statement (June 13, 2003) consistent with SEPA. The Preliminary Draft FS and Draft EIS were revised based on comments from Ecology and in September 2003 the Draft FS and Draft EIS, along with the 1996 Remedial Investigation report and 2002 Supplemental RI report, were released by Ecology for public review and comment. BNSF considered the public comments in preparing this Final FS. Ecology will carefully consider the public comments when it prepares the Draft Cleanup Action Plan (DCAP) and Final EIS.

Draft Cleanup Action Plan

The DCAP will outline the work to be performed during the actual cleanup of the site and additional public comments will be solicited. Once comments are received and reviewed and any necessary changes are made to the DCAP, BNSF and Ecology will negotiate a consent decree to implement the Final CAP. The Final CAP will be an exhibit to the Consent Decree. The Consent Decree is a legal agreement between Ecology and BNSF that establishes their rights and obligations with respect to the Final CAP. The Final CAP will contain cleanup details, cleanup levels and points of compliance where BNSF must achieve cleanup. The Cleanup Action Plan and the consent decree will also be available for public comment before they are signed by Ecology.

Cleanup Zones

One of the first steps in developing the remedial alternatives was to divide the site into cleanup zones based on land use (railyard, commercial, residential), land type (wetland, levee, upland), exposure pathways, and distribution and chemical composition of the hazardous substances. The cleanup zones are described below.

1) Aquatic Resource Zones

    - South Fork Skykomish River and Levee
    - Former Maloney Creek channel

2) Developed Zones (land that has been or will likely be developed for commercial or residential use)

    - Northwest (NW) – affected by petroleum plume composed of diesel and bunker C
    - South – affected by petroleum plume composed of diesel and bunker C
    - Northeast (NE) – affected by petroleum plume of which 75 percent or greater is diesel (less viscous, more soluble, more biodegradable)

3) Railyard Zone

    - BNSF property
    - Two small areas immediately adjacent to the yard that are contaminated with surface soil metals, one of which is also contaminated with surface and subsurface TPH.

For each suggested remedial alternative, technologies and approaches are described for each cleanup zone.

Cleanup Standards

Cleanup standards establish:

1) The cleanup level, which is the concentration of a hazardous substance that protects human health and the environment under specific exposure conditions

2) The location on the site where that cleanup level must be reached, called the point of compliance

3) Other regulatory requirements that apply due to the type of cleanup action and/or location of the site.

Cleanup levels and points of compliance are established for each type of contaminated media. At the site, there are four media with contamination: soil, sediments, surface water, and groundwater.

For all remedial alternatives presented in this Final FS, the points of compliance are the same for soils, sediments, and surface water. However, three different points of compliance have been developed for groundwater.

Groundwater Points of Compliance:

1) **Standard Point of Compliance –** Groundwater must meet cleanup levels throughout the site, from the uppermost level of the saturated zone and extending to the lower-most depth that could potentially be affected by the site.

2) **Conditional Point of Compliance, On-Property –** Groundwater must meet cleanup levels at the BNSF property boundary.

3) **Conditional Point of Compliance, Off-Property –** Groundwater must meet cleanup levels at the point it discharges to the South Fork Skykomish River and the former Maloney Creek channel, or as close as practicable to the source. (Note: affected property owners between BNSF's property boundary and the South Fork Skykomish River must agree in writing to setting this conditional point of compliance.)

Institutional Controls

Institutional controls are part of the cleanup action alternatives in the Final FS. Institutional controls are legal or administrative measures designed to limit or control activities that could result in exposures. They are particularly used in situations where contaminant residues are likely to remain above cleanup levels for an extended period of time. A Restrictive Covenant is one common type of institutional control; it limits or restricts the use of a property and is binding for all current and future owners of the property. Another common institutional control is a local ordinance or state regulation that limits installation of groundwater wells or requires special permits before excavation or drilling in contaminated soil. For example, the Town of Skykomish can, by ordinance, limit installation of groundwater wells where public water is already available. Ecology can adopt similar regulations.

Some type of institutional controls will be required for each alternative, including the "Standard" alternative, to ensure protection from residual contaminated soil and groundwater while BNSF works to achieve Ecology's cleanup standards.

Remedial Alternatives

The site-wide remedial alternatives were developed to meet the cleanup standards for the three groundwater points of compliance described above. The Standard alternative uses the standard groundwater point of compliance described above. The PB, or BNSF Property Boundary, alternatives (PB1 through PB5) use the on-property groundwater point of compliance, while the SW, or Surface Water, alternatives (SW1 through SW4) use the off-property groundwater point of compliance. In addition, a No Action alternative is evaluated for comparison. Finally, BNSF has presented a "preferred" remedial alternative which includes a conditional point of compliance for groundwater similar to SW.

Individual technologies were selected for each cleanup zone and then combined based on their ability to comply with cleanup standards and attain remediation levels.

Each alternative in this Final FS can achieve cleanup standards and protect public health and the environment. Selecting a cleanup action from among the alternatives requires balancing several additional factors, including the restoration time frame, degree of permanence (including cost), and adverse impacts to the built and natural environment. In general, more aggressive technologies cost more, work faster, and are more permanent, but they have greater adverse impacts on the built and natural environment. The following remedial alternatives are named according to point of compliance where the cleanup levels would be attained.

- **STD (Standard) Alternative –** The Standard alternative meets cleanup levels at standard points of compliance throughout the site for all media. As such, the Standard alternative represents the most permanent alternative. All free product and contaminated soil and sediment will be removed. Groundwater will eventually be restored to levels that are protective of all risk pathways (including recontamination of sediments) through natural attenuation after free product and contaminated soil is excavated. Long-term maintenance or inspection is not required. The Standard alternative relies on excavation of all free product, all impacted soil, and all sediment above cleanup levels. All contamination above cleanup levels would be removed from the sediment in the bed and banks of the South Fork Skykomish River and former channel of Maloney Creek would be restored, the levee would be excavated and rebuilt, and structures, roads and utilities would be removed, replaced or rebuilt. Institutional controls would limit exposure until monitoring shows that groundwater achieves cleanup standards.

- **PB (Property Boundary) Alternatives** – The PB alternatives meet cleanup standards for groundwater at an on-property, conditional groundwater point of compliance at the railyard property boundary. This means that groundwater must be clean at the BNSF property boundary. All free product will be removed, petroleum discharges to the River will be eliminated, surface soil metals contamination will be removed and groundwater between the railyard and River will be restored to levels protective of the environment and human health. Subsurface soil on and off the railyard and groundwater on the railyard will continue to exceed cleanup levels. Protection from this material will be achieved through containment, institutional controls, and a long-term maintenance, inspection and monitoring program.

- **SW (Surface Water) Alternatives –** The SW alternatives meet cleanup standards for groundwater at an off-property, conditional groundwater point of compliance. In other words, groundwater must be clean before it discharges into the South Fork Skykomish River and former Maloney Creek channel or as close to the source as practicable. The SW alternatives will improve groundwater at the site but will not meet groundwater or soil cleanup levels on BNSF property or on properties between the BNSF property and the River. All free product will be removed, petroleum discharges to the River will be eliminated, and surface soil metals contamination will be excavated. Subsurface soil contamination of the railyard and areas between the railyard and the River will continue to exceed cleanup levels. Protection is achieved in areas where soil or groundwater exceed cleanup levels through a protective soil cap, institutional controls, and a long-term maintenance and monitoring program.

- **BNSF's Preferred Alternative –** BNSF's preferred alternative meets cleanup standards for groundwater at a conditional point of compliance, similar to the SW alternatives. All free product will be removed, petroleum discharges to the River will be eliminated, surface soil metals contamination will be removed and groundwater discharging to the River will be restored to levels protective of environmental and human health. Subsurface soil on and off the railyard and groundwater on the railyard and areas between the railyard and the River will continue to exceed cleanup levels. Protection from this material will be achieved through containment, institutional controls, and a long-term maintenance, inspection and monitoring program.

Summary of Preferred Alternative

The preferred alternative consists of the following cleanup activities in the different cleanup zones.

1) **Levee –** excavate and rebuild portions of the levee to remove free product and contaminated soil and excavate surface sediment along and within the South Fork Skykomish River at the base of the levee. Treatment of groundwater beneath the levee using biological treatment as a contingency if necessary to achieve cleanup levels.

2) **Former Maloney Creek Channel –** treat groundwater using enhanced bioremediation and limited soil excavation

3) **NE Developed Zone –** enhanced biological treatment of soil and groundwater, and limited soil excavation

4) **South Developed Zone –** soil excavation

5) **Railyard Zone –** excavate upper 2 feet of metals-impacted soil and recover free product using interceptor trenches

6) **NW Developed Zone –** excavate metals impacted soil in the upper two feet, excavate free product and contaminated soil within 135 feet of the river, and construct trenches to recover free product and prevent free product migration into excavated areas.

Remediation Levels

All of the remedial alternatives, except for the Standard Alternative, will use remediation levels to define the extent to which different components of a remedial alternative will be applied as part of the overall cleanup action that achieves cleanup standards.

Remediation levels may be used at sites where a combination of cleanup action components are used to achieve cleanup levels at the point of compliance. Remediation levels may also be used at sites where the cleanup action involves the containment of soils. Remediation levels are not the same as cleanup levels. A cleanup level defines the concentration of hazardous substances above which a contaminated medium (e.g., soil) must be remediated in some manner (e.g., treatment, containment, institutional controls). A remediation level, on the other hand, defines the concentration (or other method of identification such as depth, location, etc.) of a hazardous substance in a particular medium above or below which a particular component of a cleanup action (e.g., soil excavation or containment) will be used.

The remediation levels that have been applied to various cleanup alternatives in the FS consist of the following:

1) Free product removal

2) Free product removal, where accessible

3) Soil treatment to 20,000 mg/kg petroleum (by NWTPH-Dx)

4) Soil treatment to 3,400 mg/kg petroleum (by NWTPH-Dx) to protect against direct contact exposure

5) Soil treatment to 2,000 mg/kg petroleum (by NWTPH-Dx)

6) Surface sediment removal with minimal damage to wetland vegetation.

Estimated Cost of Remedial Alternatives

The total costs for each alternative are as follows:

Remedial Alternative	Total Cost
BNSF's Preferred Alternative	$20,700,000
SW1	$5,800,000
SW2	$10,600,000
SW3	$14,700,000
SW4	$23,300,000
PB1	$14,000,000
PB2	$20,300,000
PB3	$24,600,000
PB4	$37,000,000
PB5	$57,100,000
Standard	$87,700,000

The most expensive elements of cleanup are the NW Developed Zone, the levee, and the railyard. In general, cost increases as the amount of contaminated material removed increases. The degree of permanence of the alternative is also considered. This correlates with the amount of material removed, and thus cost as well. The "cost effectiveness" of each remedial alternative can be approximated by comparing cost per soil removal volumes

Since a high level of protection can be achieved by all remedial alternatives, the key differences influencing decisions on a remedial alternative are permanence, restoration time frame and adverse impacts on the built and natural environment.

Restoration Time Frames

This Final FS presents the time frames estimated for removal of free product, restoration of groundwater to cleanup levels at the point of compliance, and restoration of soil to cleanup levels at the point of compliance, respectively. For each media addressed, the figures show time frame per cleanup zone.

Free product will be removed from all off-railyard areas within 10 years for alternatives SW4, PB2, PB3, PB4, PB5 and STD. Free product will be removed from all off-railyard areas within two years for the preferred alternative, except for the NW Developed Zone. Free product will remain on the railyard for greater than 30 years for most alternatives, except PB5 and STD that remove free product within a couple of years. All but four alternatives achieve cleanup standards for groundwater within 10 years. This restoration timeframe reflects the different groundwater points of compliance between the SW and PB alternatives. Only two alternatives achieve soil cleanup levels within 10 years and this assumes that an empirical demonstration will be successful for PB5. Eight of the alternatives achieve soil cleanup levels in all off-railyard zones, except the Northwest Developed Zone, within 20 years. PB4, PB5, STD and the preferred alternative reduce the restoration time frame to less than 10 years for these same zones.

Selecting a Final Remedial Alternative

This Final FS describes the minimum and "other" requirements for selecting a final remedy consistent with MTCA. Although BNSF has indicated its preferred alternative in this Final FS, Ecology makes the final selection of cleanup actions when it issues a CAP. Each alternative cleanup action developed in a feasibility study must satisfy the minimum MTCA threshold requirements. These requirements are (1) Protect human health and the environment; (2) comply with cleanup standards; (3) comply with applicable state and federal laws; (4) provide for compliance monitoring.

When selecting from among the cleanup action alternatives that satisfy threshold requirements, Ecology also considers the following additional criteria from MTCA: (1) use permanent solutions to the maximum extent practicable; (2) provide for a reasonable restoration timeframe; and, (3) public and agency comments and concerns. This Final FS provides information to Ecology to select a final remedial alternative at Skykomish consistent with MTCA. Ecology also considers probable, significant adverse environmental impacts and reasonable measures to mitigate those impacts and the Draft EIS and Final EIS provide information to Ecology to select a final remedy consistent with the State Environmental Policy Act (SEPA).

Table of Contents

1 Introduction 1-1
1.1 Purpose and Objectives 1-1

2 Background 2-1
2.1 Town and Site Description and History 2-1
2.1.1 Town Description 2-1
2.1.2 Site Description 2-2
2.1.3 Railyard Operational History 2-4
2.2 Natural Environment 2-6
2.2.1 Earth 2-6
2.2.2 Water 2-11
2.2.3 Air 2-19
2.2.4 Plants 2-20
2.2.5 Wildlife 2-24
2.2.6 Fish and Aquatic Biota 2-31
2.3 Built Environment 2-37
2.3.1 Land and Shoreline Use Plans 2-37
2.3.2 Historical and Cultural Resources 2-39
2.3.3 Public Services 2-40
2.3.4 Environmental Health 2-41
2.3.5 Transportation 2-42
2.4 Interim Cleanup Actions and Ongoing Site Maintenance 2-43
2.4.1 Barrier System 2-43
2.4.2 Oil Recovery Booms 2-44
2.4.3 Dust Suppression Application 2-44

3 Nature and Extent of Contamination 3-1
3.1 Soil Quality 3-2
3.1.1 Petroleum Hydrocarbons in Soil 3-4
3.1.2 Metals in Soil 3-7
3.1.3 Polychlorinated Biphenyls in Soil 3-7
3.2 Free Product 3-8
3.2.1 Physical Properties of Free Product 3-8
3.2.2 Location and Extent of Free Product 3-9
3.3 Groundwater Quality 3-11
3.3.1 Petroleum Hydrocarbons in Groundwater 3-11
3.4 Sediment Quality 3-14
3.4.1 South Fork Skykomish River Sediment 3-14
3.4.2 Former Maloney Creek Sediment 3-14
3.5 Surface Water Quality 3-17
3.6 Air Quality 3-18
3.7 Summary of the Nature and Extent of Contamination 3-19
3.8 Indicator Hazardous Substances 3-21

Table of Contents

4 Conceptual Site Model 4-1
4.1 Source Characterization 4-1
4.2 Indicator Hazardous Substances and Impacted Media 4-2
4.2.1 Metals 4-2
4.2.2 Petroleum Hydrocarbons 4-3
4.3 Conceptual Model Summary 4-7
4.4 Exposure Assessment 4-8
4.4.1 Current and Potential Land and Resource Uses 4-8
4.4.2 Potential Receptors 4-12
4.4.3 Transport Mechanisms 4-14
4.4.4 Potential Receptor Exposures 4-15
4.5 Summary 4-16
4.5.1 Soil 4-16
4.5.2 Groundwater 4-17
4.5.3 Sediment 4-17
4.5.4 Surface Water 4-17

5 Cleanup Standards 5-1
5.1 Indicator Hazardous Substances 5-1
5.2 Cleanup Levels 5-2
5.2.1 Soil 5-3
5.2.2 Groundwater 5-7
5.2.3 Sediment 5-9
5.2.4 Surface Water 5-10
5.3 Points of Compliance 5-12
5.3.1 Soil 5-13
5.3.2 Groundwater 5-13
5.3.3 Sediment 5-15
5.3.4 Surface Water 5-15
5.3.5 Air 5-15
5.4 Other Potentially Applicable Requirements 5-15

6 Remediation Levels 6-1
6.1 Introduction 6-1
6.2 Remediation Levels for Soil 6-2
6.2.1 Remove Free Product 6-2
6.2.2 Excavate Free Product Where Accessible 6-4
6.2.3 Remove/Treat Soil to 20,000 mg/kg NWTPH-Dx 6-5
6.2.4 Remove Soil to 2,000 mg/kg NWTPH-Dx 6-5
6.2.5 Direct Contact (Human) 6-6
6.2.6 Terrestrial Ecological Exposure 6-7
6.2.7 Soil to Air 6-8

7 Development of Remedial Alternatives 7-1
7.1 Technology Screening 7-1

Table of Contents

7.1.1 Metals in Soil 7-1
7.1.2 Petroleum Hydrocarbons in Soil 7-2
7.1.3 LNAPL 7-2
7.1.4 Dissolved Petroleum Hydrocarbons in Groundwater 7-2
7.2 Bench-Scale Testing of Cleanup Technologies 7-2
7.2.1 Results for Flushing with Surfactant and Polymer 7-3
7.2.2 Results for Biological Treatment 7-4
7.2.3 Summary of Bench-Scale Results for Chemical Oxidation with Ozone 7-5
7.3 Approach to Developing Remedial Alternatives 7-6
7.3.1 Site Cleanup Zones 7-6
7.3.2 Points of Compliance 7-7
7.4 Description of Remedial Alternatives 7-8
7.4.1 Detailed Description of Remedial Approaches by Cleanup Zone 7-8
7.4.2 Description of Site-Wide Remedial Alternatives 7-28

8 MTCA Evaluation of Remedial Alternatives 8-1
8.1 Requirements for Remedial Alternatives 8-1
8.1.1 Threshold Requirements 8-1
8.1.2 "Other Requirements" 8-3
8.2 No Action Alternative 8-5
8.3 Evaluation of Alternative SW1 8-5
8.4 Evaluation of Alternative SW2 8-6
8.5 Evaluation of Alternative SW3 8-8
8.6 Evaluation of Alternative SW4 8-9
8.7 Evaluation of Alternative PB1 8-10
8.8 Evaluation of Alternative PB2 8-11
8.9 Evaluation of Alternative PB3 8-13
8.10 Evaluation of Alternative PB4 8-14
8.11 Evaluation of Alternative PB5 8-15
8.12 Evaluation of Standard Alternative (STD) 8-16
8.13 Summary of Remedial Alternatives Evaluation 8-17
8.13.1 No Action 8-17
8.13.2 Standard Alternative 8-17
8.13.3 SW Alternatives 8-18
8.13.4 PB Alternatives 8-19

9 MTCA Remedial Alternative Selection Process 9-1
9.1 Threshold Requirements 9-1
9.1.1 Protect Human Health and the Environment 9-1
9.1.2 Comply With Cleanup Standards 9-4
9.1.3 Comply With Applicable Local, State and Federal Laws 9-5
9.1.4 Provide for Compliance Monitoring 9-6
9.2 Use Permanent Solutions to the Maximum Extent Practicable 9-6

Table of Contents

9.2.1 Protectiveness 9-6
9.2.2 Permanence 9-7
9.2.3 Cost 9-7
9.2.4 Effectiveness over the Long-Term........ 9-8
9.2.5 Management of Short-Term Risks........ 9-9
9.2.6 Technical and Administrative Implementability 9-9
9.2.7 Consideration of Public Concerns 9-10
9.2.8 Permanence to the Maximum Extent Summary 9-10
9.3 Provide for a Reasonable Restoration Timeframe 9-12
9.4 Consider Public Concerns........ 9-13
9.5 SEPA Analysis........ 9-14
9.6 Preferred Alternative Selection........ 9-14

10 Preferred Remedial Alternative 10-1
10.1 Factors Influencing Selection 10-2
10.2 Description of Preferred Alternative........ 10-3
10.2.1 Levee Aquatic Resource Zone 10-4
10.2.2 Former Maloney Creek Channel Aquatic Resource Zone... 10-6
10.2.3 Northeast Developed Zone 10-8
10.2.4 South Developed Zone........ 10-9
10.2.5 Railyard Zone........ 10-10
10.2.6 Northwest Developed Zone 10-11
10.3 Project Schedule and Phasing 10-13
10.3.1 Remedial Design........ 10-14
10.4 Regulatory Evaluation of Alternative 10-14
10.4.1 Threshold Requirements 10-15
10.4.2 Use Permanent Solutions to the Maximum Extent Practicable........ 10-19
10.4.3 Provide for a Reasonable Restoration Timeframe........ 10-25
10.4.4 Consider Public Concerns........ 10-27
10.4.5 MTCA Site-Specific Requirements 10-27
10.4.6 SEPA........ 10-30
10.4.7 Preferred Alternative Selection........ 10-31
10.5 Compliance Monitoring Plan........ 10-31
10.5.1 Compliance with Cleanup Standards........ 10-32
10.5.2 Compliance with Remediation Levels........ 10-32
10.5.3 Contingent Actions 10-36
10.6 Financial Assurance........ 10-36

11 References........ 11-1

List of Tables

Table 2-1 South Fork Skykomish River Measurements

Table 2-2 Occurrence of Federal Threatened and Endangered Species in the Site Vicinity

Table 2-3 Salmonid Presence and Timing Within the South Fork and Former Maloney Creek Channel

Table 2-4 Typical Sound Levels Measured in the Environment and Industry

Table 3-1 Potentiometric Surface Elevations for Selected Wells – December 2002 to March 2003

Table 3-2 Petroleum Hydrocarbon Concentrations in Groundwater – January 2002 and January 2003

Table 3-3 PAH Concentrations in Groundwater

Table 3-4 BTEX Concentrations in Groundwater

Table 3-5 Summary of Final Indicator Hazardous Substances

Table 4-1 Indicator Hazardous Substances and Media

Table 4-2 Selected Physical Properties of Skykomish LNAPL Samples

Table 5-1 Proposed Cleanup Levels

Table 5-2 Potentially Applicable Requirements – Cleanup Levels

Table 5-3 Potentially Applicable Requirements – Treatment and Disposal

Table 5-4 Potentially Applicable Requirements – Other Remediation Activities

Table 6-1 Remediation Levels

Table 7-1 Technologies Identified and Screened for Use in Developing Remedial Alternatives

Table 7-2 Points of Compliance for Site Media

Table 7-3 Remedial Alternative Points of Compliance and Remediation Levels

Table 7-4 Remedial Alternatives Matrix

Table 7-5 Summary Description of Remedial Alternatives

Table 8-1 Remedial Alternatives and Cleanup Standards

Table 8-2 MTCA “Other Requirements”

Table 8-3 Summary Costs of Remedial Alternatives

Table 9-1 Benefit Analysis for Disproportionate Cost Analysis

Table 10-1 Benefit Analysis for Disproportionate Cost Analysis

List of Figures

Figure 1-1 Regional Location Map
Figure 1-2 BNSF Skykomish Path Forward
Figure 1-3 Steps to Site Cleanup Under MTCA
Figure 1-4 Block Flow Diagram of MTCA Feasibility Study

Figure 2-1 General Site Layout and Site Boundary
Figure 2-2 Sites of Demolished Railroad Buildings and Structures
Figure 2-3 Geologic Cross-Section W-E
Figure 2-4 Shoreline Hydrocarbon Seeps
Figure 2-5 Conceptual Site Model for Former Maloney Creek Channel
Figure 2-6 Topography of Area South of the River
Figure 2-7 Maloney Creek Catchment Area
Figure 2-8 Skykomish Stormwater Flow
Figure 2-9 FEMA 100- and 500-Year Flood Boundaries
Figure 2-10 Hydrographs of 2A-W-1 and 1A-W3
Figure 2-11 Groundwater Surface Elevation Map – 01/31/02 and 02/01/02
Figure 2-12 Habitat Types and Land Cover
Figure 2-13 Western End of Former Maloney Creek Wetland, North of Channel – December 2002
Figure 2-14 Western End of Former Maloney Creek Wetland, South of Channel – December 2002
Figure 2-15 Upstream End of Former Maloney Creek Channel – March 2003
Figure 2-16 Zoning and Land Use Areas
Figure 2-17 Historic Resources
Figure 2-18 A-Weighted Noise Level (dB) at 50 Feet
Figure 2-19 Location of the Subsurface Barrier Wall and Product Recovery System

Figure 3-1 Extent of Free Product
Figure 3-2 Site Cleanup Zones
Figure 3-3 TPH-Dx Distribution in Vadose Zone Soil
Figure 3-4 Interpolated TPH-Dx Distributed in Smear Zone Soil
Figure 3-5 Interpolated TPH-Dx Distributed in Saturated Zone Soil
Figure 3-6 Comparison of Soil TPH by NWTPH-Dx and Sum of EPH/VPH Fractions

List of Figures

Figure 3-7 Arsenic in Surface Soil

Figure 3-8 Lead in Surface Soil

Figure 3-9 PCBs in Soil

Figure 3-10 Product Thickness and Fluid Level Elevation versus Time: MW-36

Figure 3-11 Free Product and Dissolved TPH-Diesel in Groundwater

Figure 3-12 Sum of EPH and VPH and Sum of TPH

Figure 3-13 Extent of TPH Throughout Site

Figure 3-14 Extent of TPH in Former Maloney Creek Area

Figure 4-1 Conceptual Model of LNAPL Occurrence

Figure 4-2 Schematic Cross-Section Through Free Product Plumes

Figure 4-3 Exposure Pathway Conceptual Model

Figure 5-1 Approach to Setting Method B Cleanup Levels

Figure 6-1 Maximum Extent of Levee Remediation Excavation

Figure 7-1 Site Cleanup Zones

Figure 7-2 Basis for Areal Definition of Site Cleanup Zones

Figure 7-3 Levee Surface Sediment Removal Area

Figure 7-4 Levee Enhanced Bioremediation System Layout

Figure 7-5 Levee Estimated Extent of Excavation

Figure 7-6 Former Maloney Creek Channel Surface Sediment Removal Area

Figure 7-7 Former Maloney Creek Channel Enhanced Bioremediation System Layout

Figure 7-8 Former Maloney Creek Channel Estimated Extent of Excavations

Figure 7-9 NE Developed Zone Enhanced Bioremediation System Layouts

Figure 7-10 NE Developed Zone Estimated Extent of Excavations

Figure 7-11 South Developed Zone Estimated Extent of Excavations

Figure 7-12 NW Developed Zone Estimated Extent of Surface Metals Excavations

Figure 7-13 NW Developed Zone Free Product Recovery Trench Locations

Figure 7-14 NW Developed Zone Enhanced Bioremediation System Layouts

Figure 7-15 NW Developed Zone Estimated Extent of Excavations

Figure 7-16 Railyard Estimated Extent of Surface Soil Excavations

List of Figures

Figure 7-17 Railyard Free Product Recovery Trench Locations
Figure 7-18 Railyard Enhanced Bioremediation System Layout
Figure 7-19 Railyard Estimated Extent of Excavations
Figure 7-20 Site-Wide Remedial Alternative SW1 Layout
Figure 7-21 Site-Wide Remedial Alternative SW2 Layout
Figure 7-22 Site-Wide Remedial Alternative SW3 Layout
Figure 7-23 Site-Wide Remedial Alternative SW4 Layout
Figure 7-24 Site-Wide Remedial Alternative PB1 Layout
Figure 7-25 Site-Wide Remedial Alternative PB2 Layout
Figure 7-26 Site-Wide Remedial Alternative PB3 Layout
Figure 7-27 Site-Wide Remedial Alternative PB4 Layout
Figure 7-28 Site-Wide Remedial Alternative PB5 Layout
Figure 7-29 Site-Wide Remedial Alternative STD Layout

Figure 8-1 TPH Left On-Site After Active Remediation SW1
Figure 8-2 TPH Left On-Site After Active Remediation SW2
Figure 8-3 TPH Left On-Site After Active Remediation SW3
Figure 8-4 TPH Left On-Site After Active Remediation SW4
Figure 8-5 TPH Left On-Site After Active Remediation PB1
Figure 8-6 TPH Left On-Site After Active Remediation PB2
Figure 8-7 TPH Left On-Site After Active Remediation PB3
Figure 8-8 TPH Left On-Site After Active Remediation PB4
Figure 8-9 TPH Left On-Site After Active Remediation PB5
Figure 8-10 TPH Left On-Site After Active Remediation STD

Figure 9-1 Remedial Alternatives Ranked by Permanence
Figure 9-2 Remedial Alternative Costs by Permanence
Figure 9-3 Unit Equivalent Soil Removal Cost by Permanence
Figure 9-4 Benefit and Cost by Remedial Alternative Ranked by Permanence
Figure 9-5 Benefit vs. Cost
Figure 9-6 Incremental Benefit versus Cost Savings Relative to STD
Figure 9-7 Free Product Removal Timeframe
Figure 9-8 Groundwater Restoration Timeframe

List of Figures

Figure 9-9 Soil Restoration Timeframe

Figure 10-1 Preferred Remedial Alternative
Figure 10-2 Remedial Alternatives Ranked by Permanence
Figure 10-3 Remedial Alternative Costs by Permanence
Figure 10-4 Unit Equivalent Soil Removal Cost by Permanence
Figure 10-5 Benefit and Cost by Remedial Alternative Ranked by Permanence
Figure 10-6 Benefit vs. Cost
Figure 10-7 Incremental Benefit versus Cost Savings Relative to STD
Figure 10-8 Free Product Removal Timeframe
Figure 10-9 Groundwater Restoration Timeframe
Figure 10-10 Soil Restoration Timeframe
Figure 10-11 TPH Left On-Site After Active Remediation – Preferred Remedial Alternative

List of Appendices

Appendix A Results of Supplemental Sediment Sampling – Toxicity Evaluation and Sediment Cleanup Levels

- Appendix A-1 Results of Supplemental Sediment Sampling – Toxicity Evaluation and Sediment Cleanup Levels (February 24, 2003)
- Appendix A-2 Second Supplemental Sediment Sampling Results (November 20, 2003

Appendix B Wetland Detailed Study

Appendix C Skykomish Sanborn Map – 1926

Appendix D Terrestrial Ecological Evaluation

Appendix E Re-Reported NWTPH-Dx Groundwater Data

Appendix F Ecology Supplemental Sampling Logs and Data

Appendix G Selection of Indicator Hazardous Substances

Appendix H Technical Memo No. 1 (Revision 1) – EPH/VPH Data Set for Skykomish Site (September 6, 2002)

Appendix I Technical Memo 2 – Site-Specific Input Parameters for TPH Four Phase Model (November 22, 2002) and Related F_{oc} Correspondence, Work Plans, Results and Ecology Approval

Appendix J Calculation of Surface Water CULs Protective of Human Health via Fish/Shellfish Consumption

Appendix K Groundwater Cleanup Levels for TPH Protective of Ecological Resources in Surface Water (January 17, 2003)

Appendix L Leach Testing and Response to Comments

- Appendix L-1 Report of Leach Testing to Derive Soil Cleanup Levels to Protect Groundwater (April 10, 2003)
- Appendix L-2 Response to Ecology Comments on Leach Testing

Appendix M Screening of Remedial Technologies

- Appendix M-1 Screening of Remedial Technologies
- Appendix M-2 Biodegradation Processes
- Appendix M-3 Geotechnical Shoring Analysis
- Appendix M-4 Air Monitoring Logs
- Appendix M-5 Additional Evaluation of Remedial Technologies

Appendix N Detailed Cost Estimates

Appendix O List of Potentially Affected Properties (Excluding Railyard)

List of Appendices

Appendix P	Cost-Benefit Analysis
Appendix Q	Restrictive Covenant
Appendix R	Example Financial Assurance Documentation
Appendix S	Fate and Transport Modeling

List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BMP	Best Management Practices
BNSF	BNSF Railway Company
BNRR	Burlington Northern Railroad
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British Thermal Unit
CAO	Critical Areas Ordinance
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
cm/sec	centimeters per second
CO	carbon monoxide
cP	centipoise
cPAH	carcinogenic polynuclear aromatic hydrocarbon
CSM	Conceptual Site Model
CWA	Clean Water Act
cy	cubic yard
dB	decibel (measurement of noise volume)
dBA	decibels at equivalent A-weighted sound levels
dbh	diameter at breast height
DO	dissolved oxygen
DOD	United States Department of Defense
DOE	United States Department of Energy
dynes/cm	dynes per centimeter
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
EPH/VPH	extractable and volatile petroleum hydrocarbon fractions
f_{oc}	fraction of organic carbon

List of Acronyms

FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility Study
FS/EIS	Feasibility Study and Environmental Impact Statement
ft^2	square feet
g/kg	grams per kilogram
GNR	Great Northern Railroad
gpm	gallons per minute
HDPE	high-density polyethylene
IHS	Indicator Hazardous Substances
LD50	lethal dose for 50 percent kill
LNAPL	light nonaqueous phase liquid
MACT	maximum acceptable concentration threshold
MCL	maximum contaminant level
MCLG	maximum contaminant level goal (formerly RMCL)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
msl	mean sea level
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards
NAPL	nonaqueous phase liquid
NMFS	National Marine and Fisheries Service
NO_x	nitrous oxides
NRWQC	National Recommended Water Quality Criteria
ORP	oxygen reduction potential
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
pH	measure of acidity or alkalinity
POC	point of compliance
Poise	A unit of [dynamic] viscosity. One poise is the viscosity of a liquid in which a force of one dyne is necessary to maintain a velocity

List of Acronyms

	differential of one centimeter per second per centimeter over a surface one. [Poise is a measure of absolute or dynamic viscosity.]
PPE	personal protective equipment
ppm	parts per million
PQL	practical quantitation level
PSCAA	Puget Sound Clean Air Agency
RCW	Revised Code of Washington
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
site	BNSF Skykomish site
SMS	Sediment Management Standards
SOW	Scope of Work
Stokes	A unit of kinematic viscosity (dynamic viscosity divided by the density). In the SI system the accepted unit is square meter per second (m^2/s). To convert one stokes to (m^2/s) multiply by 1.0×10^{-4}.
SVOC	semivolatile organic compound
su	standard unit
TEE	terrestrial ecological evaluation
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons – diesel
TPH-Dx	total petroleum hydrocarbons – diesel extended
TPH-MO	total petroleum hydrocarbons – motor oil
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

List of Acronyms

USFS	United States Forest Service
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbon
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health
WET	whole effluent toxicity
WSDOT	Washington State Department of Transportation
ºC	degrees Celsius
ºF	degrees Fahrenheit

List of MTCA Definitions

Free Product	[173-340200]	"a NAPL that is present in the soil…gw or sw as a distinct separate layer. Under the right conditions, if sufficient free product is present, free product is capable of migrating independent of the direction of flow of the gw or sw."
NAPL	[---200]	"a hazardous substance that is present in the soil, groundwater, surface water as a liquid not dissolved in water. The term includes both LNAPL and DNAPL."
Residual Saturation	[---747(10)(b)]	"When a NAPL is released to the soil, some of the NAPL will be held in the soil pores or void spaces by capillary force. …., the concentration of hazardous substances in the soil at equilibrium conditions is called residual saturation. At concentrations above residual saturation, the NAPL will continue to migrate due to gravimetric and capillary forces and may eventually reach the gw, provided a sufficient volume of NAPL is released."

Glossary

Agreed Order: A legal document, issued by Ecology, which formalizes an agreement between Ecology and the potentially liable persons for the actions needed at a site. An Agreed Order may be used for all remedial actions except for non-routine cleanup actions and interim actions that constitute a substantial majority of a cleanup action likely to be selected. Since an Agreed Order is not a settlement, it shall not provide for mixed funding, a covenant not to sue, or protection from claims for contribution. An agreed order means that the potentially liable person agrees to perform remedial actions at the site in accordance with the provisions of the agreed order, and that Ecology will not take additional enforcement action against the potentially liable person to require those remedial actions specified in the agreed order, so long as the potentially liable person complies with the provisions of the order. Agreed orders are subject to public comment. If an order substantially changes, an additional public comment period is provided.

Built Environment: The elements of the environment that are generally built or made by people as contrasted with natural processes, including roads, utilities, buildings and bridges.

Cleanup: The implementation of a cleanup action or interim action.

Cleanup Action: Any remedial action, except interim actions, taken at a site to eliminate, render less toxic, stabilize, contain, immobilize, isolate, treat, destroy, or remove a hazardous substance that complies with cleanup levels; utilizes permanent solutions to the maximum extent practicable; and includes adequate monitoring to ensure the effectiveness of the cleanup action.

Cleanup Action Plan: A document that selects the cleanup action and specifies cleanup standards and other requirements for a particular site. The cleanup action plan, which follows the remedial investigation/feasibility study report, is subject to a public comment period. After completion of a comment period on the draft cleanup action plan, Ecology issues a final cleanup action plan.

Cleanup Level: The concentration of a hazardous substance in soil, water, air, or sediment that is determined to be protective of human health and the environment under specified exposure conditions.

Cleanup Process: The process for identifying, investigating, and cleaning up hazardous waste sites.

Consent Decree: A legal document, approved and issued by a court, which formalizes an agreement reached between Ecology and potentially liable persons on the actions needed at a site. A consent decree is subject to public comment, and a public meeting is required. If a consent decree substantially changes, an additional comment period is provided. After satisfying the public comment and meeting requirements, Ecology files the consent decree with the appropriate superior court or federal court having jurisdiction over the matter.

Containment: A container, vessel, barrier, or structure, whether natural or constructed, which confines a hazardous substance within a defined boundary and prevents or minimizes its release into the environment.

Contaminant: Any hazardous substance that does not occur naturally or occurs at greater than natural background levels.

Dissolved-Phase Contaminants: Chemicals that are constituents of LNAPL and have dissolved into groundwater over time (see also LNAPL).

Exposure Pathway: The path a hazardous substance takes or could take from a source to an exposed organism. An exposure pathway describes the mechanism by which an individual or population is exposed or has the potential to be exposed to hazardous substances at or originating from a site.

Feasibility Study (FS): Provides identification and analysis of site cleanup alternatives and is usually completed within a year. The entire Remedial Investigation/Feasibility Study (RI/FS) process takes about two years and is followed by the cleanup action plan. The purpose of the Remedial Investigation/Feasibility Study is to collect and develop sufficient site information regarding a site to enable the selection of a cleanup action.

Free Product: A hazardous substance that is present as a nonaqueous phase liquid (that is, liquid not dissolved in water). Free product flows and accumulates as a liquid separate from water in wells.

Groundwater: Water found beneath the earth's surface that fills pores between materials such as sand, soil, or gravel. In aquifers, groundwater occurs in sufficient quantities that it can be used for drinking water, irrigation, and other purposes.

Hazardous Site List: A list of ranked sites that require further remedial action. These sites are published in the Site Register.

Interim Action: Any remedial action that partially addresses the cleanup of a site. It is an action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility; an action that corrects a problem that may become substantially worse or cost substantially more to address if the action is delayed; an action needed to provide for completion of a site hazard assessment, state remedial investigation/feasibility study, or design of a cleanup action.

Glossary

Light Non-Aqueous Phase Liquid (LNAPL): Liquid that is present as a separate phase from water, with a specific gravity less than one, that floats on groundwater and accumulates on top of water in wells, groundwater or surface water is called mobile (free-phase) LNAPL. See also residual LNAPL.

Model Toxics Control Act (MTCA): Refers to RCW 70.105D. Voters approved it in November 1988. The implementing regulation is WAC 173-340 and was amended in 2001.

Monitoring Wells: Special wells drilled at specific locations on or off a hazardous waste site where groundwater can be sampled at selected depths and studied to determine the direction of groundwater flow and the types and amounts of contaminants present.

Natural Environment: The elements of the environment frequently referred to as natural elements, or resources, such as earth, air, water and wildlife.

Polynuclear Aromatic Hydrocarbon (PAH): A class of organic compounds, common in some petroleum products, some of which are long lasting and carcinogenic. These compounds are formed from the combustion of organic material and are ubiquitous in the environment.

Public Notice: At a minimum, adequate notice mailed to all persons who have made a timely request of Ecology and to persons residing in the potentially affected vicinity of the proposed action; mailed to appropriate news media; published in the local (city or county) newspaper of largest circulation; and the opportunity for interested persons to comment.

Public Participation Plan: A plan prepared under the authority of WAC 173-340-600 to encourage coordinated and effective public involvement tailored to the public's needs at a particular site.

Recovery Wells: Special wells drilled at specific locations on or off a hazardous waste site where petroleum products can be recovered from the groundwater and recycled or disposed in accordance with state law and regulations.

Redd: A depression created in gravel beds by the upstroke of the female salmon's body and tail, used by spawning salmon to create "nests" for their eggs.

Release: Any intentional or unintentional entry of any hazardous substance into the environment.

Remedial Action: Any action to identify, eliminate, or minimize any threat posed by hazardous substances to human health or the environment, including any investigative and monitoring activities of any release or threatened release of a hazardous substance, and any health assessments or health effects studies conducted in order to determine the risk or potential risk to human health.

Remedial Investigation (RI): Any remedial action that provides information on the extent and magnitude of contamination at a site. This usually takes 12 to 18 months and is followed by the feasibility study. The purpose of the Remedial Investigation/Feasibility Study is to collect and develop sufficient site information regarding a site to enable the selection of a cleanup action.

Residual LNAPL: The oily residue that is caught up in the soil pores due to capillary pressure following the removal of mobile LNAPL (see LNAPL). Residual LNAPL can provide a continuous source of contamination to groundwater from soluble constituents.

Responsiveness Summary: A compilation of all questions and comments to a document open for public comment and their respective answers/replies by Ecology. The responsiveness summary is mailed, at a minimum, to those who provided comments, and its availability is published in the Site Register.

Risk: The probability that a hazardous substance, when released into the environment, will cause an adverse effect in exposed humans or other living organisms.

Risk Assessment: The determination of the probability that a hazardous substance, when released into the environment, will cause an adverse effect in exposed humans or other living organisms.

Seep: A point on the riverbank where the groundwater has carried the petroleum products and those products are released into the river.

Total Petroleum Hydrocarbons (TPH): A scientific measure of the sum of all petroleum hydrocarbons in a sample (without distinguishing one hydrocarbon from another). The “petroleum hydrocarbons” include compounds of carbon and hydrogen that are derived from naturally occurring petroleum sources or from manufactured petroleum products (such as refined oil, coal, and asphalt).

Toxicity: The degree to which a substance at a particular concentration is capable of causing harm to living organisms, including people, plants and animals.

1 Introduction

This report presents the Final Feasibility Study (FS) for BNSF's Former Maintenance and Fueling Facility located in Skykomish, Washington (site). Figure 1-1 shows the site boundary, which is not limited to BNSF's property. This Final FS evaluates alternatives for cleanup action at the Skykomish Site.

BNSF and Ecology released an integrated Draft Feasibility Study and Draft Environmental Impact Statement on September 3, 2003, for comment by the public and other regulatory agencies. After considering comments that BNSF and the agency received on the Draft FS and Draft EIS, BNSF developed a preliminary preferred alternative and included that in the Draft Final FS (RETEC, July 26, 2004). BNSF presented its preliminary preferred alternative to Ecology and the community, collected additional information from technology vendors, revised its preliminary preferred alternative and prepared a detailed description and analysis of the revised preferred alternative. *Preferred Remedial Alternative (Revised) Technical Memorandum* (December 3, 2004). This Final FS incorporates BNSF's revised preferred alternative and responds to Ecology's comments on that alternative.

Figure 1-2 presents a flowchart with the next procedural steps. This document is the Final FS. The Final FS will be followed by the Draft Cleanup Action Plan (DCAP) and then the Final CAP (FCAP) and Final EIS (FEIS). The public and other regulatory agencies will be invited to comment on the DCAP.

In 1993, the BNSF Railway (BNSF) entered into an Agreed Order (No. DE91TC-N213) (1993 Agreed Order) with the Washington State Department of Ecology (Ecology) to conduct a Remedial Investigation and Feasibility Study (RI/FS) and to implement certain interim cleanup actions. BNSF and Ecology entered into a second Agreed Order in 2001 (No. DE 01TCPNR-2800) under which BNSF implemented additional interim actions.

Cleanup of the site is being done under the authority of Chapter 70.105D Revised Code of Washington (RCW), *Hazardous Waste Cleanup – Model Toxics Control Act* (MTCA), and its implementing regulations, Chapter 173-340 Washington Administrative Code (WAC), *The Model Toxics Control Act Cleanup Regulation*. This statute and its implementing regulations apply to the site in their entirety and govern all remedial actions at the site.

1.1 Purpose and Objectives

The purpose of a Feasibility Study is to present and evaluate alternatives for a cleanup. The FS is used by Ecology to solicit public and agency comments and select a cleanup action for the site under WAC 173-340-360 through 173-340-390.

Figure 1-3 presents a general flow diagram of the MTCA process. This shows that the FS is one of several sequential requirements leading to site cleanup under MTCA. The FS uses data collected during the Remedial Investigation (RI) and additional data collected for the FS to develop and evaluate cleanup action alternatives. After the FS is complete, Ecology will issue a cleanup action plan (WAC 173-340-380); this plan will present the selected cleanup action(s) that will be used to address site contamination.

Figure 1-4 presents a diagram that summarizes the information presented in a Feasibility Study under MTCA. This information is presented in this FS for the BNSF Skykomish site. As shown on Figure 1-4, an FS uses general facility information, and data collected from field investigations. Some of the key elements of this FS are described below.

- **Indicator Hazardous Substance (IHS).** IHSs are typically a subset of substances that contribute the majority of the overall threat to human health and the environment. These are used to define site cleanup requirements and are defined in the FS.

- **Conceptual Site Model (CSM).** The CSM provides the nature and extent of contamination, fate and transport characteristics of the IHSs, current and potential contaminant migration pathways and receptors of site contamination, and current and potential land use and resources. The CSM is intended to further refine the definition of risk posed by site contaminants and assist with the definition of cleanup requirements.

- **Cleanup Standards.** Cleanup standards are defined in an FS for all media, such as soil and groundwater, that have been impacted by contamination and that could pose a risk to human health or the environment. Cleanup standards consist of the cleanup levels for hazardous substances present at the site and the location where these cleanup levels must be met (point of compliance).

- **Cleanup Action Alternatives.** Cleanup action alternatives are developed and presented in the FS. These alternatives consist of technologies that clean up site contaminants by reuse or recycling, destruction or detoxification, immobilization or solidification, disposal, containment with engineering controls or institutional controls and monitoring. These cleanup action alternatives must meet the following MTCA requirements (WAC 173-340-360): (1) protect human health and the environment, (2) comply with cleanup standards and applicable federal and state laws, (3) provide for compliance monitoring, use permanent solutions to the maximum extent practicable, (4) provide for a reasonable restoration time frame, and (5) consider public concerns.

- **Remediation Levels.** Remediation levels are proposed in an FS. As required, remediation levels always exceed cleanup levels and are concentrations of a hazardous substance above which a particular cleanup action component will be required as part of a cleanup action at a site. Remediation levels may be used at sites where a combination of cleanup action components are used to achieve cleanup levels at the point of compliance.

The FS is intended to provide enough information to allow Ecology to select a cleanup action. The procedures for conducting a feasibility study are set forth in WAC 173-340-350(8). The selection of a final cleanup action is documented in the Cleanup Action Plan.

2 Background

This section presents an overview of current conditions at the site, including the natural and built environment, historical information, and key environmental conditions. The objective is to present the information on the affected environment pursuant to the requirements of MTCA.

2.1 Town and Site Description and History

This section first describes the Town of Skykomish, Washington, and then locates the site within the town. It is important to not only understand the layout of the site, but also the town because the alternatives for cleanup of the Former Maintenance and Fueling Facility will impact areas of the town that are not on BNSF property. In addition to describing the town and site, the operational history of the Former Maintenance and Fueling Facility is also summarized. Sections 2.2 and 2.3 describe the natural and built environment of the town and the site.

2.1.1 Town Description

Historically, Skykomish was the commercial center of the Upper Skykomish Valley. The Town of Skykomish was incorporated in 1909, and mining, lumbering, milling, and the railroad were its economic mainstays. In 1929 the town had a population of 929, but it has since declined to its current level of 214 (U.S. Census Bureau, 2001). It is estimated that seasonal residents bring the total population to between 250-300 people (Blanck, 2003). Skykomish is located in King County, Washington at an altitude of 950 feet above mean sea level (msl).

In 1893, train service to Seattle started along the Great Northern Railway (GNR), and the Town of Skykomish became a center for railroad operations, including a roundhouse, turntable, and electrical generating substation. Active railyard operations in Skykomish had ceased by 1974. The BNSF railroad still runs through town, but railyard activities are limited to track maintenance and snow removal. The railroad continues to be a BNSF main transcontinental route with approximately 24 trains passing through Skykomish daily (Yates, pers. comm., 2003a).

Skykomish was built near the mouth of Maloney Creek where it connects to the South Fork of the Skykomish River. Maloney Creek was diverted from its original course in approximately 1912, and many channel modifications have occurred since then (USFS, 1991). The original course of Maloney Creek was located along the southern boundary of the railyard, and developed into a marshy area collecting stormwater drainage from the railyard and the southern part of town. This area is marked on Figure 2-1. The current course of Maloney Creek runs south of town.

To protect the town from flooding from the South Fork Skykomish River, the United States Army Corps of Engineers (USACE) constructed a flood control levee in 1951 along the riverfront east and west of the Skykomish Bridge, which was built in 1939. The levee is marked on Figure 2-1.

No logging or mining activities are ongoing in the Skykomish area. The town is surrounded on all sides by the Snoqualmie-Mount Baker National Forest (Figure 1-1). This portion of the National Forest is in Management Area 27-SF, part of which is Scenic Forest. Scenic Forest is managed to enhance viewing and recreational experiences (USFS, 1990 and USFS/USDI BLM, 1994). Scenic forest is a designation made by the Forest Service to describe land managed to enhance viewing and recreational experience. These areas include parcels with various designations that influence the Forest Service's management of each parcel. Area 27-SF includes stands such as Late Successional Reserve, which are managed for the growth and protection of old growth forest, recommended Wild and Scenic River, and many other designations all managed in different ways to enhance viewing and recreational experiences.

Today the town is dependent on tourism and on the Forest Service maintenance yard and ranger station. The other major employer is the Skykomish School District.

2.1.2 Site Description

The BNSF Former Maintenance and Fueling Facility in Skykomish, Washington, operated from the inauguration of the GNR line to Seattle in 1893 until 1974. The railroad line still runs through the facility, the property of which is owned by BNSF. The historical activities at the facility resulted in a release of hazardous substances that has impacted the railyard, adjacent properties, and natural features in the area such as the former Maloney Creek channel. The affected areas subject to potential cleanup action, whether BNSF property or otherwise, are collectively referred to as "the site" in this Final FS. BNSF's property is referred to as "the facility" and "the railyard." Figure 2-1 shows the general layout and boundaries of the site and the facility. The site covers approximately 40 acres, and the facility covers approximately 22 acres.

For purposes of this Final FS, the site is defined by contamination detected in soil, sediment, or groundwater samples exceeding the levels below. Boundaries were drawn to avoid cutting through properties as much as possible. The precise boundaries may be adjusted based on additional sampling that will occur during remedial design and compliance monitoring, after a final cleanup action is selected. The outline contains all areas with:

- Greater than 0.2 milligrams per liter (mg/L) of total petroleum hydrocarbons (TPH) (by NWTPH-Dx Method) in groundwater

- Any presence of free product
- Soil exceeding 20 milligrams per kilogram (mg/kg) for arsenic and 250 mg/kg for lead
- Soil TPH-Dx exceeding 20 mg/kg.

The site has been subdivided into several distinct Cleanup Zones (based on RI and Supplemental RI sampling) for this FS (see Section 6 for further discussion of Cleanup Zones):

1) **The Railyard Zone.** This area includes the former maintenance facility, together with two small adjacent areas, and covers approximately 22 acres. It has historically been used for industrial purposes. Surface and subsurface impacts are present.

2) **The Developed Zones.** These areas are or are likely to be developed for residences, commercial buildings, public buildings, or roads. These areas are primarily affected by contaminants in groundwater and surrounding subsurface soil. Hydrocarbon plumes consisting of a mixture of diesel and bunker C affect the NW Developed Zone and the South Developed Zone (Figure 2-1). The NE Developed Zone is affected primarily by diesel. In addition, there are some isolated elevated occurrences of lead in the surface soil north of the railyard.

   Diesel oil is a complex combination of hydrocarbons, having carbon numbers predominantly in the range of C9 to C20. The formulation and composition of diesel varies according to its intended use. There are two main types of diesel; these are Type 1 (kerosene and marine fuel) and Type 2 (automotive and locomotive fuel). Diesel fuel generally contains low concentrations of PAH compounds.

   The composition of bunker C fuels is less consistent than that of diesel fuel. Bunker C represents a fuel mixture which generally contains both diesel-range (C12 to C25) and oil-range (C25 to C36) hydrocarbons. In this document, NWTPH-Dx analyses have typically quantified the C12 to C36 hydrocarbon ranges to include both diesel and oil-range hydrocarbons. Bunker C fuels generally contain higher concentrations of PAH compounds than diesel fuels. The viscosity of bunker C is higher than that of diesel and when the two types of hydrocarbon are present together they form an emulsion.

3) **The Aquatic Resource Zones.** There are two Aquatic Resource Cleanup Zones; these are (i) The South Fork Skykomish River and

Levee, and (ii) The former channel of Maloney Creek. The South Fork Skykomish River and Levee includes the flood control levee downgradient of the NW Developed Zone, and the interface between land and the South Fork Skykomish River. This area is affected by seepages of hydrocarbon reaching the river. The second Aquatic Resource Zone is the former Maloney Creek channel. This area occupies a wetland area centered around the former Maloney Creek channel, which now functions as a local drainage during high runoff periods due to snowmelt or precipitation, and a stormwater conduit. This area has impacted surface sediment and also contaminated subsurface (smear zone) soil contiguous with Railyard Zone subsurface soil.

2.1.3 Railyard Operational History

As mentioned above, the facility was originally owned and operated by the GNR, starting in the summer of 1893. GNR owned the property from the late 1890s until 1970 when GNR merged with four other railroads and became the Burlington Northern Railroad (BNRR). The facility is currently owned and operated by BNSF that was formed with the merger of BNRR and the Atchison, Topeka and Santa Fe Railway in 1994.

The facility has gone through five overlapping operational eras. Each era is discussed below in terms of the activities conducted and the products used during the era. Figure 2-2 shows the location at the facility of the major elements discussed below.

2.1.3.1 Coal and Steam Era

Steam produced by coal heat was used to power locomotives operating out of the facility during this era. Structures reportedly present during this time period included an engine house and turntable, sandhouse, blacksmith and machine shop, coal tower and chute, depot, and water tower. The engine house originally had nine stalls for repair work but, by 1902, only six stalls were being used. Each stall had a pit where a repairperson could service the underside of a locomotive.

Repair activities reportedly performed during this era included insulation of engine parts and boilers, cleaning and rebuilding seals, cleaning and repairing boilers, testing gauges, oil and degreasing, painting, and cleaning engine parts. The turntable was used to turn the locomotives around. The sand tower dispensed sand that the locomotives used for traction on steep grades. The machine and blacksmith shops were used to manufacture parts for repairs. Petroleum-related products reportedly used during this period included grease, lubricating oil, and fortnite oil (kerosene-like petroleum product used to clean parts).

2.1.3.2 Oil and Steam Era

Bunker C oil replaced coal as the heat source in steam locomotives in about 1908. An oil-unloading shed and sump and an aboveground oil storage tank replaced the coal tower and chute. Bunker C oil was stored at the facility in below-grade wooden, concrete, and steel sumps, and aboveground steel tanks. Fortnite oil was the only cleaning fluid reported to be used during this period. The depot was moved from the south side of the tracks to its present location north of the tracks on Railroad Avenue.

2.1.3.3 Electric Era

Construction of an 8-mile-long tunnel between Skykomish and Leavenworth and of an electric substation was completed in 1929. Electric-powered locomotives replaced bunker C oil-powered locomotives through the tunnel to eliminate exhaust fumes. The facility became the transition point for bunker C oil- to electric-powered locomotives.

The engine house was used for repairs on both road and helper engines, until it was destroyed by a fire in 1943. However, evidence suggests that some elements of engine repair and maintenance continued at the facility through the mid-1950s.

2.1.3.4 Diesel Era

Diesel was used for locomotives traveling west of Skykomish as early as the mid-1940s and replaced both bunker C oil and electricity. In 1956, installation of a tunnel ventilation system permitted diesel locomotives to operate within the tunnel and electric locomotives were abandoned. The diesel was stored at the facility in aboveground and underground storage tanks until 1974 when BNRR discontinued fuel-handling activities at Skykomish.

2.1.3.5 Maintenance Era

Most engine repair and maintenance activities ceased in the mid-1950s. The electric substation building was used as a sandblasting facility for a period in the 1960s. The sandblasting facility is the probable source of the elevated concentrations of lead in the immediate vicinity of the former substation. BNRR discontinued all fueling operations at their Skykomish facility in 1974. At the same time, they also reportedly excavated and removed all known sources of petroleum product.

The demolished buildings and structures of the facility are shown on Figure 2-2. The substation was demolished in August 1992. The depot building and maintenance building are the only structures remaining at the facility. Three sets of railroad tracks and at least four spur lines surrounded by railroad ballast and gravel make up the remainder of the facility, which is currently used as a base of operations for track maintenance and snow removal crews.

2.2 Natural Environment

This section describes the natural environment of the Town of Skykomish and the site. The intention of this section is to describe the geology (soil and sediments) that exists under and around the town and site in order to understand the potential migration of contaminants.

Contaminants can potentially migrate through, and over, the ground via groundwater flow, surface water flow, stormwater runoff and infiltration, and floods. As such, to determine the movement of surface water and groundwater, one must first understand the surface topography and geology (Section 2.2.1). Then one can understand how the soil materials either facilitate or limit the movement of water both horizontally and vertically. The next aspects of the natural environment that will be described in this section are water (Section 2.2.2) and air (including wind) (Section 2.2.3).

Finally, this section will describe the plants, animals, and aquatic life that exist on and around the town and site (Sections 2.2.4 to 2.2.6). The human (or built) environment of the town and site is described in Section 2.3. This includes features such as historic and cultural resources, buildings, roads, bridges and railyard facilities. Adverse impacts to the built and natural environment, and mitigation measures, are described in Section 7 of the Draft FS/EIS and will be further described in the DSEIS and the Final EIS.

2.2.1 Earth

This section describes the geology, soils, sediment, topography, and unique physical features of the town and the site.

2.2.1.1 Geology and Soils

The Former Maintenance and Fueling Facility is located in the Skykomish Valley on the southern bank of the South Fork Skykomish River in Washington State. The Skykomish Valley is a classic, glacially scoured valley with steep sidewalls and a relatively flat bottom. The South Fork Skykomish River, flowing from east to west adjacent to the site, now occupies the northern side of the valley at the railyard. Over time, the river has meandered from the north side of the valley to the south side of the valley, as evident in the riverine deposits that dominate the geology on the valley floor. These deposits include sand, gravel, cobbles and boulders.

The South Fork Skykomish River receives its water from small tributaries upstream and spring snowmelt. Further downstream from the site, the Skykomish and Snoqualmie Rivers merge and form the Snohomish River, which flows into Puget Sound at Everett, Washington.

The Town of Skykomish is primarily underlain by highly heterogeneous glaciofluvial sediments. These glaciofluvial sediments consist mainly of sand

and gravel, and underlie a generally thin layer of topsoil and/or fill. Figure 2-3 presents a typical cross section through the site that illustrates the variability of the soils underlying the site.

Silty sand and/or fill generally up to 2 feet thick is present throughout residential and commercial areas within the site. The silty sand is loose to medium dense, and is gravelly in places and contains trace amounts to abundant organic material ranging from leaf matter and twigs to logs. The fill is a sandy silt containing brick fragments, broken glass, nails, and is in some areas underlain by a distinct orange burn horizon.

Native soils generally underlie the topsoil although in places the topsoil is underlain by fill that was used to level the land surface or fill in marshy areas. The fill contains brick fragments, broken glass, nails, and is in some areas underlain by a distinct orange burn horizon that was produced when the land was being deforested for development. This burn horizon is present up to 5 feet below the ground surface, indicating that the top 5 feet of the ground in some areas consists of fill. The native soils consist primarily of sand and gravel, with shallow discontinuous lenses of silt and clay. The ratio of sand to gravel varies greatly with depth and laterally throughout the site, and the grain size of the sand and gravel is also highly variable. The sand is generally medium- to coarse-grained and the gravel is fine to coarse. There are frequent cobbles up to one foot in diameter and occasional boulders up to 3 feet across.

The cross section in this FS (Figure 2-3) and the cross-sections presented in the Supplemental RI (RETEC, 2002) differ slightly from the cross-sections provided in the RI (RETEC, 1996) and reflect new information developed about the site since 1996. The geologic interpretations have been based primarily on the geologic logs collected for the Supplemental RI, because the boreholes were advanced using RotoSonic drilling for the Supplemental RI compared to Air Rotary for the RI. The RotoSonic drilling method provided more complete, continuous soil samples than the samples provided for the RI, and therefore the logs and cross-sections prepared during the Supplemental RI and this FS are more complete than those prepared for the original RI. A layer of dense silt is generally present within the sand and gravel throughout the entire site. This is at least 4 feet thick and in places is greater than 10 feet in thickness. The top of the silt shows subsurface relief that probably results from irregular erosion by the South Fork Skykomish River; however, in general, the upper surface of the silt gently rises from an approximate elevation of 905 feet at the western part of the site to 925 feet at the eastern end. The silt is present at depths between 10 and 27 feet below the ground surface.

Previous site investigations have not reached bedrock; however, the base of the soils is estimated at an approximate depth of 200 to 250 feet according to local area well logs (GeoEngineers, 1993). Additional information on soil is provided in Section 3.2.1, which summarizes soil quality data collected as part of the site RI and Supplemental RI (RETEC, 1996 and RETEC, 2002a).

2.2.1.2 Sediment

The site includes two separate areas where sediment may be subject to cleanup activities. These are the former Maloney Creek channel and the south bank of the South Fork Skykomish River west of the 5th Street Bridge. These two areas have substantially different characteristics. The former Maloney Creek channel is discussed in more detail in the next section (Former Maloney Creek Channel/Wetlands). The South Fork Skykomish River is discussed below.

The South Fork of the Skykomish River is a high-energy river (gradient is approximately 27 feet per mile) carrying a relatively low load of suspended sediment. In general, depositional environments are few and ephemeral in the South Fork, and the riverbed is dominated by heavier glaciofluvial materials (sands, gravels, and cobbles), which are less subject to scour than the finer sand and silt typically considered "sediment." Sand occupies many of the interstices of the larger substrate materials in the channel.

In Skykomish, the river makes a significant bend at the Fifth Street Bridge (Fig. 2-2). Along the River's southern shoreline, adjacent to the levee and the locations of hydrocarbon seeps (Figure 2-4), finer sediment may be deposited as a result of lower river velocities, particularly during low seasonal flows. The sediment deposited in this area is typically eroded on at least a seasonal basis during higher flows and, as a result, these deposits are considered ephemeral in nature. In addition, large riprap and cobble substrates associated with the levee form a near-vertical shoreline edge along the south riverbank, approximately 1 to 2 feet in height, relative to the riverbed elevation, also indicating a non-deposited environment where hydrocarbon seeps have historically been observed.

The larger riprap and boulders emplaced during levee construction along this shoreline may reduce flow velocities near the bank by creating eddies where water flows around these larger substrates. At times, sediment accumulates in these areas. However, the sediment seldom appears to exceed a few inches in depth, except in the interstices between cobbles. This sediment grades into bank soils accumulated between cobbles in the riparian zone. The total width of this area is approximately 10 feet and represents the extent of the sediment resource in the South Fork Skykomish River.

A sediment impact zone was identified as part of the Supplemental RI (Figure 2-4). The Supplemental RI and subsequent sediment work detailed in the *Results of Supplemental Sediment Sampling – Toxicity Evaluation and Sediment Cleanup Levels* (RETEC, 2003a) identified an area of sediment concern covering approximately 440 feet along the bank, for a total area of approximately 8,117 square feet (see Appendix A). The actual extent of sediment accumulation areas affected by bank seepage is generally limited to transient accumulations in a strip less than 10 feet (generally 1 to 3 feet) wide inside the study area, for a total of 440 to 1,320 square feet.

The sediment accumulation is dominated by sand with lesser amounts of silt. The organic carbon content in the sediment appears to vary seasonally. Samples collected higher on the bank for the Supplemental RI during summer of 2001 had an average total organic carbon (TOC) of 1.1 percent. Samples collected lower on the bank during fall of 2002 had an average TOC content generally lower than 0.3 percent. The higher TOC samples are submerged only during high flows.

Further information on sediment quality in the South Fork Skykomish River is presented in Section 3.

2.2.1.3 Former Maloney Creek Channel

The former Maloney Creek channel is present along the southern boundary of the railyard to the east of 5th Street. A Wetland Detailed Study of the former channel appears in Appendix B. This former Creek channel has been impacted by former site conditions, and may be potentially affected by the cleanup actions. The eastern boundary of this area is from the culvert under Old Cascade Highway where the drainage ditch crosses to the north side of the road adjacent to the site. Stormwater drains into ditches adjacent to the road and flows through the culvert under Old Cascade Highway to the north side of the road adjacent to the site. Flow is intermittent through these ditches, and the ditches are dry for much of the year. At the western boundary, the former Maloney Creek channel passes through a culvert under the intersection of 5th Street and Old Cascade Highway to a point downstream of the Fire Station, where the flow emerges before reaching the current channel of Maloney Creek (Figure 2-5).

The preliminary delineation that was previously used is larger than that shown in Figure 2-5. As such, the estimates of volume and cost in the Former Maloney Creek Aquatic Zone are conservative.

Maloney Creek occupied the former Maloney Creek channel prior to being rerouted to its current location in approximately 1912 (USFS, 1991). Wetlands or other low-lying areas may have existed in the riparian corridor along the borders of the former creek prior to being rerouted, but the former channel and associated wetlands are now classified as a depressional outflow wetland. The former Maloney Creek channel now receives runoff from roads and residential yards via a culvert from the ditches on the south side of the Old Cascade Highway (Figure 2-5). The Wetland Detailed Study contained in Appendix B provides additional description of the wetland.

In the area between the culverts the channel widens and forms a wetland covering approximately 0.95 acres. The area is wooded, with a healthy population of alder, cottonwoods, and other native and non-native water tolerant shrubs. The BNSF facility bounds the area to the north, and residential properties and Old Cascade Highway bounds it to the south. The complete Wetland Detailed Study contained in Appendix B provides the delineation, characterization, and functional analysis of this wetland. Water content is intermittent, fed primarily by runoff from the drainage ditches and the railyard, but probably also by groundwater recharge during times of high water tables. During times of water flow salmonid fish have been observed in the wetland as well as in the drainage ditches upstream of the wetland (Ecology 2002b).

Figure 2-5 shows the former Maloney Creek channel, with a longitudinal cross section illustrating its hydrogeologic relationship with the surrounding soil. The channel substrate consists of silt and sandy silt of varying depth, but generally extending a few feet, overlying the typical glaciofluvial deposits of the area. Groundwater levels generally are deeper than the bed of the channel by 1 foot or more.

Contaminated soils are present in the subsurface along portions of the channel, and may reach the surface locally near location 02SED-5. The biologically active top foot of the wetland is dominated by historical and current surface runoff via the stormwater collection systems described in Section 2.2.3, and probably some localized intermittent upwelling in the neighborhood of 02SED-5.

The sediment quality in the former Maloney Creek channel sediment will be discussed further in Section 3.4.2. Contamination present in the glaciofluvial deposits in the deeper subsurface is contiguous and congruent with the subsurface contamination in the railyard soil, and will be addressed separately from the surface wetland. The quality of the deeper zone is also discussed in Section 3.2.1.

2.2.1.4 Topography

The topography of the town and the surrounding area south of the river is shown on Figure 2-6. The east end of the town is generally the highest part of town, nearing 950 feet above sea level. The west end of town descends to 920 feet above sea level. The lowest portions of the town include the former Maloney Creek channel, Maloney Creek, and the South Fork Skykomish River. The land south of the former channel of Maloney Creek is relatively flat-lying within 500 feet of the Site. This area is also relatively low-lying (approximately 920 ft-msl). As seen on Figure 2-6, the railroad tracks are built up higher than the rest of the town. North of the railroad tracks, the topography is relatively flat, but gently slopes down from east to west towards the South Fork Skykomish River.

2.2.1.5 Unique Physical Features

Human activity has strongly modified three distinct areas in the town. These include residential and business areas, flood berms, and the railyard. The residential and business areas contain single-family homes, and commercial and public buildings. Areas that are not covered by buildings or roadways generally consist of grass lawns.

Fifteen-foot high levees (berms) have been installed near the South Fork Skykomish River for flood protection. These berms are composed of fill material made up of sand and gravel. Boulders armor the surface of the north side of the berms, but the percentage of boulders within the berm is unknown. The locations of the berms are shown on Figure 2-1.

The third distinct area is the railyard. Gravel up to 1 inch in diameter surfaces the railyard on the majority of BNSF property (Figure 2-1).

The former Maloney Creek channel, along the southern boundary of the railroad yard, conveys stormwater draining from the railyard and street as well as runoff from residential yards south of the Old Cascade Highway. It includes a wetland that is described in detail in subsequent sections and Appendix B (see Figure 2-1). This area has a layer of silt or silty sand overlaying glaciofluvial area sediments.

2.2.2 Water

This section describes the occurrence and flow of groundwater and surface water throughout the Site. This section also introduces references to water quality; greater detail is provided in the analysis of nature and extent of contamination in Section 3. The water described in this section includes surface water, runoff and infiltration, floods, groundwater, and water supply wells.

2.2.2.1 Surface Water Movement, Quantity, and Quality

Surface waters in and nearby the town include the South Fork Skykomish River, the wetland in the former Maloney Creek channel, and Maloney Creek (Figure 2-1). These three surface water features are described below.

Additional information is provided in Section 3.5, which summarizes surface water quality data collected as part of the remedial investigations at the site.

South Fork Skykomish River

The South Fork Skykomish River is a fast flowing river with fluctuating flow and water levels throughout the year. It receives its water from small, upstream tributaries and spring snowmelt. The South Fork Skykomish River contains flowing water all year.

Water levels are lowest in the late summer (July, August, September, October). Table 2-1 summarizes mean river flow in cubic feet per second (cfs) and river height. River flow is gauged at the Gold Bar gauging station, located approximately 20 miles downstream of the town. River height is gauged at a USACE electronic water level gauge on the 5^{th} Street Bridge over the South Fork Skykomish River. Gold Bar data can be accessed in real time while 5^{th} Street Bridge data is available on a time-delay basis. There is a correlation between the Gold Bar flow data and river depth at the 5^{th} Street Bridge. Therefore, Gold Bar flow data can used to calculate water depths at the Skykomish Bridge in real-time (RETEC, 2002b). Tributaries flowing into the river between Skykomish and Gold Bar cause the flow at Gold Bar to be greater than the flow at Skykomish. A heavy storm event can cause the water level to rise several feet overnight as the water flow increases.

Low-velocity areas are present in the river margin along the base of the levee throughout much of the southern shoreline. Particularly downstream of the bridge, large riprap and cobble substrates form a vertical shoreline edge along the south riverbank which is approximately 1 to 2 feet in height, relative to the riverbed elevation. The larger riprap and boulders present along this shoreline reduce flow velocities near the bank by creating eddies where water flows around these larger substrates. Low-flow areas are also present within the interstices of the larger boulders and riprap. The base of this shoreline edge is at approximately 4.5 to 5 feet gauge height. During flows above this height, water adjacent to the shoreline edge is approximately 1 to 2 feet deep. Below this height, the river recedes from the base in most areas.

Substrates within the South Fork Skykomish River are dominated by cobbles, and vary in size from large boulders and large cobbles, to smaller gravels and sands. Larger boulder substrates are more frequent along the northern portions of the channel, with smaller cobbles, gravels, and sands occurring along the southern shore. Larger cobbles, boulders, and riprap associated with the base of the flood control levee in the NW Developed Zone are also present along the southern shoreline. Gravels and sands occupy many of the interstices of larger substrates within the river channel.

The Former Maloney Creek Channel

Maloney Creek is thought to have originally flowed in a northerly direction across what is now the railyard and directly into the South Fork Skykomish River, without a significant change in flow direction. In about 1912, Maloney Creek was diverted to a new channel (USFS, 1991). A Sanborn Map, dated 1926 (Appendix C), shows Maloney Creek flowing along the same approximate course as the currently defined Former Maloney Creek Channel. In addition there is an area defined as a “shallow gulch” underlying the present site of the Skykomish library on the west side of 5^{th} Street. The Sanborn Map suggests that the gulch was not connected with the creek channel and that the gulch was a closed basin. Subsequent infill has eliminated part of the southern portion of the channel and the Maloney creek channel has since been re-diverted to its current course; but the greater part of the Former Maloney Creek channel remains a wetland with intermittent water flow primarily from stormwater runoff from surrounding areas. This is the former Maloney Creek wetland (Figure 2-5).

The topography of the land adjacent to the former Maloney Creek channel indicates that historically, discharges and runoff from the southern portion of the railyard as well as from the residential areas to the south probably flowed through the former Maloney Creek channel. Although no hydrologic studies are available for confirmation, it is likely that most of the intermittent flow during low water table conditions in the channel, and a significant portion of the water flowing through the channel during high water table conditions, is derived from surface runoff and drainage (see Appendix B). Sediment cores and samples were collected and analyzed as part of the Supplemental RI (RETEC, 2002a).

The former Maloney Creek channel can be described as three distinct segments, as described below:

- **The Upstream Segment.** This segment is south of the Old Cascade Highway. It is approximately 4 to 5 feet wide and is confined within a series of drainage ditches. Culverts convey flow beneath numerous roads and driveways along the south side of the highway. The substrate in this area is dominated by gravels and sands, with occasional small cobbles present.

- **Middle Section.** This segment is south of the railyard and north of the Old Cascade Highway and includes the wetlands described in Appendix B. Second-growth deciduous trees dominate this segment. The wetland, with its associated channel, is approximately 60 to 80 feet wide. The channel within the wetland is undefined throughout most of its length, with surface layers dominated by sands and silts overlain with varying amounts of organic debris. Small patches of gravel are also present in places. At lower flows, ponding occurs throughout this area.

- **The Downstream Segment.** This segment is downstream of the Old Cascade Highway culvert south of the firehouse. This segment is dominated by small cobbles and gravels, with areas of sand deposition. The channel is approximately 3 to 5 feet wide. The entrance to the culvert beneath the firehouse is approximately 400 feet upstream of the confluence, and the culvert itself is approximately 220 feet long.

The plant and animal species that live in these three areas will be discussed in Sections 2.2.4 and 2.2.5. The geology of this area is discussed in Section 2.2.2.4.

Maloney Creek (Current Channel)

Maloney Creek receives runoff from its drainage (catchment area), which includes the former Maloney Creek channel. Its catchment area is estimated to be approximately 1,914 acres and is shown on Figure 2-7. Maloney Creek drains into the South Fork of the Skykomish River to the west of the city. Maloney Creek contains flowing water all year; however, no gauging data is available. It demonstrates a pattern similar to that of the South Fork Skykomish River. Maloney Creek is also considered shoreline under the Shoreline Management Act of 1971 (Chapter 90.58 RCW).

2.2.2.2 Stormwater Runoff and Infiltration

There are three catchments that capture and pipe stormwater in the Town of Skykomish: the town catchment, the former Maloney Creek catchment, and the railyard catchment. The town catchment captures stormwater runoff north of the railroad tracks; the former Maloney Creek catchment, south of the railroad tracks; and the railyard catchment, from the south side of the railroad tracks. These three catchments are described below and illustrated on Figure 2-8.

Surface water infiltrates in unpaved areas on the north side of the railroad tracks.

Town Catchment

North of the railroad tracks, stormwater accumulates in one of four collection basins that flows by way of one of three culverts through the berms to the west of the South Fork Skykomish River Bridge and directly into the South Fork Skykomish River. The locations of these features are shown on Figure 2-8. In unpaved areas on the north side of the railroad tracks, stormwater does not accumulate in these collection basins but infiltrates through surface soil.

There is no municipal storm water treatment system in Skykomish.

Former Maloney Creek Catchment

The catchment area for the former Maloney Creek channel is approximately 42 acres, as shown on Figure 2-7. It is bounded by 5th Street to the west, the railroad tracks to the north, and extends no further than the residential areas to the east and south.

Stormwater runoff passes along ditches and through culverts in the former Maloney Creek catchment area. Figure 2-8 illustrates the locations of the culverts. Twenty-four-inch culverts generally pass in the east/west direction under streets and driveways along the Old Cascade Highway. The easternmost culvert passes under 4th Street and passes under each street and driveway to the west until it passes under the Old Cascade Highway in the northwest direction, connecting the flow to the former Maloney Creek channel. Water then flows through the channel to the west, receiving runoff from the railyard (discussed below).

Flow from the former Maloney Creek channel then passes through a 36-inch culvert under the fire station to the southwest. After the culvert, the stream runs approximately 400 feet until it joins the current Maloney Creek channel, leading to the South Fork of the Skykomish River.

Railyard Catchment

The former Maloney Creek channel receives runoff from the railyard. Stormwater on the southern side of the railyard flows to the west along the tracks to a depression just east of 5th Street. This depression or catch basin (cb) may be seen on Figure 2-8. At this depression, one culvert passes from this depression to the south where it discharges into the former Maloney Creek channel. Another culvert historically transferred stormwater from this depression to the north under the tracks, but has since been blocked by a telephone pole, which stops flow through this culvert.

2.2.2.3 Floods

The 100-year and 500-year flood map is provided as Figure 2-9. This map was prepared using 2003 FEMA data. A flood protection levee is located along the southern side of the South Fork Skykomish River to the west of the Skykomish River Bridge (Figure 2-1).

The 100-year flood is anticipated to flood all of the areas to the west of 5th Street and north of the railroad tracks, with the exception of the railroad tracks; the railroad tracks are elevated above the rest of the town, preventing much flooding in a 100-year flood on and to the south of the railroad tracks. The area north of East River Road and portions of the block between Railroad Avenue and East River Road will likely also be inundated in a 100-year flood. However, flooding would follow the Maloney Creek drainage corridor and flood the areas south of the creek.

A 500-year flood would cover the entire town north of the railroad tracks, but the entire portion south of Old Cascade Highway would be safe from flooding.

2.2.2.4 Groundwater Movement, Quantity, and Quality

To understand and predict the movement of groundwater, one must understand the types of soil that exist at a site because groundwater exists in the ground in spaces between soil particles. Water moves easiest through soil with larger grain sizes because these soils cause larger spaces between them. Water has a more-difficult time moving through soils with smaller grain sizes.

Soils with larger grain sizes at the site are gravel and sand; whereas, soils with smaller grain sizes include clayey silt. As such, the movement of groundwater based on the geology of the site will be analyzed in this section.

Regionally, the site is located within the Skykomish Valley, a relatively steep-sided, rock-walled valley that has been partially filled with glaciofluvial sediments. These glaciofluvial sediments consist mainly of sand and gravel. The direction of regional groundwater flow along the Skykomish Valley is westerly, in a downslope direction coincident with the slope of the floor of the valley.

Shallow groundwater is present in the sand and gravel aquifer underlying the site. The aquifer materials vary greatly in the size and proportion of the sand and gravel; however, in general, little silt or clay is dispersed throughout. The concentration of total organic carbon in the sand and gravel generally ranges between approximately 0.1 and 0.5 percent. Where limited silts and clays are present within the upper sand and gravel, they typically occur as thin discontinuous lenses that will not affect the overall horizontal groundwater flow rate or direction throughout the aquifer; however, they may retard vertical groundwater flow, as described below. The lower silt that underlies the shallow sand and gravel is thicker than the abovementioned silts and clays and will retard vertical groundwater flow.

Depth to Groundwater

The depth to groundwater ranges approximately from 3 to 17 feet below ground surface throughout most of the site. In low-lying areas immediately adjacent to the South Fork Skykomish River, drainage ditches, and the former channel of Maloney Creek the groundwater may intersect the ground surface and therefore the depth to groundwater in those limited areas may be zero feet below the ground surface. The groundwater is generally shallowest close to the South Fork Skykomish River and increases in depth to the south. The shallow groundwater is hydraulically connected with surface water in the South Fork Skykomish River and former Maloney Creek channel. The South Fork Skykomish River bank is composed of sand and gravel, and is similar to the sand and gravel underlying the site, except that the bank is armored in places with coarse riprap. Groundwater flow through the bank is unlikely to be reduced or enhanced by the riprap.

The groundwater levels throughout the site are influenced by the river level, precipitation, temperature, and local drainage. These factors cause the groundwater levels to vary seasonally. Figure 2-10 shows hydrographs with monthly groundwater levels during 2002 and 2003 in 1A-W-3 and 2A-W-1. These hydrographs show that the measured groundwater levels have varied by 4 to 7 feet since January 2002. They were high during winter and spring and low during summer and fall. Precipitation patterns affect the exact duration and periods of the high and low water levels, as well as the magnitude of the groundwater level changes.

Groundwater elevations are the highest at the southeast corner of the Former Maintenance and Fueling Facility and decrease to the northwest towards the South Fork Skykomish River. Groundwater elevations are generally higher during late fall, winter, and spring (November to April) and lower in the summer and early fall (June to early November) (RETEC, 2001).

A 600-foot long subsurface barrier wall was installed in 2001 to intercept the migration of free product towards the river. This barrier wall was designed so that the groundwater levels would not increase by more than 5 inches behind the wall. Monthly fluid levels have been collected from selected wells behind the wall; these levels indicate that groundwater does not appear to be mounding behind the wall, and that groundwater passes under the wall without hindrance.

The former Maloney Creek channel is an intermittent wetland fed primarily by runoff but also occasionally by groundwater influx. The water table is located well below the bed of the channel during seasonal low groundwater levels. During measured seasonal high water levels the groundwater rises to a foot or less below the channel, and it is likely that at times groundwater surfaces in the former creek bed and feeds the channel. The former Maloney Creek channel is discussed further in the surface water section (above) and in Section 2.2.4.

Hydraulic Conductivity

Hydraulic conductivity values, a measure of permeability of the sand and gravel, have been calculated using laboratory and field tests; these tests have provided hydraulic conductivities between 41 and 84 feet per day for the shallow sand and gravel (RETEC, 1996). These values are representative of sand and gravels (Todd, 1980).

A clayey silt bed, which is 4 to more than 10 feet thick, underlies the entire site. The top of this silt is present at depths between 10 and 27 feet below the ground surface. The hydraulic conductivity of this unit has not been tested. However, the hydraulic conductivity of a similar clayey silt was measured to be 0.4 feet per day in the RI (RETEC, 1996); this is a representative value for silt (Todd, 1980). Because of the significantly lower hydraulic conductivity, this silt bed impedes vertical groundwater flow within the sand and gravel aquifer and acts as an aquitard.

Groundwater Flow Direction and Gradient

The groundwater flow in the shallow, unconfined sand and gravel aquifer varies throughout the site; however, most groundwater flow throughout the site is horizontal. There is no evidence that preferential channels are present within the site that may affect groundwater flow direction, although silt and clay lenses within the gravelly sand unit can potentially change groundwater flow direction due to the difference in hydraulic conductivity between the silt and the sand and gravel. Groundwater usually has some vertical component to flow; however, the vertical flow is restricted by the silt aquitard.

Groundwater levels measured during several gauging events indicate that the overall flow directions within the site are relatively consistent with time. Figure 2-11 presents a groundwater surface elevation map that was prepared using groundwater levels collected during January and February 2002. East of 4th Street, the groundwater generally flows from south to north, towards the South Fork Skykomish River with an average gradient of 0.14 feet per foot (that is 0.14 vertical feet per one horizontal foot). To the west of 4th Street, the groundwater flows from the southeast to the northwest with an average gradient of 0.01 feet per foot (RETEC, 2002a). The hydraulic gradient indicates that groundwater flows at an average rate of 2.5 feet per day (ft/day) (RETEC, 2002a). Groundwater contour maps and additional details on groundwater flow are contained in the Supplemental RI (RETEC, 2002a).

Vertical gradients within the site have been measured using several pairs of wells co-located, but screened at different depths (RETEC, 1996). The measurements show that the gradients are low and do not indicate a strong vertical flow component. The downward vertical gradients are greatest during periods of high groundwater (heavy rainfall) and the lowest gradients have occurred during periods of low rainfall, when groundwater levels are low. This downward gradient is due to rainfall infiltration recharging the groundwater and the effect of the aquitard impeding flow from the overlying sand and gravel to the underlying sand and gravel.

Groundwater Quality

Additional information is provided in Section 3.2.3, which summarizes groundwater quality data collected as part of the Supplemental RI (RETEC, 2002a).

2.2.2.5 Water Supply

No water supply wells are located in the Town of Skykomish. The people of Skykomish are served by two public water supply wells that are located about 1,100 feet east (upgradient) of Skykomish. The primary well is completed to a depth of 216 feet below ground surface (bgs) and is screened across three intervals between 181 and 216 feet bgs. A backup well is located adjacent to the primary well and is completed to a depth of 219 feet bgs. In 1993, the water system pumped an average of 70,000 gallons per day and 2,100,000 gallons per month. Storage capacity was provided by one water tank with a capacity of 220,000 gallons. Water from the public water system has been sampled and no contaminants related to the site have been detected.

2.2.3 Air

2.2.3.1 Climate

The climate of the project region is predominately maritime with cool and relatively dry summers and mild, wet, and cloudy winters. Total annual precipitation is approximately 110 inches per year with an annual average snowfall of 55 inches. Mean average temperature in Skykomish is 49.3 °F. Daily mean high and low temperatures for January are 49.3 °F and 35.8 °F, respectively. Daily mean high and low temperatures for August are 79.6 °F and 68.7 °F, respectively (National Climatic Data Center, Washington State Narrative Summary, 2003).

The influence of semi-permanent high- and low-pressure areas over the North Pacific Ocean dominates winds in the area. Air circulates in a clockwise direction around the semi-permanent high-pressure cell and in a counter-clockwise direction around the semi-permanent low-pressure cell. During the summer, the low-pressure cell becomes weak and moves north of the Aleutian Islands and the high-pressure cell brings a prevailing westerly and northwesterly flow of comparatively dry, cool, and stable air into the Pacific Northwest. Winds in the area are predominately southwesterly to westerly during most of the year. Northeasterly to easterly winds dominate from November to February. Annual average wind speeds are 5.6 knots with peaks of up to 32 knots in the winter months.

2.2.3.2 Air Quality

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards set at levels protective of human health. Based on an ambient monitoring data collected from a network of monitoring stations throughout the region, areas are designated as being in "attainment" or "nonattainment" for particular pollutants.

Skykomish is currently in attainment of ambient air quality standards for all criteria pollutants. This status indicates that the region meets the National Ambient Air Quality Standards (NAAQS) for all pollutants. However, the site is located on the boundary of an area that was designated as nonattainment for ozone until 1996. This area, which incorporates all but the extreme northwest portion of King County, is currently subject to a maintenance plan for ozone approved by the United States Environmental Protection Agency (EPA). The maintenance plan for ozone addresses fuel specifications for mobile sources, inspection and maintenance programs for automobiles, and industry-specific rules. The only significant sources of ozone precursors in the Skykomish area are automobile and train traffic. This project will not be directly affected by the current ozone maintenance plan.

The Puget Sound Clean Air Agency (PSCAA) is currently in the process of updating the maintenance plan for the region.

No stationary industrial sources of air pollution have been identified in the proximity of the site. Automobiles travel in the town and on the busier Northeast Stevens Pass Highway (U.S. 2) at the north end of town. Approximately 24 trains pass through Skykomish on a daily basis (Yates, 2003a) and are responsible for diesel exhaust emissions, but they do not routinely stop and idle in town.

Additional information is contained in Section 3.2.6, which summarizes air quality data collected as part of the RI, Supplemental RI and other investigations.

2.2.3.3 Odor

No industrial odor sources are present in Skykomish. Emissions resulting from diesel exhaust from daily trains passing through Skykomish may be a source of odors. Seepages of hydrocarbons have been noted at a number of locations along the South Fork Skykomish Riverbank. These seepages are the source of hydrocarbon odors along the levee, particularly during low flow conditions and calm winds.

2.2.4 Plants

This section describes the plant life in the Town of Skykomish and at the site. It includes information on the habitats of plants, special plant status, and noxious weeds. Additional information on terrestrial species is provided in the *Revised Terrestrial Ecological Evaluation* submitted to Ecology on March 26, 2004 (Revised TEE). The Revised TEE is Appendix D to this Final FS.

2.2.4.1 Plant Habitat Diversity

The site is located in the western hemlock (*Tsuga heterophylla*) vegetation zone, the most widespread vegetation zone in western Washington (Franklin and Dyrness, 1973). The mild climate of this zone supports growth of productive coniferous forests dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock, and western red cedar (*Thuja plicata*). Common understory plants include swordfern (*Polystichum munitum*), salal (*Gaultheria shallon*), red osier dogwood (*cornus sericea*), vine maple (*Acer circinlum*) and huckleberry (*Vaccinium spp.*).

The majority of the site is within the developed portions of the Town of Skykomish, consisting of BNSF railyards, and residential and commercial properties. Two small parcels of undeveloped, forested land are adjacent to the site, north of Maloney Creek and at the Maloney Creek outlet. Figure 2-12 shows the habitat types present in the site vicinity. The botanical resources of each of the mapped habitat areas at the site are described below.

Railyard

The railroad yard is an open habitat mostly covered in gravel and sparsely vegetated with grasses and weedy forbs. The area is subjected to high levels of soil and vegetation disturbance, including heavy railroad traffic. It provides low quality habitat for plants.

Residential and Commercial

Habitat in these areas includes buildings, paved roads and sidewalks, paved and graveled driveways, turf grass lawns, home gardens, and a variety of trees and shrubs. Small shrub thickets and young to mature second-growth trees are scattered throughout the area. Weedy non-native species are present along disturbed roadsides.

South Fork Skykomish River Flood Control Levee and Shoreline

The south bank of the South Fork of the Skykomish River, which borders the Town of Skykomish, is developed and disturbed to the water's edge along most of its length. Young- and mid-successional-aged deciduous trees and scattered patches of shrubs are present along portions of the shoreline. Riparian habitat is poorly developed along the shoreline.

The riprap flood control levee occupies less than 1 acre along the south side of the river (Figure 2-1). Adequate soil is present to support understory vegetation and low density of trees and shrubs along the top and sides of the levee. The northern side of the levee, extending to the ordinary high water line of the river, is dominated by young big-leaf maple (*Acer macrophyllum*) and red alder averaging about 5 inches diameter at breast height (dbh).

Swordfern, Himalayan blackberry (*Rubus discolor*), and giant knotweed (*Polygonum sachalinense*) are present in the understory. The top and southern side of the levee are dominated by grasses and shrubs with a few scattered small trees. Grand fir (*Abies grandis*), black hawthorn (*Crataegus douglasii*), tall Oregon grape (*Mahonia aquifolia*), and snowberry (*Symphoricarpos albus*) are present. Orchardgrass (*Dactylis glomerata*), English plantain (*Plantago lanceolata*), common tansy (*Tanacetum vulgare*), and mullein (*Verbascum thapsis*) are among the common non-native species present at the levee.

Upstream and downstream of the levee, the bank of the South Fork Skykomish River is occupied by residences with associated lawns and outbuildings. A few scattered trees and shrubs are present along the riverbank.

Former Maloney Creek Channel

The former Maloney Creek channel is dominated by early to mid-seral deciduous trees and shrubs, with the exception of the culvert inlet site, which is dominated by herbaceous species (see Appendix B). Black cottonwood, red alder and big-leaf maple are the dominant tree species. Red-osier dogwood (*Cornus sericea*) and salmonberry are the dominant shrub species. Native herbaceous species present in the wetland include large-leaf avens (*Geum macrophyllum*), small-fruited bulrush (*Scirpus microcarpus*), piggy-back plant, and common horsetail (*Equisetum arvense*). Non-native species observed at the site include giant knotweed, Himalayan blackberry, and Scot's broom (*Cytisus scoparius*).

The boundaries of the wetland area of the former Maloney Creek Channel are generally discernable, as it is bounded by the railyard area to the north and the Old Cascade Highway and residential development to the south, which have distinct slope breaks. The formal delineation and functional assessment is contained in Appendix B.

The following describes the plant species in the three segments of the former Maloney Creek channel introduced in Section 2.2.2.

- **Upstream Segment**. At the upstream end, the former Maloney Creek channel is confined to a narrow ditch vegetated with grasses, swordfern, salmonberry, and weedy forbs (Figures 2-13 and 2-14). Overstory trees are scattered along the south side of the ditch and include red alder, big-leaf maple, and a few young western red cedar (Figure 2-15). This reach functions as a roadside stormwater drainage ditch.

- **Middle Segment**. The middle section of the historic channel passes through a wetland (see Section 2.2.2, Surface Water Movement, Quantity and Quality). The wetland habitat is dominated by second-growth deciduous trees including red alder, big-leaf maple, and black cottonwood. The understory is dense in places and consists primarily of salmonberry, willow, and weedy species such as giant knotweed and Himalayan blackberry.

- **Downstream Segment**. At the downstream end, the channel is well-defined for a distance of about 400 feet, between the Old Cascade Highway culvert and the confluence with Maloney Creek. Vegetation along the lower section of the historic creek channel is disturbed second growth forest of big-leaf maple and red alder. The sparse understory is composed of salmonberry, vine maple, and sword fern. Residential yards and storage areas impinge in this area.

2.2.4.2 Special Status Plant Species and Habitats

All of the habitats at the site have been disturbed by human activity, such as industrial, residential or commercial development and timber harvest. Native, forested habitat is limited to a small second growth area along the former

Maloney Creek channel. This area is disturbed, with a high number of non-native understory species. The site habitats provide low potential for rare plant species, based on the level of current and historical disturbance. No populations of rare, threatened or endangered plant species are known or expected to occur on the former channel of Maloney Creek and none have been observed or reported.

The following lists the results of research on the special status plant species and habitats for the site:

- A search of the Washington State Department of Natural Resources Natural Heritage Program Database was requested for the site and surrounding areas. No data records for rare plants or high quality ecosystems are present in the database (WDNR, 2002).

- The Washington Department of Fish and Wildlife (WDFW) Priority Species and Habitats database was queried for the presence of priority habitats in the vicinity of the site. Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species. No priority habitats were noted in the database (WDFW, 2003a). Riparian areas along the South Fork of the Skykomish River and Maloney Creek would qualify as priority habitats under the state guidelines. Wetland habitats, such as the wetland within the former Maloney Creek Channel, would also be classified as a state priority habitat.

- The United States Fish and Wildlife Service (USFWS) noted that white-top aster (*Aster curtus*), a federal plant species of concern, has been reported from King County (USFWS, 2003). This species is restricted to grassland habitats in the Puget lowlands; suitable habitat for the species does not occur in the Skykomish area.

- The Town of Skykomish Critical Area Ordinance (CAO) lists the South Fork Skykomish River and Maloney Creek shorelines as Primary Fish and Wildlife Habitats. For purposes of this evaluation, the former Maloney Creek channel and associated wetland are ranked as secondary fish and wildlife habitats, based on the lack of documented presence of species listed by the federal government or state of Washington as endangered, threatened, or sensitive (see Section 2.2.6, Fish and Aquatic Resources).

2.2.4.3 Noxious Weeds

Weed control activities on private and state lands in the Skykomish area are managed through the King County Noxious Weed Control Board.

Management goals for noxious weeds vary based on weed class: eradication of Class A weeds is required by state law; Class B designated weeds must be prevented from producing seed; and Class B non-designates and Class C weeds may be designated for control at the option of the local weed control board. On National Forest System lands near Skykomish, the United States Forest Service (USFS) administers weed management programs.

No Washington State Class A weeds are known or suspected to occur in the site vicinity. Six species of Class B designate weeds are known to occur in and near the Town of Skykomish (King County 2003a and 2003b):

- Orange hawkweed (*Hieracium aurantiacum*)
- Diffuse knapweed (*Centaurea diffusa*)
- Spotted knapweed (*Centaurea biebersteinii*)
- Dalmatian toadflax (*Linaria dalmatica ssp. dalmatica*)
- Sulfur cinquefoil (*Potentilla recta*)
- Policeman's helmet (*Impatiens glandulifera*).

One species of Class C weed, yellow toadflax (*Linaria vulgaris*), has been recorded in the area.

Orange hawkweed is common along roadsides throughout the Town of Skykomish and in the railyard area. Policeman's helmet is found in moist areas in the southwest side of town between Helen and Thelma Streets. BNSF currently implements management activities for orange hawkweed, diffuse knapweed, spotted knapweed, dalmatian toadflax, yellow toadflax, and sulfur cinquefoil along the rail line in the vicinity of Skykomish.

The USFS weed management program targets three weed species in the Town of Skykomish (USFS, 1999). Japanese knotweed and giant knotweed are present along the South Fork Skykomish River corridor and Maloney Creek corridor, and are prescribed for control efforts on National Forest System lands. Scot's broom is present on National Forest System lands along a transmission line corridor that passes through Skykomish. These species are listed as noxious weeds of concern by King County; control of these species is recommended (King County, 2003a).

2.2.5 Wildlife

This section describes the animal life in the Town of Skykomish and at the site. It includes information on the habitats of animals, special status species, and threatened and endangered species.

2.2.5.1 Wildlife Habitat Diversity

Wildlife habitats at the site are affected by ground disturbance, high human activity levels, and urban conditions, and are suitable primarily for wildlife species that are tolerant of these conditions. The wildlife on each of the mapped habitat areas at the site is described below (as illustrated on Figure 2-12).

Railyard

The railyard area receives high levels of human, vehicle, and train activity, and provides low value to wildlife. The grass and weed-dominated site is used primarily by birds and small mammals. Generalist species of disturbed habitats, such as coyote and raccoon, may also use the railyard area on occasion.

Residential and Commercial

Residential back yards in the Town of Skykomish support wildlife habitat for birds and small mammals that use inhabited sites and are tolerant of human activity. Bird species that are expected to be present in the area include, but are not limited to, American robin, house sparrow, Stellar's jay, white crowned sparrow, common raven, common crow, barn swallow, violet green swallow, cliff swallow, rough-winged swallow and starling.

South Fork Skykomish River Flood Control Levee and Shoreline

The riparian zone along the south bank of the South Fork Skykomish River is of low quality due to the extent of development close to the shoreline. Animals that may use the shoreline habitat include, but are not limited to, common crow, coyote, raccoon, and mink.

Former Maloney Creek Channel and Wetland

The patches of forested and wetland habitat along the former Maloney Creek channel are expected to be used by various birds and mammals, including, but not limited to, towhee, dark-eyed junco, common bushtit, common crow, coyote, and raccoon.

2.2.5.2 Special Status Wildlife

The WDFW, USFS, and USFWS were contacted to determine the presence of special status wildlife species in the vicinity of the Site (Township 26 North, Range 11 East, Sections 26, 27, 33, 34, and 35), the results of the data requests are summarized below:

- **Cascades Frog.** The Cascades frog is a federal species of concern and a state monitor species. In Washington, the Cascades frog occurs at mid-to high elevations in the Cascades and the Olympic mountains (Leonard *et al*., 1993). It is rarely found below elevations of 2,000 feet. The species is most commonly found in small pools in sub-alpine meadows and also inhabits sphagnum bogs, forested swamps, small lakes, ponds, and marshes near streams.

No suitable habitat for Cascades frog is expected to occur in or near the Town of Skykomish at an elevation of 950 feet. No occurrences of Cascades frog were documented in state or federal databases (USFWS, 2003; WDFW, 2003a).

- **Northern Red-Legged Frog.** The northern red-legged frog is a federal species of concern that occurs at low to moderately high elevations in western Washington. It typically uses small ponds, pools, and swamps within forest stands (Leonard et al,. 1993). During the breeding season, the species is most abundant in ponds and pools that are seasonally, rather than permanently, flooded. Red-legged frogs breed in winter, attaching the egg masses weakly to emergent vegetation or underwater branches. Newly metamorphosed frogs, as well as mature adults, are more terrestrial than aquatic, inhabiting shrub and forested areas near permanent water.

  Red-legged frogs were not detected during wetland surveys of the former Maloney Creek Channel in July 2003. This species may occur in the vicinity of the site.

- **Oregon Spotted Frog.** Oregon spotted frog is a candidate for federal listing and a Washington State endangered species. Historically, Oregon spotted frog was present in the Puget trough lowlands from southern British Columbia to northern California and east into the Cascade Mountains in southern Washington and Oregon (Leonard et al,. 1993). Habitat loss, through modification of riparian and wetland habitat, is thought to be a major factor in the population decline. Currently, three populations of Oregon spotted frog are known in Washington State: one in the south Puget Sound, and two in the Cascade Mountains of south-Central Washington (McAllister and Leonard, 1997). One population is known from British Columbia and another 20 populations are documented in Oregon.

  Suitable habitat for Oregon spotted frogs is shallow, emergent wetlands, typically in forested settings (Leonard et al,. 1993). Oregon spotted frogs rarely leave the aquatic environment and are usually found in standing, shallow water with abundant emergent or floating vegetation. No suitable habitat for Oregon spotted frog occurs at the project site or vicinity of the Town of Skykomish. No observations of Oregon spotted frog have been reported in the vicinity of Skykomish (USFWS, 2003; WDFW, 2003a).

- **Tailed Frog.** The tailed frog is a federal species of concern and a state monitor species that occurs in cold, rocky streams from

British Columbia to northern California (Leonard et al., 1993). Tailed frogs inhabit cold, rocky streams from low to high elevation, spending several years as tadpoles. Adults are nocturnal and infrequently seen, emerging at night to feed on insects near the stream and in the adjacent forest. Adults can be found in summer, and tadpoles year-round, by turning over rocks in the stream. Tailed frogs do not inhabit ponds or wetlands.

Suitable habitat for tailed frog is not present at the site. The higher gradient reaches of Maloney Creek to the south of the site may support tailed frog. The population status is unknown.

- **Harlequin Duck.** The harlequin duck is a federal species of concern that has been documented to breed upstream of Skykomish along the Beckler River and downstream near the Miller River confluence (WDFW, 2003a). No records of breeding harlequin ducks have been reported along the section of the South Fork Skykomish River that borders the Town of Skykomish, or along Maloney Creek. Suitable breeding habitat occurs along fast-flowing streams and rivers with a well-developed, forested riparian zone. The site does not provide this type of habitat. Harlequin ducks may forage and loaf along the section of the South Fork Skykomish River that borders the Town of Skykomish.

- **Northern Goshawk.** The northern goshawk is a federal species of concern and a state candidate for listing. Northern goshawk has been documented within 1 mile of the site (USFWS, 2003; USFS, 2003); however, nesting status is unknown (USFS, 2003). Goshawks inhabit mature- to old-growth coniferous and mixed forests, and open woodlands. No mature or old-growth forests are present within the Habitat Assessment Area. Goshawks may occasionally pass through or forage in the Town of Skykomish.

- **Peregrine falcon.** Formerly classified as federally endangered, the American peregrine falcon was delisted in August 1999. The Washington State Status Report for the Peregrine Falcon (Hayes and Buchanan, 2002) notes the falcon is still listed as state endangered, but will likely be reclassified as sensitive in the future. No peregrine falcon nest sites are known to exist in the vicinity of the Town of Skykomish (USFS, 2003; USFWS, 2003; WDFW, 2003a).

- **Pileated woodpecker.** Pileated woodpecker is a Washington State candidate species and a USFS management indicator species. These woodpeckers are closely associated with mature and old-growth forests, using large diameter snags for nesting and roosting.

Late- and old-successional forests on the Mount Baker-Snoqualmie National forests provide high-quality habitat for pileated woodpecker. Because of the extent of timber harvest activity near the Town of Skykomish, and the lack of mature forested habitats at the site, use of the site by pileated woodpeckers is expected to be low. Occasional foraging may occur in snag in and around the Town of Skykomish.

- **Pacific Townsend's big-eared bat.** The Pacific subspecies of Townsend's big-eared bat is a federal species of concern, a USFS sensitive species, and a Washington State candidate for listing. The species is an insectivore that inhabits forested regions primarily west of the Cascade Mountains. Townsend's big-eared bats are primarily cavity-dwellers, typically selecting roost sites in caves or abandoned mines; they also use human-made structures such as barns, attics, and bridges, as long as human disturbance is very low (Pierson and Rainey, 1998). They require different sites with specific microclimatic conditions for roosting, hibernation, and reproduction. Caves have reportedly been used as maternal roost sites and hibernacula; bridges have also been documented as maternal sites (Fellers and Pierson, 2002).

  The status of Pacific Townsend's big-eared bat in the Skykomish vicinity is unknown; no occurrences have been reported (USFWS, 2003; WDFW, 2003a).

2.2.5.3 Threatened and Endangered Wildlife Species

The USFWS, USFS, and the WDFW provided information on federally listed, proposed, and candidate wildlife species and Washington State threatened and endangered species that may occur in the vicinity of the site. Three listed species of birds are known to occur in the general vicinity of the site. These species, bald eagle, marbled murrelet, and northern spotted owl, are discussed below. Three listed mammal species, Canada lynx, gray wolf, and grizzly bear, could potentially occur in the site vicinity; however, no suitable habitat for these three mammals is present in the site vicinity and no sightings of the species have been documented (USFS, 2003). These species are not expected to occur in the site vicinity (USFS, 2003; Stinson, 2001) and are not discussed further in this document. A summary of threatened and endangered species is given in Table 2-2.

- **Bald Eagle.** The bald eagle is a federal and state threatened species. Recovery efforts for the bald eagle have been successful in the lower 48 states, including the Pacific region. In 1999, the bald eagle was proposed for removal from the list of threatened and endangered species, as recovery goals had generally been met or exceeded (64 FR36543).

The South Fork Skykomish River basin is used by bald eagles primarily during the winter months when spawning salmon are available as a food resource. A winter concentration area is located approximately two miles west of the Town of Skykomish along a tributary to the South Fork Skykomish River (USFWS, 2003). Another area of regular winter use by foraging bald eagles is located about a mile northeast of the Site along a tributary river (USFS, 2003).

Bald eagles may roost communally near feeding areas during the winter months. Roost sites are often located in mature or old-growth forest stands in close proximity to feeding areas. A communal night roost is located about one mile west of the Town of Skykomish (USFWS, 2003; WDFW, 2003a).

Bald eagles occasionally use of the South Fork Skykomish River in the vicinity of the Town of Skykomish (USFS, 2003). Few suitable perch trees are present along this reach of the river, and use of the shoreline is limited. The majority of trees along the riverbank and the flood control levee are red alder and big-leaf maple of about 5 inches in diameter (maximum). These trees are not of suitable diameter and height to support bald eagles or to provide good visibility of the river. Bald eagles are reported by the Skykomish Environmental Coalition to commonly perch in trees along the north shoreline west of 5th street, especially during December and January.

There are no bald eagle nest sites within the Site vicinity (WDFW, 2003a; USFS, 2003).

- **Marbled Murrelet.** The marbled murrelet is a federal and state threatened seabird that nests in old-growth coniferous forests. Suitable habitat for marbled murrelet is present in the South Fork Skykomish River basin, primarily within unlogged stands of Douglas fir and western hemlock. In the Project vicinity, critical habitat for marbled murrelet has been designated within Late Successional Reserves (LSRs) designated under the Northwest Forest Plan (USFWS and USDI, 1994 as amended) for the management of northern spotted owl and other old-growth species including marbled murrelets. The LSRs occur exclusively on National Forest System lands.

  No records of marbled murrelet detections were present in the WDFW or Forest Service databases. Few, if any, surveys have been conducted in the Skykomish vicinity (USFS, 2003; WDFW, 2003a). Suitable murrelet habitat is not present within one-half mile of the Town of Skykomish (USFS, 2003).

- **Northern Spotted Owl.** The northern spotted owl was federally listed as threatened in Washington, Oregon, and California in July 1990 (55 FR 26114); it is a Washington State endangered species. Factors that contributed to the federal listing were the declining population trends, the loss of suitable forested habitats throughout the species range, and the lack of adequate regulatory mechanisms to protect existing habitat for the species.

  Competition with barred owls may be a factor in the population decline of spotted owls; barred owls have become common in some parts of the Washington Cascades and may outcompete spotted owls for nest-sites and prey in areas where mature and old-growth forests have been fragmented by timber harvest (Dark *et al*., 1998, Herter and Hickes, 2000). Fragmented forest stands with openings in the forest canopy, such as result from clear-cutting and thinning, promote use by great horned owls, a major predator of spotted owls (Johnson, 1993).

  Spotted owls are strongly associated with mature and old-growth forests for nesting, foraging, and roosting. Nesting and roosting occur in coniferous forests characterized by moderate to high levels of canopy closure, high density of standing snags, large diameter overstory trees with deformities such as broken tops and witches' brooms, and abundant coarse woody debris on the forest floor (USDI Fish and Wildlife Service, 1987). Foraging occurs in nesting and roosting habitat, and in coniferous forest of younger age and less structural diversity, where key prey species are present. Important forage species of spotted owls in mesic Douglas-fir forests include northern flying squirrel and woodrat species; these species occur at relatively low density and the spotted owl has a correspondingly large home range (USDI Fish and Wildlife Service, 1992).

  Critical habitat was designated for the northern spotted owl in 1992 (57 FR 1796). In the project site vicinity, spotted owl critical habitat coincides with Forest Service Late Successional Reserves, all of which are located on National Forest System lands.

  The WDFW database shows three spotted owl activity centers representing established territories in the vicinity of the Town of Skykomish (WDFW, 2003a). The site centers of all three territories are over two miles from the edge of town; none of the sites have been surveyed in recent years and the status of the sites is unknown (USFS, 2003). Suitable habitat for spotted owl does not occur closer than one-half mile from the edge of town (USFS, 2003).

It is possible that spotted owls, if present in the basin, could use forested habitats to the north of the South Fork Skykomish River or to the south of Maloney Creek. No habitats within the site are suitable for use by spotted owl.

2.2.6 Fish and Aquatic Biota

This section describes the fish and aquatic life in the water bodies in Skykomish. It includes information on the habitat diversity and threatened and endangered species of fish and aquatic biota.

2.2.6.1 Habitat Diversity

The obvious habitats for fish and aquatic biota at the site are the South Fork Skykomish River and the former Maloney Creek channel, which are described below. It should be noted that aquatic habitat and fish populations in the Snohomish Basin (including the South Fork of the Skykomish River) may be limited by natural low-flow conditions. These conditions typically occur in the summer months.

South Fork of the Skykomish River

The South Fork Skykomish River channel immediately below the Skykomish River Bridge ranges from approximately 150 to 250 feet wide. The channel gradient in this area averages approximately 27 feet per mile. The channel contains mostly glide habitat, with occasional riffles at lower flows. Larger sections of riffle are present approximately 2,900 feet downstream of the existing levee. Substrate within the channel varies in size from large boulders and cobbles to smaller gravels and sands. Larger boulder substrates are more frequent along the northern portions of the channel, with smaller cobbles, gravels, and sands occurring on a gravel bar adjacent to the southern shore.

Low-velocity shoreline habitat, which provides refuge for migrating juvenile salmonids, is present along the base of the existing levee throughout much of the site. The larger riprap and boulders present along this shoreline reduce flow velocities near the bank by creating eddies where water flows around these larger substrates. Low-velocity areas are also present within the interstices of the larger boulders and riprap.

However, natural low flows within the Snohomish River basin, particularly during the summer months, may limit fish access to low-velocity shoreline habitat areas. These natural low flows may also limit access to pockets of spawning gravels, while also potentially dewatering redds.

Overhanging vegetation present along the shoreline offers refuge from predators for juvenile fish, while helping to reduce water temperatures and increase water quality. In addition, overhanging vegetation provides a food source for juveniles through the deposition of detritus, which is a primary food source for aquatic insect larvae.

Aquatic habitat features present near the site include boulder substrates that provide refuge from high flows, large woody debris that provides refuge from predators, and large holding pools for migrating fish. The Biological Assessment being prepared for the project will describe the aquatic habitat present in the South Fork of the Skykomish River in greater detail.

Former Maloney Creek Channel

The culvert that connects to the segment of the former Maloney Creek channel (wetland) downstream of 5th Street is passable to adult salmonids during flowing periods, as they have been observed at various locations upstream of the culvert (Ecology, 2002b). The channel within the wetland adjacent to the railyard is undefined throughout most of its length, with surface sediment layers dominated by sands and silts overlain with varying amounts of organic debris. Ponding occurs throughout this area. The wetland contains several aquatic habitat features including an invertebrate food source and shading provided by dense canopy cover. Canopy vegetation is dominated by second-growth deciduous trees.

As mentioned above, the Biological Assessment being prepared for the project will discuss the aquatic habitat near the site in more detail.

2.2.6.2 Threatened and Endangered Species

Historically, Sunset Falls presented a barrier to the upstream migration of anadromous fish in the South Fork of the Skykomish River. Anadromous fish access to the upper South Fork has only been possible since 1952, when a trap and haul operation was commenced by the Washington Department of Fisheries at Sunset Falls (DEA, 1999).

Two threatened or endangered species of fish occur in the South Fork of the Skykomish River: Puget Sound chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*). Juvenile chinook would be expected to be present within the South Fork of the Skykomish River near the Town of Skykomish from mid to late February through May. Juvenile bull trout rear in their natal headwater streams, and are not expected to be present within the South Fork. As mentioned above, water levels within the South Fork at this time are such that the shoreline edge habitat is available to juvenile salmonids.

This section only describes Threatened and Endangered species. Coho, a federal candidate species, is discussed below in the section entitled Other Fish.

Chinook

Puget Sound chinook salmon are listed as threatened by the National Marine Fisheries Service (NMFS). They utilize the South Fork of the Skykomish River for spawning, migration, and rearing from the confluence with the North Fork Skykomish River, up to Sunset Falls (WDFW and WWTIT, 1994). Spawning in the upper South Fork basin occurs in suitable mainstem reaches, as well as the lower reaches of larger tributaries, including the Miller, Beckler, Tye, and Foss Rivers (Pentec and NW GIS, 1999).

Chinook life history, presence, and habitat use in the South Fork of the Skykomish River will be discussed in more detail in the Biological Assessment being prepared for the project.

The chinook stock present within the South Fork of the Skykomish River basin is the Bridal Veil Creek fall chinook, which typically spawn from late September through October (USFS, 1999). Juvenile emergence occurs from February to mid-March (Pentec and NW GIS, 1999). Chinook rear in freshwater habitats from several months to a year before emigration.

As described in Section 2.2.2, the substrates within the South Fork of the Skykomish River near the site are dominated by cobbles, with larger cobbles and boulders also present; therefore, large areas of suitable chinook spawning habitat is not likely to be present. However, small pockets of spawning gravels may be present near the site. The nearest large spawning riffle for Chinook is located approximately 2,900 feet downstream of the site. Overhanging riparian vegetation, which is present along the existing levee, provides many important habitat functions for juvenile salmonids (Meehan et al., 1977). Particularly, it increases the quality of the low-velocity shoreline edge habitat for juvenile salmonids by providing refuge from predators, decreasing water temperatures, and increasing production of food resources.

As mentioned in Section 2.2.2, low-velocity river margin areas are present along the base of the levee, containing areas of deeper water adjacent to the shoreline. Flows within the South Fork are typically high enough for juvenile salmonids to utilize this habitat from September to July. In July, the flows decrease to the point where the shoreline edge habitat is dewatered. However, at that time it would be expected that any juvenile salmonids still present would be large enough to occupy areas within the mainstem with higher velocities.

Shoreline edge habitat consisting of larger riprap and boulders offers rearing and refuge habitat to juvenile salmonids, including chinook (Pentec and NW GIS, 1999). The larger substrates slow water velocities near the margins of the streams, allowing juveniles to use these areas for refuge from both high flows and predation, as well as sources of food (Pentec and NW GIS, 1999).

Bull Trout

Bull trout are also listed as threatened by the NMFS. Bull trout in the upper South Fork of the Skykomish River basin exhibit three life history strategies: anadromous (migratory between saltwater and freshwater), fluvial (migratory within river systems), and resident (non-migratory). Bull trout present near the Town of Skykomish are predominantly anadromous, and utilize the South Fork as a migratory corridor, traveling upstream to spawning grounds on the lower East Fork Foss River. However, fluvial and resident bull trout may also be present near the site. Bull trout are opportunistic feeders that prey on a wide variety of organisms. Juveniles utilize terrestrial and aquatic insect larvae, zooplankton, amphipods, and various other invertebrates as a food source. Adults and sub-adults typically feed on juvenile salmonids, sculpin, and whitefish.

Bull trout require cold, clear water and loose, clean gravels for spawning, and prefer habitat with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (WDFW, 1997b). Spawning reaches must contain clean gravels over larger cobbles, with a very low quantity of fines. Bull trout spawning typically occurs from late August through early November, commencing when water temperatures drop below 46 ^{o}F (WDFW, 1998). Preferred bull trout spawning habitat is not likely to be present in the South Fork of the Skykomish River or the former Maloney Creek channel.

Fry typically emerge from the gravel from January through March and April, with juveniles remaining close to their natal headwater areas while rearing (Pentec and NW GIS, 1999). Anadromous bull trout generally leave headwater areas as 2-year olds and migrate to estuarine waters during the spring. During this migration, bull trout are large enough that they do not depend on the low-velocity river margins present within the South Fork.

In addition to bull trout, Dolly Varden (*Salvelinus malma*), a closely related species, may also be present near the site. Dolly Varden exhibit the same life history strategies and habitat requirements as bull trout (WDFW, 1998).

As mentioned above, bull trout life history, presence and habitat use in the South Fork of the Skykomish River will be discussed in more detail in the Biological Assessment being prepared for the project.

Other Fish

There are several other species of fish that may occur in the upper South Fork of the Skykomish River, including coho (*O. kisutch*), pink (*O. gorbuscha*), and chum (*O. keta*) salmon, steelhead (*O. mykiss*) and coastal cutthroat trout (*O. clarki clarki*), pacific lamprey (*Entosphenus tridentatus*), river lamprey (*Lampetra ayresi*), and mountain whitefish (*Prosopium williamsoni*). These species are not listed as threatened or endangered.

The juveniles of the salmonid species would be expected to utilize the shoreline edge habitat of the South Fork of the Skykomish River upon emergence. Juvenile coho, pink, and chum salmon typically emerge from the gravel from late February and early March through April and May. The low-velocity shoreline edge habitat of the South Fork would be used by these species. However, pink and chum generally migrate to estuarine waters immediately after emergence, and would likely only be present for a very short period.

The following describe these other salmonids. Table 2-3 summarizes salmonid presence and timing within the South Fork of the Skykomish River near Skykomish, as well as the former Maloney Creek channel.

- **Coho Salmon**. Coho utilize the South Fork as migratory, rearing, and spawning habitat, generally spawning from late October through January (Pentec and NW GIS, 1999). Coho spawning grounds include appropriate areas of the mainstem South Fork, as well as the lower reaches of Miller, Beckler, Foss, and Tye Rivers. Coho have also been observed in Maloney Creek (White, 2003). They typically prefer spawning habitat similar to chinook; as such, coho spawning habitat is unlikely to be present within the South Fork near Skykomish.

  Coho generally emerge from the gravel from March through May (Pentec and NW GIS, 1999). As with chinook, they would likely utilize the low-velocity shoreline habitat in the South Fork of the Skykomish River from March until June and July while migrating downstream in search of appropriate off-channel rearing habitat.

  The former Maloney Creek channel area contains small, quiet pools with large amounts of organic detritus, which likely offer quality rearing habitat for coho. Coho have been observed in the former Maloney Creek channel, as well as in the main channel of Maloney Creek (Ecology, 2002b).

- **Pink Salmon**. Pink salmon spawn in the upper South Fork basin from mid-September through October in odd-numbered years only, utilizing the mainstem South Fork as well as the Beckler River (Pentec and NW GIS, 1999). Pink salmon have also been documented in Maloney Creek (White, 2003). Pink salmon generally prefer smaller cobbles and gravels for spawning, and therefore would not likely spawn near the site.

  Pink salmon fry emerge from the gravel in March through April, and immediately begin their migration to estuarine waters. Pinks generally only reside in fresh water for 1 to 2 weeks, depending on the length of their seaward migration (Pentec and NW GIS, 1999).

However, they may occasionally utilize river shoreline edge habitat for rearing during their migration.

- **Chum Salmon**. Chum salmon are known to spawn in the mainstem Skykomish River as far upstream as Gold Bar (Pentec and NW GIS, 1999). Chum salmon in this area generally spawn from mid-November through mid-January. Spawning information for the upper South Fork of the Skykomish River is scarce, but adult chum have been recorded in the lower reaches of Maloney Creek (Ecology, 2002b). Chum likely spawn in appropriate mainstem reaches along the South Fork of the Skykomish, as well as the lower reaches of larger tributaries. Because of their larger size, chum have similar spawning habitat requirements as chinook. As such, suitable spawning habitat for chum is not likely to be present in the vicinity of the site area.

  Chum fry emerge from the gravel in the spring, usually from February and March into May (Pentec and NW GIS, 1999). As with pink salmon, chum typically do not rear in freshwater, usually residing in freshwater for only a couple of weeks. Limited use of South Fork mainstem rearing habitat may occur during their estuarine migration.

- **Steelhead**. Steelhead use the upper South Fork basin and its tributaries for spawning, rearing, and migration. Summer steelhead spawn from February to April in the lower reaches of Miller, Foss, and Tye Rivers, while winter steelhead spawn from early March to early to mid-June in the lower reaches of Miller, Beckler, and Foss Rivers (Pentec and NW GIS, 1999). Steelhead prefer fast-moving, higher gradient reaches with larger substrates for spawning (WDFW, 1997a). Therefore, the habitat present within the South Fork near Skykomish likely does not contain suitable spawning habitat for steelhead.

  Juvenile steelhead typically emerge from the gravel from June through August. Juvenile steelhead primarily utilize mainstem habitat for rearing, typically overwintering for two or more years before emigrating to saltwater (Pentec and NW GIS, 1999). They prefer fast-moving water with larger substrates for rearing, utilizing the areas behind larger cobbles and boulders (WDFW, 1997a). As their emergence time generally corresponds with lower flows and dewatering of the shoreline edge within the South Fork, steelhead likely utilize this habitat for only a short period of time before moving to faster waters.

- **Coastal Cutthroat Trout**. Anadromous coastal cutthroat trout are generally not found above the town of Gold Bar in the Skykomish River (WDFW, 2000). Coastal cutthroat typically prefer slower-moving, lower-gradient streams, and therefore would not likely be found in the mainstem South Fork Skykomish River near the site (Pentec and NW GIS, 1999).

  Fluvial cutthroat trout may be present in limited numbers within the mainstem South Fork and Maloney Creek (WDFW, 2000). Fluvial cutthroat present in mainstem rivers generally migrate upstream to spawn in smaller tributaries and side channels. Fluvial cutthroat in the Snohomish Basin spawn from January through mid-June. Juveniles emerge from the gravel within eight to nine weeks, and generally seek out slow-moving side channels and tributaries (WDFW, 2000).

In addition to the salmonids described above, several other species of fish may be present near the site. Pacific lamprey and river lamprey are both listed as Federal Species of Concern, with river lamprey also listed as a State Candidate species by WDFW (WDFW, 2003c). Both species spawn in gravel in clear streams, with ammocoetes developing in mud, silt, and sand substrates at the bottoms of pools and backwater eddies. In addition, mountain whitefish (*Prosopium williamsoni*), which is listed as a State Species of Concern, may also be present near the site (WDFW, 2003c). Mountain whitefish prefer fast, clear or silty streams, feeding primarily on aquatic insect larvae, mollusks, fish, and fish eggs (Froese and Pauly, 2003).

2.3 Built Environment

This section describes land use plans, historic resources, public services, environmental health considerations, and transportation. The town and site are described in Section 2.1.

2.3.1 Land and Shoreline Use Plans

This section describes how the Town of Skykomish is zoned in the subsection called Zoning Ordinances. It also describes the CAO, which includes information on shoreline use. Finally, this section describes the housing and demographics of the Town of Skykomish and the aesthetic and historical structures.

2.3.1.1 Zoning Ordinance

The Town of Skykomish is a rural town and is surrounded on all sides by the Mt. Baker-Snoqualmie National Forest. It is divided into five zoning districts: residential, commercial, industrial, historic commercial, and public (Ordinance 235, 1995). The industrial zone of Skykomish consists of the railyard. There are commercial zones on the north bank of the South Fork of the Skykomish River and south of the railyard. The Town of Skykomish has designated a Historic Commercial Zone north of the railyard.

The remainder of the town is residential with the exception of the public buildings, such as the school, community center, and town hall. There is a public park outside of the city limits on the north side of the South Fork of the Skykomish River, as described below.

The majority of businesses in Skykomish are small retail but also include gas stations, motels, and hotels that cater to local residents and tourists (Town of Skykomish, 1993). Besides the BNSF railroad maintenance activities, there is no other industry in Skykomish. The National Forest Service maintains a depot in Skykomish.

The site includes land in each of the five zoning areas, as shown on Figure 2-16. The site includes the historic commercial zone in the downtown area, most of the industrial zone, and most of the public zone. The site covers approximately 230,000 square feet of residential land.

2.3.1.2 Critical Areas Ordinance

A CAO (Ordinance 269, 1998) for the town was adopted by the town council in 1999. The CAO was adopted to designate and classify environmentally sensitive and hazardous areas, including wetlands, fish and wildlife habitats, flood hazard areas, geologic hazard areas, and aquifer recharge areas. The CAO regulates alterations in and adjacent to critical areas to protect natural resource values, public resources and facilities, and public safety. The CAO also meets the requirements of the Washington Growth Management Act (RCW 36.70A) with regard to the protection of critical areas and the Shoreline Management Act (RCW 90.58) with regard to protecting shorelines. The CAO is used to coordinate environmental review and permitting of proposed actions affecting critical areas.

Areas protected under the CAO include the former Maloney Creek channel and wetland, Maloney Creek, and the South Fork of the Skykomish River. The South Fork of the Skykomish River and Maloney Creek meet the definition of Primary Fish and Wildlife Habitat. The former Maloney Creek channel and wetland are ranked for this evaluation as secondary fish and wildlife habitats, based on the absence of documented federal and/or state-listed species. The former Maloney Creek channel and wetland are shown on Figure 2-1. The site of the South Fork Skykomish River is considered a “shoreline of statewide significance” with the receipt of water from Beckler Creek, just upstream of the town (WAC 173-18-20).

Areas within the 100-year floodplain are defined as Flood Hazard areas under the CAO. The 100-year floodplain associated with the South Fork Skykomish

River and Maloney Creek may be seen on Figure 2-9, and is discussed in more detail on Section 2.2.2 under the title "Floods."

The CAO is also the primary regulation applicable to management of activity in and around shorelines. The requirements of the CAO must be met in order to receive a Shoreline Conditional Use permit, a Shoreline Substantial Development permit, or a Shoreline Variance.

2.3.1.3 Housing and Demographics

The majority of housing units in Skykomish are single-family residences (U.S. Census Bureau, 2001). Twenty-six residences lie within the footprint of the site. Some of the residences in Skykomish are mobile homes and approximately one-third of these are used as seasonal residences. The commercial buildings are predominantly small retail but also include gas stations, a church, motels, and hotels that cater to local residents and tourists (Town of Skykomish, 1993). There are 10 commercial buildings on the site.

The most recent census (U.S. Census Bureau, 2001) reports 214 people living in Skykomish of which 29 (13 percent) are under the age of 19. It is estimated that up to 30 seasonal residents live in Skykomish at any time of the year (Dohran, pers. comm., 2003). The decline of the railroad as a primary form of transportation resulted in the loss of railroad-related jobs in Skykomish. Now the school is the major year-round employer in Skykomish. Since automotive use has increased, residents of Skykomish have been able to commute to major employment centers and Skykomish has become more accessible to seasonal residents and visitors. The economy of Skykomish is now dependent on tourism and the USFS (Town of Skykomish, 1993).

2.3.2 Historical and Cultural Resources

The Town of Skykomish includes areas, structures, and buildings listed on the National and State Registers of Historic Places, and contains an area zoned by the Town of Skykomish as Historic Commercial. The Historic Commercial zone lies mainly to the north of the railyard and is defined differently by the National Register of Historic Places and an Interlocal Agreement for landmark services between the Town of Skykomish and King County (both are shown on Figure 2-17). The Town of Skykomish Zoning Ordinance #235 encompasses all areas covered by the national and local historic designations. The National Register of Historic Places is defined as Railroad Ave., from 3rd Street to west of N 6th Street, and part of Old Cascade Hwy. The National Register designation includes 12 buildings and the Skykomish Bridge as well as the Skykomish Masonic Hall along Old Cascade Highway. Prior to the national designation of the Skykomish Historic Commercial District, the Great Northern Depot and Maloney's General Store were listed separately in the National Register of Historic Places. The local designation includes 12 buildings as well but does not include the bridge.

Several of the cleanup alternatives require moving historic buildings temporarily to allow for excavation beneath them. The buildings would then be returned to their original sites in such a way that the rail-oriented configuration of lots and buildings, streetscape and location of buildings relative to the street are maintained. The Secretary of the U.S. Department of the Interior has issued Standards for the Treatment of Historic Properties. These Standards do not 'apply' to the cleanup action because there is no grant-in-aid involved (see 36 CFR Part 68), however, these Standards are 'relevant and appropriate' under MTCA to the extent the cleanup will affect historic buildings, sites, structures or districts. Potential impacts to historic resources that may result from temporary relocation might include loss of landscape features, movement or setline of buildings, and some changes of surface grade, for example. These impacts are evaluated in the Draft EIS and will be further addressed, including any necessary mitigation measures, in the Final EIS.

To respond to public and agency comments on the Draft FS and Draft EIS, and to further document historic resources in Skykomish, BNSF retained a Historical and Cultural Resources Specialist to expand the descriptions of the various designations and districts in accordance with industry practices. BNSF is also conducting an archaeological survey of the project area at the request of Ecology and the Washington State Office of Archaeology and Historic Preservation. The results of this work will be presented in the Final EIS.

2.3.3 Public Services

This section describes the public services that the Town of Skykomish provides to its citizens. These include schools, parks and recreation, and utilities. In addition, Skykomish provides the following services:

- Fire fighting services through a contract with King County Fire District No. 50
- Police protection through a contract with the King County Sheriff (Yates, 2003b)
- Road maintenance including snow plowing and repairing of road surfaces (Yates, 2003b).

The nearest hospital to Skykomish is approximately 40 miles away in Monroe, Washington.

2.3.3.1 Schools

There are no private or charter schools in Skykomish. The Skykomish Elementary and High Schools of School District 404 are located at 105 Sixth Street (Figure 2-16). There are 70 students enrolled in grades K-12 for the

2002–2003 school year. In general, the enrollments of the Skykomish Schools are decreasing. The School District stretches from Index in Snohomish County to the eastern side of Stevens Pass. School buses bringing students to school enter the Town of Skykomish on 5th Street, take a right on Railroad Avenue, and then a right onto 6th Street. The buses turn left at the three-way intersection at the end of the block and turn around (Moore, 2003).

2.3.3.2 Parks and Recreation

Skykomish has one small community park that is south of U.S. Highway 2 and north of the South Fork of the Skykomish River. Access to the park, which includes a baseball diamond, lies approximately half a mile east of the 5th Street Bridge over the South Fork Skykomish River. In addition, there is a small park, the Depot Park, located at the intersection of 5th Street and Railroad Avenue. Other nearby recreational facilities include the South Fork of the Skykomish River and neighboring National Forest lands. There are no trailheads or camping grounds within the Town of Skykomish limits nor is there public access to the river on or near the site, although the public can access the river using a path just north of the Skykomish River Bridge across the South Fork Skykomish River.

2.3.3.3 Utilities

There are no municipal storm or sanitary sewer systems or wastewater treatment plants in Skykomish. Residents use septic systems consisting of tanks and leach fields to treat and dispose of sanitary waste. The people of Skykomish are served by two public water supply wells that are located about 1,100 feet east (upgradient) of Skykomish, as discussed in Section 2.2.2.

2.3.4 Environmental Health

In this section describes how the built environment of the Town of Skykomish could affect environmental health. Noise, vibrations, and hazardous substances are all factors that could affect environmental health.

2.3.4.1 Noise

Noise can be defined as unwanted sound that is disturbing or annoying. Sound can be objectionable due to pitch or loudness. Pitch depends on the frequency of vibrations that produce the sound. Loudness is the intensity of sound waves. Decibels (dB) measure the relative amplitude of sound. The decibel scale is logarithmic, meaning that an increase of 10 decibels is a ten-fold increase in acoustic energy. The A-weighted sound level (or dBA) gives greater weight to sound frequencies to which the human is ear is more sensitive, as shown on Figure 2-18. Table 2-4 gives descriptions of different levels of sound. Since environmental sounds are often made up of time-varying events, most environmental sounds are described using an average level that has the equivalent acoustical energy as the summation of all the time-varying events.

Noise attenuates in the atmosphere as a function of distance between the receiver and the source. Typically noise is reduced 6 dB for every doubling in distance. Additionally noise is attenuated by intervening structures.

The two main sources of noise in Skykomish are the BNSF railroad that passes through town and traffic along U.S. Highway 2. Stationary idling locomotives exceed 85 dB (the occupational limit) at 30 feet (Union Pacific Railroad, 1999) while a train traveling 30 to 40 miles per hour produces 88.7 dB of noise at a distance of 100 feet (RETEC, 2003c). Approximately 24 trains pass through Skykomish on average each day, but do not regularly stop and idle in town.

2.3.4.2 Vibrations

Train traffic passing through Skykomish is the only significant source of vibrations on a regular basis.

2.3.4.3 Hazardous Substances

The most significant risk of explosion or new releases to the environment on the site is an accident on the railroad or highway. There is an existing potential of exposure to hazardous substances from the subsurface contamination that is being addressed in this Final FS. In addition, heating oil is used throughout the town and is stored in underground storage tanks throughout the town. The school also has a diesel boiler.

2.3.5 Transportation

This section describes roads, transportation systems, and traffic through Skykomish.

2.3.5.1 Roads and Transportation Systems

There is no public transportation within Skykomish or to Skykomish. U.S. Highway 2 is a federal highway. U.S. Highway 2 goes west from Skykomish to Everett, Washington, and east from Skykomish to Chelan, Washington. Figure 1-1 shows U.S. Highway 2 and Figure 2-16 shows roads in the town.

The Washington State Department of Transportation (WSDOT) maintains the steel truss bridge into town from U.S. Highway 2. The bridge is 102 feet long with 10 feet of clearance (Department of Highways, 1938). There are no posted load restrictions on the bridge.

There are about 3.3 miles of local roads composed predominantly of asphalt concrete in Skykomish (Town of Skykomish, 1993).

2.3.5.2 Traffic

The average annual daily traffic count for U.S. Highway 2 north of town is approximately 4,750 vehicles (Taylor, 2003). There is limited traffic within Skykomish itself and there are no traffic lights.

2.4 Interim Cleanup Actions and Ongoing Site Maintenance

This section describes the interim cleanup actions and ongoing maintenance of them at the site.

2.4.1 Barrier System

In August 2001, a barrier system was constructed along the West River Road at the site. The barrier system consists of a 600-foot cement-bentonite slurry wall constructed to a depth of 15 feet bgs, and recovery wells. The purpose of the barrier system is to contain and recover free product migrating to the South Fork Skykomish River. Free product was present within the levee downgradient of the wall when the barrier system was installed and is being recovered to extent feasible with booms and pads, as described in Section 2.4.2. The barrier wall and booms are not designed to contain all hydrocarbons dissolved in groundwater.

The wall is positioned along West River Road adjacent to the levee. This location was selected to intercept oily seeps and thereby minimize risk to human health and the environment. The length and configuration of the wall is based on the location of product seeps and the free product plume. Because the wall alignment is not perpendicular to the groundwater flow direction, wing walls were constructed for extra protection against free product flow around the downgradient end of the wall and to enhance product recovery throughout the recovery zone (area immediately upgradient of the wall). The barrier wall extends deeper than historical low water levels of about 10 feet bgs. This ensures containment of free products but is not designed to capture petroleum dissolved in groundwater that may migrate beneath and around the wall.

Recovery wells have been installed upgradient from the barrier wall. These wells are screened across the water table and are 6- or 8-inch diameter, stainless steel wells with a 20 slot wire-wound screen. These have been gauged on a monthly basis and skimmer pumps have been installed and are operational in those wells in which free product has been accumulating. The free product is pumped from the wells into subsurface vaults. These vaults are evacuated, as necessary. Figure 2-19 shows the configuration of the recovery wells and barrier wall. The free product between the river and the barrier wall was there prior to the barrier wall construction. This is an ongoing source of free product to the river and is being recovered to extent feasible with booms and pads, as described in Section 2.4.2. Further details are provided in the *Interim Action Completion Report* (RETEC, 2001). *Phase 2 Interim Action Completion Report* (RETEC, 2003d), and in BNSF's monthly progress reports to Ecology.

2.4.2 Oil Recovery Booms

Seeps of free product have been observed on the southern bank of the South Fork of the Skykomish River downstream of the Skykomish Bridge. The source of these seeps is free product that was present downgradient of the barrier wall when the barrier system was installed. The oil seeps consist of a dense, thick, heavyweight product with a viscosity similar to bunker C fuel oil. The specific gravity is slightly less than one, thus the product is present at the water surface. Product has been observed in the form of sheens or occasional globules up to 0.5 inch in diameter seeping out of the riverbank with groundwater. To mitigate such seeps while completing the RI/FS, BNSF implemented the boom deployment and mitigation program, described in the Interim Action Plan (RETEC, 1995) and *Boom Maintenance Technical Memorandum* (RETEC, 2002b). Boom deployment and maintenance supplements the oil recovery system and subsurface barrier wall. The current boom maintenance program entails placing oil-absorbent booms along the riverbank year round at the seep locations. These booms are inspected regularly and are replaced, as needed. Single or multiple rows of boom have been used for the free product recovery. In addition, LNAPL is recovered from the water behind the boom and from the seep on the river bank using pom-pom booms and oil-absorbent pads. Further details are provided in the *Boom Maintenance Technical Memorandum* (RETEC, 2002b) and in BNSF's monthly progress reports to Ecology.

2.4.3 Dust Suppression Application

Currently, the dust suppressant Soil Sement® is being applied annually at the site to control dust and erosion. Soil Sement® is an environmentally safe non-hazardous polymer emulsion that bonds surface dust and aggregate together into a hard, dust-free, and water-resistant surface. The sealant is applied to reduce dust generation from areas of the railyard that contain elevated concentrations of lead and arsenic. The purpose of the interim action of applying the sealant is to minimize human environmental exposure to the contaminants (lead, arsenic) through direct contact and windblown dust. A map that shows the extent of metals impacts on the railyard has been provided to BNSF workers, and during routine track maintenance activities care is taken to avoid excessive disturbance of the areas potentially impacted by lead, arsenic and PCBs.

3 Nature and Extent of Contamination

This section describes the type of contaminants at the site (nature) and the distribution of these contaminants vertically and horizontally across the site (extent). The nature and extent of contamination was determined based on data collected for the RI and Supplemental RI.

Petroleum hydrocarbons are the most widespread and significant group of contaminants in the site. They are present throughout much of the site in soil, groundwater, and sediment. These have been tested for as TPH in the diesel and motor oil range throughout the site. In addition, the hydrocarbon composition and hydrocarbon constituent compounds have been tested from selected samples as polynuclear aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); and extractable and volatile hydrocarbon fractions (EPH/VPH).

Plumes of free product extend from the railyard northwest to the South Fork Skykomish River (Figure 3-1). The free product plumes act as sources for soil contamination and for dissolved hydrocarbons in groundwater. Free product seeps are present in the South Fork Skykomish River adjacent to the upland plumes. Currently, the highest concentrations of TPH coincide with the locations of free product in soil and sediment. The extent of free product has been reduced over time by seepage into the South Fork Skykomish River, by attenuation processes such as biodegradation, and by removal during barrier wall construction and subsequent recovery wells along the barrier wall. The areas that typically formerly contained free product, now contain high concentrations of residual TPH and the soil is heavily stained with hydrocarbons. These areas still contain high concentrations of TPH in the soil and groundwater.

Metals, specifically lead and arsenic, are also contaminants within the site. The metals impacts are generally restricted to shallow soil on the railyard, although there are some elevated concentrations of lead in shallow soil on seven properties, including Town property, in the residential and commercial area north of the railyard.

Polychlorinated biphenyls (PCBs) have also been detected in soil at the site in a limited area. These are related to a former substation and transformers on the railyard. They are restricted to the shallow soil on the railyard.

The contamination across the site is present within similar lithologies; however, the methods that may be used to clean it up vary in different parts of the site because of surface constraints and differing cleanup requirements. Figures 6-2 through 6-6 in the Supplemental RI (RETEC, 2002) show the affected lithologies. These cross sections indicate that contamination is predominant within sand and gravel and does not extend far into the underlying silt. Site cleanup zones (Figure 3-2) have been developed for the site to facilitate development and description of remedial alternatives, and designate areas of the site that may be amenable to common treatment technologies. The site has been divided into zones based on land use (railyard, commercial, residential), land type (wetland, levee, upland) and TPH composition. Based on the above assessment, the following zones were created:

- **Aquatic Resource Zones –** Includes the South Fork Skykomish River, the levee and the former Maloney Creek channel.

- **Northeast Developed Zone –** Includes land that has been or will likely be developed for commercial or residential use and is affected by petroleum plume primarily composed of diesel fuel.

- **Northwest and South Developed Zones –** This includes land that has been or will be developed for commercial or residential use. The smear zone soil and groundwater have been impacted by plumes consisting of a mixture of diesel and bunker C, and isolated elevated concentrations of lead in surface soil.

- **Railyard Zone –** Includes land historically used for industrial purposes and portions of two immediately adjacent residential properties. The soil in this zone has been impacted by petroleum hydrocarbons (diesel and bunker C) in the surface, vadose and smear zone, and by lead, arsenic and PCBs in the surface soil. Some groundwater within the zone contains dissolved petroleum hydrocarbons and there are some areas with free product. This land is all owned by BNSF, except for the two residential properties that are owned by James W. Hawkins and Lorna M. Goebel.

The zones are further described in Section 6 and are referred to in the remainder of this section.

3.1 Soil Quality

Soil samples have been collected from locations throughout the site and have been analyzed for petroleum hydrocarbons (TPH-Dx, EPH/VPH, PAHs, and BTEX), lead, arsenic, PCBs and dioxins. The soil samples have been collected to support several site investigations; the most extensive soil investigations are reported in the RI (RETEC, 1996) and in the Supplemental RI (RETEC, 2002a). Details of the other investigations are provided in Section 2 of the Supplemental RI Report (RETEC, 2002a). The soil samples have been collected from several depth intervals ranging from the ground surface to approximately 20 feet below the ground surface. These depth intervals have been defined as the surface, vadose, smear and saturated zones, and are described below.

- **Surface Zone –** The surface zone has been defined as the upper 6 inches outside the railyard and the upper 2 feet in the railyard. This is the uppermost soil within the vadose zone; however, this uppermost interval has been designated as the surface zone to distinguish those impacts that do not extend far below the ground surface. The soil in this zone is unsaturated with groundwater at all times.

- **Vadose Zone –** The vadose zone is located between the surface zone and the smear zone. This zone is located above the water table under normal conditions and consists of unsaturated soil. Contaminants within this zone will migrate vertically downwards under the influence of gravity and will not be transported by groundwater flow. This zone varies in depth and thickness throughout the area. The top of the vadose zone always underlies the base of the surface zone. The base of the vadose zone corresponds to the maximum groundwater levels and the top of the smear zone. This depth averages approximately 4 feet north of the railyard and is approximately 10 feet in the vicinity of the railyard; as a result, the thickness of the vadose zone varies between 2 and 8 feet. In a few low-lying areas and close to the barrier wall, the base of the vadose zone may be as shallow as 2 feet below the ground surface or may even be absent because of high water levels that may intersect the ground surface.

- **Smear Zone –** The smear zone is defined as the range of depths within which the groundwater will fluctuate under normal seasonal conditions, and therefore, in which free product would move and "smear" the soil in response to these seasonal changes in the water level elevation. The smear zone soils may therefore be saturated or unsaturated with groundwater at any given time. In addition to groundwater fluctuations influencing contaminant migration, the contaminants may be transported laterally through the aquifer in the direction of groundwater flow by the movement of groundwater.

  The smear zone does not change seasonally but refers to a range of depths through which the groundwater table fluctuates seasonally. The top of the smear zone varies from a minimum depth of 2 feet near the barrier wall to a maximum depth of approximately 10 feet in the railyard. The base of the smear zone ranges from an approximate depth of 10 feet near the barrier wall and north of the railyard to a maximum depth of approximately 18 feet on the railyard. The thickness of the smear zone varies according to the groundwater elevation and the depth to groundwater; typically, it is 5 to 10 feet thick. In areas where the ground surface is much lower than the surrounding area, the smear zone is closer to the ground surface. The former Maloney Creek channel is an example of this. In the former channel, the depth to groundwater is typically very shallow and may actually be at the ground surface when the groundwater levels are high. Therefore, in the Maloney Creek area, the smear zone may extend to the ground surface

- **Saturated Zone –** The saturated zone is defined as the depths where groundwater is always present regardless of groundwater elevation fluctuations. This contrasts with the smear zone in which the soil is saturated with water for some of the year, and unsaturated for the remainder of the year. The top of the saturated zone is considered the base of the smear zone. Since free product floats on and near the water table, it does not enter the saturated zone. The base of the smear zone is the top of the saturated zone and occurs generally between 10 and 18 feet below the ground surface.

The positions of the vadose zone, smear zone, and saturated zone are shown on the schematic cross section shown in Figure 4-2. The smear zone is the zone outside the source area containing free and residual product.

3.1.1 Petroleum Hydrocarbons in Soil

Petroleum hydrocarbons are present within the surface zone, vadose zone and smear zone in parts of the site. Soil samples have been analyzed for TPH (as diesel and motor oil) using methods WTPH-D, NWTPH-Dx, NWTPH-D and EPA Method 418.1. In addition, fractionation data on specific carbon chain-length hydrocarbons were collected from samples at depth using EPH/VPH and selected soil samples have been analyzed for BTEX and PAHs.

3.1.1.1 Total Petroleum Hydrocarbons in Soil

The analyses show that TPH is present in the surface, vadose and smear zones within the railyard. The concentrations of TPH (diesel and oil) in vadose and smear zone soil are presented in Figures 7-2 though 7-6 of the Supplemental RI. In general, the surface and vadose zone impacts coincide with historical railroad operational areas that acted as sources of contamination, although some surface zone impacts were also caused by road asphalt. These operational areas included the fueling station and diesel tank, and areas topographically downgradient from the oil unloader pits, timber oil sump and oil pump house. Figure 3-3 presents the extent of petroleum hydrocarbons, measured as NWTPH-Dx, in vadose zone soil throughout the site.

TPH is more widespread in the smear zone. Figure 3-4 presents the extent of petroleum hydrocarbons, measured as NWTPH-Dx, in the smear zone soil throughout the site. Figures 3-3 and 3-4 have been revised since the data were presented in the Supplemental RI (RETEC, 2002a) to present NWTPH-Dx data (sum of diesel-range and oil-range hydrocarbons) and to ensure that the extent of contamination in the soil is consistent with the extent of TPH in groundwater and location of free product. In addition, Figure 3-4 has been revised to provide a conservative estimate of contamination for designing the remediation systems for the site.

In the smear zone, TPH is generally located in areas coincident with the vadose zone impacts and is hydraulically downgradient from those impacted areas. This reflects free product migration with groundwater downgradient (to the northwest) from the former operational areas. The maximum TPH concentrations are 78,000 mg/kg and 59,000 mg/kg in the vadose zone and smear zone, respectively (RETEC, 2002a – Table 7-2). No free product was present in the surface or vadose zone during the field sampling. The residual saturation in the vadose zone varies with differences in the lithology throughout the site. These data indicate that the residual saturation on the railyard may exceed 20,000 mg/kg. Soil in the saturated zone contains hydrocarbons at concentrations exceeding 20 mg/kg throughout much of the site, coincident with the smear zone, because the free product extends slightly below the water table. Therefore, the uppermost portion of the saturated zone may also be impacted with petroleum hydrocarbons. Figure 3-5 shows the estimated extent of petroleum hydrocarbons, measured as NWTPH-Dx in saturated zone soil.

The saturated zone samples (Table 7-4 Supplemental RI Report, RETEC, 2002) indicate that contamination has not been detected in soil more than 25 feet below ground surface. In addition, groundwater samples collected from wells (DW-1 through DW-5) completed below the silt have not contained detectable concentrations of hydrocarbons (RETEC, 1996). This indicates that the silt bed that underlies the site at approximately 15 to 25 feet is an effective barrier to vertical migration of contaminants.

3.1.1.2 Composition of Hydrocarbons in Soil

Diesel fuel and bunker C were historically used on the railyard. As such, the petroleum hydrocarbons present throughout the site consist of these two fuels in varying proportions. Soil was analyzed for diesel and bunker C using the NWTPH-Dx method. The NWTPH-Dx method reports TPH as diesel (C9 to C20) and oil (C20 to C32). Diesel fuel generally includes hydrocarbon ranges C9 to C20 whereas bunker C is a fuel mixture that generally contains both diesel range and oil range hydrocarbons (C9 to C32). Therefore, TPH-diesel analysis will provide the concentration of diesel fuel and/or the lighter hydrocarbons in bunker C within a sample, whereas TPH-oil will only provide concentrations of the heavier hydrocarbons present in bunker C. As a result the relative extents can be determined from the concentrations of TPH-diesel and TPH-oil; TPH-oil is used to assess the extent of bunker C only. Furthermore the ratio of TPH-diesel to TPH-oil indicates the relative proportions of diesel to bunker C within the samples. The diesel: oil ratio varies considerably throughout the site, indicating that the composition is not uniform; this is consistent with visual observations made during collection of the soil samples. These observations showed the product to be an emulsion (or immiscible combination) of bunker C and diesel. The geometric mean of the diesel: oil ratio for all soil samples is 1:1.3; however this ratio varies from a maximum of 10:1 to a minimum of 1:10. The ratio of diesel to oil also varies depending upon the depth from which the soil sample was collected. The geometric mean of ratios from the surface and vadose zones is 0.5, whereas the geometric mean of samples from the smear zone equals one. This indicates that there is relatively more diesel in samples below the high groundwater table than in the vadose zone. Diesel constitutes the lighter weight, more mobile hydrocarbons, and therefore this observation is not surprising.

3.1.1.3 Extractable and Volatile Petroleum Hydrocarbons in Soil

EPH/VPH samples have been collected from soil samples in the vadose, smear and saturated zones both inside and outside the railyard (RETEC, 2002a). These analyses indicate that the petroleum hydrocarbons consist mainly of C12 to C34 carbon ranges for aromatics and aliphatics; this is consistent with the diesel and motor oil range hydrocarbons present at the site and indicates that both diesel and bunker C are present in these samples. Further details of the hydrocarbon ranges detected in the soil samples are provided in Section 7.1 of the Supplemental RI (RETEC, 2002). A correlation has been developed between NWTPH-Dx and total EPH/VPH (Figure 3-6). The figure shows that a strong correlation exists between EPH/VPH and NWTPH-Dx in soil and that the reported concentrations of NWTPH-Dx will typically be approximately 1.24 times the concentration of total hydrocarbons measured using the EPH/VPH method.

3.1.1.4 Polynuclear Aromatic Hydrocarbons in Soil

PAHs have been reported in soil samples from the site; these are generally reported in the soil samples that contain the highest concentrations of TPH. These samples are in former source areas or in areas within the smear zone with free product or high concentrations of residual petroleum hydrocarbons. All PAHs that have been tested for have been detected in soil samples; the most widespread include acenaphthene, fluoranthene, fluorene and pyrene. Further details, including a more complete discussion of the results, are presented in Section 7.5 of the Supplemental RI.

3.1.1.5 Benzene, Toluene, Ethylbenzene, and Xylenes in Soil

BTEX compounds are not common constituents of the petroleum hydrocarbons, though low concentrations have been detected. The low BTEX concentrations are not surprising considering that the petroleum hydrocarbons used at the railyard are primarily composed of the heavier-end hydrocarbons, and that the releases occurred at least 30 years ago.

3.1.2 Metals in Soil

During initial investigations, arsenic and lead were identified as the primary metals of concern and are, therefore, the only metals that were subsequently investigated. Samples were collected primarily from surface zone soils; however, several samples were also collected from shallow subsurface soils.

3.1.2.1 Arsenic in Soil

Arsenic (Figure 3-7) is present at concentrations above MTCA Method A concentrations (20 mg/kg) on the railyard. The majority of samples with levels above 20 mg/kg were collected near current and former railyard facilities. The sources of arsenic in soil are not completely understood; arsenic is commonly associated with treated railroad ties and therefore the distribution may be associated with areas in which the ties were stockpiled. Arsenic is also frequently present in sandblasting grit, and therefore the arsenic may be associated with some historic sandblasting operations. Elevated arsenic concentrations have also only generally been detected within samples from the upper 2 feet of soil collected from the railyard. Only one deeper sample (MW-31 at 4 feet bgs) contained arsenic greater than 20 mg/kg; this sample contained arsenic at a concentration of 27 mg/kg.

3.1.2.2 Lead in Soil

Lead (Figure 3-8) is elevated above the site-specific background concentration of 24 mg/kg (as calculated in Appendix G) within some areas of the railyard that coincide with historical railyard operations. On the railyard, elevated lead concentrations coincide with historical operations. The potential sources of lead include sandblast grit, leaded-fuel train exhaust and paint. The maximum lead concentration (3,600 mg/kg) was detected in a surface sample (B-9) from the railyard. Within the railyard, lead concentrations are elevated in the surface soil only. Elevated lead concentrations are present in sporadic surface soil samples from outside the railyard; the sources of this lead are unknown. See Section 4.2.1 for additional details.

3.1.3 Polychlorinated Biphenyls in Soil

Low concentrations of PCBs are present near the former transformer pads on the railyard (Figure 3-9). The PCBs are localized in extent and have not been detected anywhere other than close to the site of the historic transformer pads on the railyard. Further details are provided in the *Supplemental RI Report* (RETEC, 2002a).

3.2 Free Product

This section describes the nature and extent of free product. The movement of free product via groundwater through soil is described in Section 4.2.3.

3.2.1 Physical Properties of Free Product

The predominant types of product used or stored at the railyard were historically bunker C and diesel. Fortnite oil (a kerosene-like product) was reportedly used as a cleaning solution during repair activities that occurred at the maintenance yard from the 1890s to the mid-1940s. In addition, gasoline, and waste oil have been used and stored on the railyard. Free product samples collected at the site are characterized as a mix of diesel and bunker C fuel, consistent with the predominant product types used on the site.

Bunker C is usually blended with lower-molecular-weight fractions, such as diesel, to decrease viscosity and improve flow characteristics. The groundwater contains 43 to 49 percent petroleum hydrocarbons in the diesel range, with the exception of MW-39, which contains approximately 21 percent petroleum hydrocarbons in the diesel range. The free product in well MW-39 consists primarily of bunker C fuel with little, if any, diesel.

Product characteristics have been determined by laboratory analysis of four product samples collected at the site (RETEC, 1996 – Table 6-11). These samples comprise a mixture of diesel and bunker C. The nature of the hydrocarbons in the samples was evaluated using Washington Method WTPH-HCID. Samples were obtained from the river seep near SED-4/SED-5 and from wells MW-22, MW-27 and MW-39, and analyzed for physical parameters including specific gravity, viscosity, surface tension and interfacial tension. The test results are summarized below:

- Specific gravity ranges between 0.9676 (MW-27) and 0.9922 (MW-39). This indicates that the specific gravity is relatively consistent, and that the specific gravity is slightly less than water (Specific Gravity = 1). Therefore, the product will float on water.

- Viscosity at 7.5 ºC (45 ºF) ranges between 1,035 centipoise (cP) (MW-27) to 95,350 cP (MW-39). This indicates that the viscosity varies greatly. This is probably due to the different product composition of the samples. The viscosity of lighter hydrocarbons present in diesel is much lower than the heavier hydrocarbons that are present in bunker C, and the chemical analyses demonstrate that sample MW-39 contains mainly heavier hydrocarbons. The lower viscosities are more typical of the free product present throughout most of the plume area and seeping into the river.

- Surface tension ranges from 33 dynes/cm (MW-22) to 39 dynes/cm (the river seep). Surface tension describes the force required to break the surface of the liquid. The surface tensions of the product samples are relatively consistent and lower than water (72.8 dynes/cm at 20 ºC).

- Interfacial tension ranges from 25 dynes/cm (MW-39) to 81 dynes/cm (MW-27). The other two samples contained interfacial tensions of 27 and 49 dynes/cm; this indicates that the value of 81 dynes/cm may be an overestimation since this number exceeds the surface tension of water and is disproportionately higher than the other sample results. Interfacial tension is the force required to rupture the interface between two liquids (in this case, the product sample and water. This varies considerably for the different samples; it indicates that the two liquids will remain fully separate rather than mixing.

3.2.2 Location and Extent of Free Product

Several discrete areas of free product are present within the site. A site-wide fluid gauging event was conducted in January and February 2002 for the *Supplemental RI*. Figure 3-1 shows the estimated extent of free product throughout the site based on the 2002 measurements. The areas of free product are discontinuous and are present both on and off the railyard. The "apparent" thickness of the free product within the plumes has been as great as 4 feet (in well MW-36); however, it tends to have an average thickness of approximately 0.5 foot (RETEC, 2002a). Between many of these areas of free product are areas of residual product. The lateral extent and location of free product measured in the monitoring wells changes as a result of water table fluctuations in the smear zone, expanding and contracting within a relatively constant overall area of residual product. This fluctuation also affects the product thickness measured in wells as LNAPL moves slowly with respect to water table changes. Fluid levels have been gauged from selected wells on a monthly basis since the site-wide gauging event in 2002. The fluid levels have been provided to Ecology in the monthly progress reports for the site. These measurements indicate that free product is also typically present on the railyard in wells MW-8, MW-6 and 2A-W-4.

Figure 3-1 also shows areas of suspected or potential free product. No data are available to confirm whether free product is present in these areas. Extrapolations from data in other areas of the site indicate that free product may be present in these areas; however they have not been included in the areas of known free product based on area soil quality data, and groundwater quality data.

The largest two free product plumes are present in the northwest part of the site, underlying residential and commercial properties. These two plumes have migrated downgradient from the source areas on the railyard since the original releases, and extend to the northwest and towards the South Fork Skykomish River. The migration of free product in the plumes has been curtailed by the installation of the hanging barrier wall in 2001 along West River Road. The rate of migration is slow, as in evidence that the plume is still present within the site, many years after the original releases. The actual rate of migration is not known. Oil was observed seeping into the South Fork Skykomish River as early as the mid-1920s.

Downgradient from the barrier wall, the extent of free product in the levee has not been determined from examination of soils in the levee or soil sample data. However, the locations of seeps in the river bank approximately line up with the plume locations south of the barrier wall; therefore, it is assumed that the plumes extend to the river and detailed delineation of the plume under the levee is not considered necessary for this Final FS.

The extent of free product, presented on Figure 3-1, is slightly different from the extent of free product presented in the Supplemental RI. This is based on a more extensive comparison between the fluid-level measurements and the soil and groundwater data, and because fluid levels have been measured from some additional wells (most notably 5-W-5) since the Supplemental RI was completed.

The rate of free product migration is slow, and the extent of free product does not appear to have changed significantly since the Draft RI (RETEC, 1996). The plume boundaries appear to fluctuate over time. The fluctuation may be due to changes in the water table elevation; therefore only general assumptions can be made from the product thickness data. The occurrence and thickness of free product has been measured from selected wells on a monthly basis. Table 3-1 presents fluid gauging results from selected wells for 2002 through 2004. These measurements indicate that the thickness of free product in a well may fluctuate over time. Figure 3-10 presents a graph of product thicknesses in MW-36. This shows that the product thickness can vary significantly without showing discernable trends on a monthly basis. Figure 3-10 also presents a hydrograph for the same time period. Comparison of the hydrograph with the product thickness indicates that there may be a negative correlation between product thickness and fluid levels; that is, the measured product is thicker when the groundwater levels are lower. The reason for this correlation is unclear, however it suggests that free product is trapped in the soil below the groundwater surface as the groundwater level rises. This is a reasonable conclusion, since the specific gravity of the LNAPL is close to that of water and the viscosity is higher than water. With respect to product migration, the rate of change can be measured in years;

therefore, the extent of free product can be considered relatively constant for purposes of estimating cleanup requirements.

3.3 Groundwater Quality

Water has been sampled from wells throughout the site to assess the impacts of site contamination on groundwater quality. The most extensive groundwater sampling was conducted for the Supplemental RI (RETEC, 2002a); it consisted of site-wide sampling during January 2002 and January 2003. These groundwater-sampling rounds included samples from approximately 50 monitoring wells, many of which were installed for the Supplemental RI. The Supplemental RI provided the most comprehensive data on groundwater quality for the site. Groundwater samples were submitted for analysis of TPH-Dx. Selected samples were also submitted for analysis of PAHs, BTEX, and/or EPH/VPH. In addition, one sample was submitted for PCB analysis.

3.3.1 Petroleum Hydrocarbons in Groundwater

Groundwater has been contaminated with petroleum hydrocarbons. All groundwater samples have been analyzed for TPH. Groundwater samples have also been collected from selected wells for PAHs, BTEX, and/or EPH/VPH. Groundwater samples were analyzed for PAHs, BTEX and EPH/VPH to provide additional information on the composition of the petroleum hydrocarbons, to provide information for the development of cleanup levels using MTCA Method B criteria, and in accordance with MTCA (WAC 173-340-900, Table 830-1).

3.3.1.1 Total Petroleum Hydrocarbons in Groundwater

TPH in groundwater was analyzed using method NWTPH-Dx. This method reports diesel range (TPH-D, C12–C25) and motor oil range (TPH-MO, C25-C36) organics. Groundwater samples were collected site-wide during January 2002 and January 2003. The January 2002 TPH data are presented in the Supplemental RI (RETEC, 2002a). The groundwater analyses from samples collected in January 2003 were re-reported to reflect detected concentrations between the method detection limit (MDL) and the reporting limit (RL). North Creek Analytical data reports for the re-reported data are provided in Appendix E. Figure 3-11 shows the extent of TPH (measured as NWTPH-Dx) in groundwater at concentrations above the MTCA Method B cleanup level (208 µg/L – see Section 5) that was measured during January 2003 and re-reported as described above. Table 3-2 presents the TPH data for both sampling events and includes the re-reported data. The TPH-D concentrations from the two sampling events ranged from below detection limit (0.25 mg/L) to 2.6 mg/L in 2002 and 3.33 mg/L in 2003. The highest concentration was present in 2A-W-6 during both sampling events. The highest concentration appears to be in the eastern part of the site. This relates to the eastern free-product plume that contains a higher diesel-to-motor oil ratio.

The TPH-Dx concentration generally was greatest in or close to the free product plumes in nearby areas that contain high concentrations of residual product. TPH concentrations in the area generally exceed 0.5 mg/L.

3.3.1.2 Polynuclear Aromatic Hydrocarbons in Groundwater

Groundwater samples from selected wells were analyzed for PAHs in January 2002 and in August 2002. The groundwater data (Table 3-3) indicate that concentrations of most PAHs in most groundwater samples were generally below detection levels during both sampling events. Where PAHs were detected, concentrations generally decreased between the two sampling events. The data showed that PAH occurrences are closely related to areas with free product on the railyard. PAHs are not detected in samples collected within 300 feet of the South Fork Skykomish River. PAHs may sorb to soil closer to the source and are not as mobile and will not transport as quickly as other chemicals in the plume. This 'partitioning' is another possible reason for the difference in chemical differences across the site.

Fluorene is the most widely distributed PAH, followed by acenaphthene. The data also show a compositional difference between dissolved PAH in the groundwater in the western part of the site and the groundwater in the eastern part of the site. The dissolved hydrocarbons in the western part of the railyard contain elevated concentrations of fluorene and low concentrations of acenaphthene, whereas the dissolved hydrocarbons in the southern and eastern parts of the railyard contain several additional PAHs. The reason for the variations are not fully understood, however the variations are consistent with changes in the hydrocarbon ranges present within the site and probably result from different sources across the railyard.

3.3.1.3 Benzene, Toluene, Ethylbenzene, and Xylenes in Groundwater

BTEX are not significant contaminants associated with the Former Maintenance and Fueling Facility. Groundwater samples from 31 wells were submitted for analysis of BTEX using EPA Method 8020 during the Supplemental RI. The BTEX components were below the detection limits in all samples except for toluene (1.80 µg/L) in MW-11. This is consistent with the BTEX results presented in the Draft RI Report (RETEC, 1996) Groundwater samples were also collected during August 2002 for BTEX analysis (Table 3-4). A comparison of the data collected during the two sampling events indicates that only two groundwater samples have contained BTEX compounds and no consistent trends are evident from the data.

3.3.1.4 Extractable and Volatile Petroleum Hydrocarbons (EPH/VPH) in Groundwater

Groundwater samples collected from 20 wells have been analyzed for EPH/VPH as part of the Supplemental RI. These analysis indicate that they detected fractions are the C10 to C34 aliphatics and C12 to C34 aromatics. EPH/VPH fractions were only detected in groundwater samples from five wells. Only the groundwater sample from MW-39, a well containing free product, contained detectable EPH/VPH in several fractions. EPH/VPH was detected in 2003 but not in 2002 from this well. The discrepancy indicates that free product may have been entrained in the 2003 sample whereas no free product was entrained in the 2002 sample. Furthermore, most of the EPH/VPH results from this well and the others report hydrocarbon fractions greatly above their respective solubility limits. This implies that, where detected, EPH/VPH in groundwater results from the presence of entrained free product in the groundwater samples.

Data collected from the site show no correlation between EPH/VPH and NWTPH-Dx analyses for groundwater. Figure 3-12 provides a comparison of the groundwater data to illustrate this lack of correlation.

3.3.1.5 Metals in Groundwater

The extent of elevated metals concentrations in groundwater has been evaluated in previous studies (RETEC, 1996; RETEC, 1997). These previous studies concluded that metals are not significant site groundwater contaminants, and that the metals appear to be at background concentrations.

3.3.1.6 Polychlorinated Biphenyls in Groundwater

PCBs were not detected in any wells during the 1996 RI. Thirteen wells located in the vicinity of previous PCB detections in soil or other areas of potential concern were sampled quarterly for PCBs. In 1993, PCBs were detected in well MW-32 at a concentration of 0.11 µg/L (Aroclor 1254). Groundwater samples from MW-32 were tested for PCBs during two quarters of the RI sampling and during the Supplemental RI; PCBs were not detected.

3.3.1.7 Physical Chemistry of Groundwater

For the Supplemental RI (RETEC, 2002a), groundwater samples from selected wells were analyzed for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, turbidity and temperature. The DO data indicate that dissolved oxygen concentrations from samples from wells within areas of known contamination or hydraulically downgradient from these areas (with the exception of MW-44, located west of the barrier wall) are below the detection limit of the field measurement instrument. Dissolved oxygen concentrations in groundwater samples that are not from areas with petroleum hydrocarbon contamination ranged from 0.2 to 5.4 mg/L, which is within the range of typical concentrations of dissolved oxygen in groundwater.

The lowest ORP values are generally present in wells in the vicinity of the railyard. Low ORP values can indicate anaerobic or anoxic conditions often seen in contaminated groundwater. Higher values are present in the wells in the western portion of the site, with the highest value in MW-44.

The pH, turbidity, conductivity, and temperature of groundwater were measured in the field during the Supplemental RI. A summary of the results is provided below.

- pH was 5.02 to 6.47 standard units
- Turbidity was 1.7 and 20.5 Nephelometric Turbidity Units
- Conductivity was 37 to 268 micromhos per centimeter (µmhos/cm)
- Temperature ranged from 2.8 to 8.6 ºC.

Additional details are provided in the Supplemental RI (RETEC, 2002a).

3.4 Sediment Quality

There are two separate areas of sediment affected by contaminants at the site, as described in Section 2.2.1. The first is along the south bank of the South Fork Skykomish River and the second is along the former Maloney Creek channel. The sediment quality in these two areas is summarized below.

3.4.1 South Fork Skykomish River Sediment

Sediment has been impacted by free product seeps and dissolved groundwater fractions entering along South Fork Skykomish River. The free product has resulted in high TPH concentrations (maximum TPH of 87,000 mg/kg) at the identified seep locations. The TPH concentrations decrease rapidly away from the actual seep locations and data indicates that impacts extend no more than ten feet into the river, and often considerably less.

Sediment along the bank of the South Fork Skykomish River has been sampled for the RI and the Supplemental RI (RETEC, 1996; RETEC 2002a). In addition, sediment samples were collected during 2002 for additional sediment bioassays; these samples were analyzed for TPH, EPH/VPH, BTEX, and PAHs. Additional sediment sampling was conducted during 2003 to establish cleanup levels for groundwater that protect aquatic organisms in sediment (RETEC, 2003). Figure 3-13 shows the extent of TPH in the sediment along the bank of the South Fork Skykomish River. The results from this testing and a more complete discussion of the sediment sampling are presented in Appendix A.

3.4.2 Former Maloney Creek Sediment

The former Maloney Creek channel and in adjacent areas were investigated as part of the Supplemental RI. Figure 3-11 presents a longitudinal transect from sample 3-SD-1 downstream of the culvert to 2B-SD-6 immediately downstream of the upper road culvert and five transverse transects. The profiles show that the fine-grained sediment is limited in vertical extent, and that although TPH is present within the shallow sediment, higher concentrations are present in the underlying sand and gravel. The contamination data is summarized on Figure 3-14 in two ways: (a) impacted (visual, odor, sheens, or product) soil noted during the drilling is indicated by cross-hatching, and (b) TPH-T (diesel and lube oil range) values from collected samples in the intervals indicated next to the boring.

The transects indicate that the following distinct segments can be identified in the former Maloney Creek channel, based on differences in topography and lithology. These areas are described in Section 2.2.2 and are summarized below.

1) An upstream segment with a steep gradient in which the channel is narrower and channelized between steeper banks, and essentially is a drainage ditch for the Old Cascade Highway and surrounding residential areas. This section contains silty sand (possibly older fill material) in the surface layers. The sample 2B-SD-6 is located at the point were the drainage ditch widens into a marshy swale.

2) A middle segment encompassing samples 2B-SD-5, 2B-SD-4 and 2B-SD-3. This area has a gentle gradient and wider profile and one to three feet of silty sediment typically overlays the alluvial sands and gravels typical of the area. This area is wooded and marshy, with slower water flow and presence of side channels and marshy swales. The section narrows just south of 2B-SD-5 by a private residence and adjacent yard. A pool area is present on the western end of this segment containing samples 2B-SD-2 and 2B-SD-1. At 2B-SD2 gravelly alluvial material reaches the surface and may represent an old riffle area with steeper slope. Downstream of 2B-SD-2 a deeper scour or plunge pool is present behind the road culvert. The plunge pool is filled with a foot of silt overlying 5 feet of silty sand. The pool area is marshy and open, lacking tree growth.

3) A segment downstream of the 5th Avenue/Old Cascade Highway culvert. This portion is a steeper, scoured channel, with limited accumulation of fines. This area has the characteristics of a creek. Sample 3-SD-1 was collected here.

Groundwater gauging data indicate that groundwater levels are located well below the bed of the channel during seasonal low groundwater levels. During measured seasonal highs the groundwater typically rises to within a foot of the channel, and at times groundwater may surface in the former creek bed. This is significant because it indicates that hydrocarbons that are typically contained in the sand and gravel that underlies the former channel may in some areas also affect the shallow sediment contained within the channel (i.e. the sediment is within the groundwater smear zone).

Low concentrations of TPH, up to 48 mg/kg, were detected in sediment from the upper segment.

The middle segment of the former Maloney Creek channel is underlain by contaminated sand and gravel in the smear zone below the surface sediment. This contamination in the smear zone is continuous with the affected property, and is similar in concentration, type, and hydrogeological characteristics to that found in the surrounding soils. In general, contamination is greater in the sand and gravel beneath the surface sediment and does not appear to be significantly impacting the sediment near the ground surface. This is illustrated on Figure 2-5, where it can be noted that visibly impacted subsurface soil is generally confined to the deeper gravel layers, as is the situation in the adjacent railyard. Near-surface concentrations of TPH are notably lower than in the visibly impacted deeper layers. This suggests that there appears to be no upwards transport component of contaminants in most of the former Maloney Creek channel.

However, in the area around 2B-SD-5, substantial contamination is present close to the ground surface, particularly immediately adjacent to the private residence at location 2B-B-4. This is the only area where the subsurface smear zone extends into the silty depositional material. This contamination could be due to smearing of underlying contamination in groundwater or possibly from historic drainage into the channel through an oil drain immediately upstream of 2B-SD-5 (Figure 2-2).

The lower segment (pool area) upstream of the culvert contains moderate contamination (500 mg/kg TPH) in the depositional surface layers. This area functions as a sink for contaminated sediment from upstream, as evidenced by the deep layer of sedimentary material at this location. Deeper sediment shows declining concentrations, indicating that older, historical releases, if any, are not resulting in significant deleterious impacts. No high concentrations of TPH indicative of residual contamination remaining from the time when active discharge occurred to the channel are present.

The channel section downstream of the culvert contains some contamination with TPH immediately downstream of the culvert, however the lower section is generally scoured free of fine-grained sediment, and therefore contamination is unlikely to accumulate in this area for extended periods of time.

The hydrocarbon composition provided by EPH/VPH data (RETEC, 2002a) indicates that the TPH is similar to that found elsewhere throughout the site, with heavier aliphatics and aromatics typical of diesel and motor oil range hydrocarbons (TPH-MO) predominant. PAHs were detected in the smear zone of the former channel, where TPH concentrations are highest; however, PAHs are generally absent from the surface sediment and underlying sediment (0 to 2.5 feet). Note that although surface sediment is defined as the top 10 centimeters, sample collection consisted of a composite of the top 2.5 feet, and is here used as an estimate for the surface sediment. BTEX is absent from the sediment, which is consistent with the soil and groundwater quality in this area. Metals (arsenic and lead) were consistent with background concentrations. PCBs were not detected within the sediment at quantitation levels generally in the 0.1 mg/kg range or less (RETEC, 2002a).

3.5 Surface Water Quality

Groundwater from the site recharges the two surface water bodies in the study area: the South Fork of the Skykomish River and, more occasionally, the former Maloney Creek channel. Free product seeps migrate slowly into the river throughout much of the year, and groundwater with dissolved petroleum hydrocarbons flows into the river. The river level seasonally varies with flow. There are generally two high and low flow periods each year. One of the periods of high flow generally occurs in November through early March, the other high flow period occurs between May and July during runoff from snowmelt.

Seeps have not been observed during high flow conditions. This is probably largely because the seepage face is submerged under several feet of fast flowing river water. The seeps are also likely to be less during times of high water because the hydrostatic pressure from the higher river water would form resistance to seepage, and the water would also lower the temperature of the product and increase the viscosity, resulting in more limited product mobility.

During low water conditions, the riverbank is typically dry and there are either pools of water close to the bank or low flowing water. The seeps are more noticeable during these times and product seeps may lead to sheens on the water close to the bank, or accumulate in pools of low/no flowing water. Booms have been placed and maintained along the riverbank as an interim cleanup action, to contain the product close to the actual seep locations. Absorbent pads and pom-pom booms are used to clean up seeped petroleum. Surface water samples were collected from seven locations in the South Fork Skykomish River, Maloney Creek and the former Maloney Creek channel on four occasions during the RI (RETEC, 1996). Historical correspondence dated from 1926 to 1931 suggests that free product releases to the South Fork Skykomish River may have been more extensive in the past. Product was reported in these correspondences to have been observed in 1930 at one location a few miles downgradient from the Site. Recent surface water samples show that there are generally no impacts to surface water in the South Fork Skykomish River, Maloney Creek, or the former Maloney Creek channel (Table 11-15, RI Report, RETEC, 1996).

Surface water temperature, pH, DO and conductivity were collected as part of the RI sampling (RETEC, 1996). These data indicate that the water in both the South Fork of the Skykomish River and the former Maloney Creek channel is neutral to basic (6.6 to more than 10 standard units [su]), has relatively low conductivity (22 to 338 µmhos/cm), and is well oxygenated (greater than 9 mg/L DO). No significant differences were noted between the river readings and those from the creek.

3.6 Air Quality

Air monitoring was conducted during drilling and excavations for the RI and Supplemental RI (RETEC, 1996: RETEC 2002a). This monitoring indicated that vapors from petroleum hydrocarbons have not adversely impacted air quality. This data demonstrates that there is no significant potential for migration of volatile compounds to the air from impacted soil and groundwater. During health and safety monitoring for the Supplemental RI, readings of total volatile organics taken during sampling were consistently non-detect in the breathing zone, with the exception of one reading of 0.5 parts per million (ppm) during sediment sampling. Volatile organics were only detected at appreciable levels during hollow-stem auger drilling of boring B-10, and from the top of the casing during air rotary drilling of boring B-7.

In most cases, detected values correspond to wells with measurable free product accumulations. Only four compounds have estimated air concentrations that total greater than 0.00001 mg/kg, including mercury, 2-methylnaphthalene, butyl benzyl phthalate, and xylenes.

Indoor air sampling was performed under the 1993 Agreed Order with Ecology in six buildings between 1997 and 1999. Samples were analyzed for an extensive suite of VOCs by EPA Method IP-1A and SVOCs by EPA Method IP-7. Indoor air was sampled in response to requests by Skykomish residents. The Washington State Department of Health (WDOH) in its "Health Consultation" dated August 30, 1999 concluded that 'exposure to contaminants detected in indoor air over the seven sampling events are not at concentrations expected to pose a health threat' and that 'there were no apparent public health hazard from exposure to contaminants detected in any of the locations' and communicated this conclusion to the public by issuing an "Environmental Health Update" in June 1999 (WDOH, 1999) and presenting their findings at a public meeting in Skykomish.

3.7 Summary of the Nature and Extent of Contamination

The following summarize the conclusions of the nature and extent of contamination:

- The most common contaminant at the site is petroleum hydrocarbons. These have been measured as TPH, PAH, BTEX and EPH/VPH in compliance with WAC 173-340-900, Table 830-1.

- It is estimated that several plumes of free petroleum product are present at the site. These plumes are present on the railyard, in residential and commercial areas, and along the riverbank as free product seeps through portions of the riverbank west of the Skykomish River Bridge.

- The highest concentrations of petroleum hydrocarbons in soil, groundwater and sediment are typically present in the same location as free product.

- Petroleum hydrocarbons are present in the surface and vadose zone in historical source areas on the railyard and limited areas off the railyard. These areas may contain high TPH concentrations in the surface zone and vadose zone soil, but do not always coincide with the highest concentrations of TPH in smear zone soil.

- TPH is more widespread in the smear zone, and is typically found in both the soil and groundwater. This distribution is due to migration of petroleum hydrocarbons as free product with groundwater downgradient from the original source areas.

- Free product has migrated to the South Fork Skykomish River and is seeping through the banks into the river. The impacts to sediment in the South Fork Skykomish River appear to be restricted primarily to those seep locations.

- Shallow sediment in the former Maloney Creek channel, adjacent to the railyard, has been impacted. The shallow sediment in the creek is underlain by sand and gravel with high TPH concentrations similar to the condition observed in surrounding smear zone soils. The sediment contamination may result from smearing from the underlying soil at times of high groundwater levels.

- Elevated concentrations of lead and arsenic are present in some soil on the railyard. These concentrations are restricted to the surface zone soil.

- Lead and arsenic are not elevated in groundwater.

- There are some isolated areas with lead in surface soil in the residential/commercial area north of the railyard. The source(s) of this lead are unknown.

- PCBs have been detected in surface soil from portions of the railyard. The PCBs are generally present in the vicinity of the former substation and old transformer pads.

- PCBs have not been detected in smear zone soil or in groundwater anywhere throughout the site.

This Final FS summarizes the nature and extent of contaminants based on data collected to date for the RI (RETEC, 1996), Supplemental RI (RETEC, 1999) and other referenced investigations. Some public comments expressed concern that certain areas that should have been sampled were not sampled, and that the lack of data from these areas constituents data gaps. These areas include the Former Channel of Maloney Creek, the area south of the Former Channel of Maloney Creek and the flood control levee on the South Fork Skykomish River.

The main comments concerning the Former Channel of Maloney Creek are that the channel may have followed a difference course and that there may have been other low-lying areas into which contaminants could have migrated while releases were occurring, and that the former channel bed itself has not been sampled. In addition, there were comments that samples collected from the current channel bed were too shallow. BNSF does not believe additional sampling is necessary in this area because historical records such as the 1926 Sanborn map indicate that the course of the former Maloney Creek channel is unchanged since the mid-1920s and that no additional low-lying areas were connected to the former channel of Maloney Creek.

The comments regarding the area south of the Former Channel of Maloney Creek request that additional soil samples are collected south of the Old Cascade Highway to place a southern boundary around the contamination adjacent to the former Channel of Maloney Creek. BNSF does not believe that additional sampling is needed in this area because this area is upgradient of the historic source areas, and there were no formerly existing transport pathways to transport contamination to these areas.

The comments relating to the levee state that the nature and extent of contamination under the levee is unknown. BNSF does not believe additional sampling is needed in this area because the seeps into the South Fork Skykomish River appear to be downgradient of the free product plumes upgradient of the barrier wall. The extent of free product in the levee is closely related to the upgradient plume locations and it is unnecessary to advance boreholes through the levee at this time to confirm the conclusion that free product is present under the levee.

Ecology has collected additional soil and groundwater samples from areas mentioned in the public comments. These data have been used, as applicable, to revise the maps depicting the nature and extent of contamination. The investigation logs and data are presented in Appendix F. BNSF completed extensive, additional sampling during the Supplemental RI in response to public comments and comments form Ecology.

3.8 Indicator Hazardous Substances

This section identifies indicator hazardous substances for purposes of defining site cleanup requirements. Indicator hazardous substances are the compounds found at the site that are most prevalent and comprise the greatest risk to human health and the environment at the site. Also, by focusing site cleanup on these compounds, the majority of the risk at the site is eliminated.

MTCA allows for the elimination "from consideration those hazardous substances that contribute a small percentage of the overall threat to human health and the environment. The remaining hazardous substances, or indicator hazardous substances (IHSs) can be implemented at sites that are contaminated with a large number of hazardous substances" for monitoring during "any phase of remedial action for the purpose of characterizing the site or establishing cleanup requirements for the site" (WAC 173-340-703). The use of IHSs in development of a final remedy for this site is appropriate, because from the large number of chemicals, only a few have been detected commonly and only a few contribute to a significant overall threat. The RI and Supplemental RI (RETEC, 1996; RETEC, 2002a) were designed to investigate the presence and distribution of all hazardous substances at the site.

The data collected for the RI and Supplemental RI was rigorously screened to develop the list of IHSs for the Skykomish site. Note that TPH is considered an IHS for all media, and was not subjected to the screening process. Details of the analysis are presented in Appendix G. This information is summarized below by medium and in Table 3-5:

- In addition to TPH, soil at the site has eight IHSs: arsenic, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo-(k)fluoranthene, chrysene and indeno(1,2,3-cd)pyrene.

- In addition to TPH, the sediment has the following four IHSs: lead, benzo(a)anthracene, benzo(b)fluoranthene and chrysene.

- The groundwater IHSs consist of TPH, benzo(a)anthracene, chrysene and fluoranthene.

- Surface water does not contain any IHSs as such, other than TPH; however, since groundwater discharges to surface water and groundwater must be protective of surface water, the IHSs for groundwater will also apply to surface water for purposes of developing cleanup levels in Section 5.

The distribution and movement of IHSs is summarized in Section 4, as part of the Conceptual Site Model.

4 Conceptual Site Model

Data collected during the RI, Supplemental RI and interim actions provide all the information necessary to understand the nature and extent of contamination and potential exposure to human health and the environment at Skykomish. This section of the Final FS synthesizes the available data into a conceptual model of contaminant occurrence, movement, and potential exposure. The conceptual site model presented herein is primarily qualitative in nature and serves to translate available physical, chemical, and biological data into an accurate narrative and graphical representation of site conditions. The model serves as a useful aid to the development of cleanup standards and cleanup action alternatives that are the subject of Sections 5 though 10 of this Final FS.

4.1 Source Characterization

There are no active, operating sources of hazardous substances at the Site. Past releases from storage facilities and from former fueling and maintenance activities at the facility are the presumed original primary sources of contaminants. Three distinct areas can be defined on the basis of historical structures and known operations. These areas are the maintenance area, fueling area, and the substation and sandblasting area. Railcar and locomotive maintenance activities were conducted at the engine house, turntable, machine and boiler shop, and areas immediately east of these structures. Fueling operations were performed at the fueling stations, concrete oil unloader pits and oil pump house. Finally, transformer pads near the east substation were used to store electrical transformers, and in the 1960s the substation was used as a sandblasting facility.

There are no continuing primary sources of hazardous substance releases at the site. All existing contamination derives from historical releases that occurred during operation of the Former Fueling and Maintenance Facility (from 1893 to 1974). Historical releases (e.g. spills, leaks, discharges) from storage facilities and former fueling and maintenance activities are the presumed primary sources of contaminant release. A search of historical records revealed no documentation of fuel or other contaminant releases.

Figure 2-2 shows three generally contiguous primary source areas (Maintenance, Fueling, and Electrical Substation/Sandblasting), defined on the basis of historical records of structures and known operations. The three areas are all located east of 5th Street between the existing rail lines and the former Maloney Creek channel.

Potential secondary sources of contamination are areas currently containing free product in the smear zone and vadose zone soil.

4.2 Indicator Hazardous Substances and Impacted Media

The conceptual site model focuses on contamination of soil, groundwater, surface water and sediment arising from releases of metals (primarily arsenic and lead), petroleum fuels and PCBs (Table 4-1). The analysis of all hazardous constituents detected at the site (see Section 3.3) demonstrates that risks to human health and the environment are dominated by these contaminants.

In Section 5, cleanup levels are ultimately established for metals, petroleum hydrocarbons, select PAHs and the more updated IHSs detected at the site (e.g., PCBs). However, near-surface metal deposits within the railyard and the magnitude and impact of petroleum fuel releases, are the central driving force behind the development and evaluation of cleanup action alternatives presented in this Final FS.

With the exception of near-surface soil, the IHSs at the site are TPH and the PAH associated with the TPH residues. The TPH is relatively free of volatile contaminants (BTEX) that are common to lighter fuels (e.g., gasoline). Surface soil (0 to 2 feet bgs) is considered separately from deeper soil in this analysis because metals are found predominantly only in surface soils.

The following sections demonstrate how the IHSs listed in Table 4-1 have or have not migrated from their source.

4.2.1 Metals

The nature and extent of metals contamination at the site were described extensively in Section 3.1.1. Lead and arsenic are the only metals IHSs at the site. Moreover, soil is the only medium that contains metals above background and IHS screening levels. The distribution of metals is largely confined to the railyard where potential sources resulted from railyard operations such as coal-burning locomotives, sandblasting, use of lead-containing fuels, painting and other metal-producing activities. Consistent with these near-surface source activities, metal impacts are confined to surface and near-surface (less than 5 feet bgs) soil. Further, there are no observable groundwater impacts from these near-surface metal deposits. This suggests that dissolution of metals into surface water and infiltration of surface water to groundwater is not detrimental to groundwater quality.

Soil sampled off the railyard contained occasional and sporadic detections of lead and arsenic above background. The source(s) of this lead and arsenic is unknown.

4.2.2 Petroleum Hydrocarbons

The nature and extent of petroleum hydrocarbons at the site is described extensively in Section 3. The source(s) of these contaminants were releases of petroleum fuels during operation of the former fueling and maintenance facilities. While these sources no longer exist, the resulting impacts to soil and groundwater quality require an assessment of exposure risks (Section 4-4) and development of cleanup standards (Section 5).

A continuing impact of the historical petroleum releases on soil and groundwater quality results from the presence of free and residual product in the subsurface. Free product (oil) discharges to the river are observed at a number of seep locations opposite the levee and west of 5th Street. The residual product (i.e., that which does not appear as a distinct separate layer or move as a separate phase under the influence of gravity and groundwater flow conditions) serves as a secondary source of petroleum hydrocarbons that dissolve in groundwater, which ultimately discharges to the river. Therefore, knowledge of the characteristics and behavior of free and residual product and its interaction with groundwater and soil is important to understanding current site conditions.

4.2.2.1 Characteristics and Behavior of Free and Residual Product

LNAPLs or "light nonaqueous phase liquids" can describe both free (mobile) and residual product. MTCA defines LNAPL as a "hazardous substance that is present in the soil, bedrock, groundwater or surface water as a liquid not dissolved in water." LNAPLs derived from petroleum fuels are complex mixtures of organic (carbon-based) molecules with slight solubility in water. The term "light" refers to the density of petroleum liquids as typically being less than that of water. The term "nonaqueous" refers to the fact that petroleum liquids are not miscible with water (i.e., they do not mix with and fully dissolve in water to form a single phase). Instead, LNAPL exists as a separate phase in contact with water and soil particles. LNAPL at the Skykomish site is derived from releases of petroleum fuels (primarily diesel and bunker C fuel oil) used at the Former Fueling and Maintenance Facility.

The general character and behavior of free and residual product in the subsurface environment is illustrated on Figure 4-1. MTCA defines "free product" as LNAPL "present in the soil, bedrock, groundwater or surface water as a distinct separate layer" and "capable of migrating independent of the direction of flow of groundwater or surface water." Figure 4-1 graphically depicts contaminated and uncontaminated soil conditions. LNAPL that reaches the water table remains near the groundwater table because the density of the LNAPL is less than that of water. Once at the water table, LNAPL becomes "free product." As the water table fluctuates seasonally, related to river level changes and precipitation events, the free product rises and falls with the groundwater level and "smears" the soil within the fluctuation interval. The "smear zone" is generally defined by the seasonal low water level at the base, and the seasonal peak high water level at the top. The buoyancy of product in water inhibits LNAPL migration below the seasonal low water table.

Petroleum hydrocarbons and water share soil pore space (Figure 4-1). This sharing limits product mobility and complicates its recovery from the subsurface. Released product migrates downward through the vadose zone under the influence of gravity. Above the groundwater table, volatile product components, where present, separate into soil gas and form vapor plumes local to the release. This is not a significant concern at the Skykomish site based on empirical data obtained from indoor air sampling during seven sampling events at six residences and structures throughout town (refer to Section 5.2.1.4 for additional discussion). Upon reaching groundwater, the product spreads laterally and begins to dissolve into groundwater, thereby forming the dissolved-phase plume (Figure 4-1(5)). Typically, dissolved-phase plumes attenuate via biological processes over short distances (e.g., a few hundred feet) (Wiedemeier et al., 1999). Over extended periods of time, the product is degraded and the most soluble compounds weather out of the product, leaving behind a mixture of low-solubility compounds that collectively have a relatively high viscosity. The viscosity of product samples taken from the site is very high (Table 4-2) compared with values typical of diesel and bunker C fuel oil; this is one indication that the product at the Site is highly degraded.

The soil medium within which LNAPL exists is physically described as a porous medium consisting of solids (e.g., soil grains) and void space (soil pores). The void spaces in soil contain water (Figure 4-1(1)). Above the water table (vadose zone) air coexists with water in the pore space. Water is preferentially attracted to the solid surfaces, forms a continuous wetting phase about the soil grains, and fills the smaller pore spaces. Thus, water occupies the margins of the pore space, leaving the remaining central portions filled with air (a non-wetting fluid).

LNAPL flows downward through the vadose zone as a non-wetting phase that partially displaces air between soil particles (Figure 4-1(3)). Water remains on the particles as a continuous wetting phase. If the LNAPL is of sufficient volume (as was the case at the Skykomish site until the mid-1970s), then the LNAPL will eventually reach the groundwater table. Here, the LNAPL displaces water from the interior regions of the soil void or pore space (Figure 4-1(4)) and becomes "free product." Selective entry of free product into larger pores reflects the fact that it is physically easier for free product to displace water from large pores than smaller pores.

Initially, free product occurs in the smear zone as a continuous network of interconnected pores that contain product (Figure 4-1(4)). The product is surrounded by water that forms a continuous liquid phase about the solids. Product does not float above groundwater as suggested by the analogy of oil floating on water in a tank. Instead, product is largely submerged and its movement is constrained by the pressures needed to displace water from the pores at the margins. Product can move when it has sufficient volume to overcome these pressures.

Water and LNAPL coexist in the pores under different pressures. The difference in pressure between the product (non-wetting phase) and water (wetting phase) is defined as capillary pressure. Capillary pressure is a result of the two liquids (water and product) having different densities. This property governs the distribution and potential mobility of product in groundwater. The greater the pressure in the non-wetting phase (e.g., LNAPL), the more fully the pore space is filled (saturated) by the non-wetting phase.

The fraction of pore space occupied by LNAPL decreases over time as the volume of LNAPL is depleted. Depletion occurs from the volumetric movement of free product in the direction of groundwater flow and attenuation processes such as dissolution. With depletion, free product flow paths become smaller and more tortuous. This reduces the ease with which free product can move (mobility). Ultimately, the free product then breaks into isolated blobs and ganglia that are discontinuous and immobile as a separate residual liquid phase (Figure 4-1(6)).

Residual product is present wherever LNAPL has come into contact with soil. Thus, source areas where releases occurred and areas in the path of LNAPL migration contain residual product. Residual product is "trapped" in the soil pores by capillary pressures and will not flow under the influence of gravity or groundwater flow.

Residual product is immobile and not "free product" but may remain a source of dissolved contaminants in groundwater. In the smear zone (the depth zone through which fluid levels fluctuate), soluble fractions of petroleum are dissolved and mobilized from the residual product until an insoluble residue remains. This is different than residual product left in the vadose zone (the unsaturated zone above the smear zone) that will not move under the force of gravity. Residual product in the vadose zone is also subject to dissolution, but because the smear zone is below the groundwater table some of the time, the rate of dissolution is likely to be greater within the smear zone.

MTCA (WAC 173-340-747(10)(b) defines residual saturation as the "concentration of hazardous substances in the soil at equilibrium conditions. At conditions above the residual saturation, the NAPL will continue to migrate through the soil due to gravimetric and capillary forces and may eventually reach the groundwater, provided a sufficient volume of NAPL is released." This definition implies that the term residual saturation refers to the vadose zone only. This residual saturation concentration depends on the physical properties of the product and the soil. Following dispute resolution, Ecology has imposed the following standard for residual saturation of TPH in soils – 2,000 mg/kg. BNSF respectfully disagrees with this decision and reserves the right to seek review of Ecology's decision to the full extent provided under by law.

4.2.2.2 Influence of the Barrier Wall on Free Product

The barrier wall constructed parallel to the South Fork Skykomish River in August 2001 was part of an interim action to block free product from entering the river. The barrier wall extends from near the ground surface (above the water table) to below the seasonal groundwater table. The free product, which tends to move with groundwater, is thereby prevented from moving further downgradient towards the river and is collected in recovery wells. Seeps observed since the barrier wall construction are attributable to free product that existed under the levee between the barrier wall alignment and the river.

The barrier wall was constructed to allow groundwater to flow around and beneath the wall, but prevent downgradient movement of free product. In the absence of product removal, mobile free product is expected to accumulate behind the barrier wall.

Groundwater generally flows in a northwesterly direction along most of the barrier wall. Groundwater elevation and flow direction near the wall have been largely unaffected by the barrier wall. Therefore, mobile free-phase LNAPL should continue to migrate toward the wall and recovery wells.

4.2.2.3 Dissolved Petroleum Hydrocarbons Groundwater

Both residual and free product are sources of groundwater contamination at the site. Individual chemical constituents of product dissolve into the passing groundwater in accordance with chemical and physical properties of the product and soil at this site. In the absence of natural degradation, these properties control the distribution of TPH constituents dissolved in groundwater. Once released into groundwater, the dissolved TPH constituents are subject to natural attenuation, such as resorption to soil particles, volatilization, dispersion, dissolution and biodegradation.

The data show that dissolved-phase TPH in groundwater is distributed in a manner that is very similar to TPH in soil. The data also show that dissolved contaminants in groundwater attenuate rapidly with distance from free product and residual LNAPL in soil. This is consistent with the generally accepted understanding of petroleum LNAPL dissolution and attenuation as reported in the literature.

4.3 Conceptual Model Summary

Figure 4-2 provides a physical conceptualization of impacts to the site. The figure summarizes and integrates existing knowledge of site geology, hydrogeology and contaminant distribution as previously discussed in this and previous sections of the Final FS. The figure is a cross section of the town from the Old Cascade Highway south of the railyard to the river north of the railyard. The geology is generalized based on information from boring logs. The seasonal high and low groundwater table defines the region labeled as the "smear zone."

Petroleum releases in former maintenance and fueling areas at the site deposited fuel (LNAPL) on the ground surface. The LNAPL migrated vertically downward into the subsurface under the influence of gravity. While a portion of the LNAPL accumulated within soil pores above the groundwater table (vadose zone) and ceased moving (residual), the releases were of sufficient volume to migrate to the water table where the LNAPL forms a discrete layer and becomes free product. Further vertical movement of product through the water table was precluded by the density differential between water and the product. Consequently, the free product spread in the upper horizon of the water table both laterally and in the direction of groundwater flow. Over time and under the influence of the prevailing hydraulic gradient, free product migrated in a north to northwesterly direction beyond the railyard boundary to the South Fork Skykomish River where seeps of free product are currently observed. These seeps resulted in sediment impacts near the south embankment of the South Fork Skykomish River where groundwater recharges the river.

Residual hydrocarbon contamination in the vadose zone is restricted to the railyard where petroleum fuel was originally released and migrated from the surface vertically to the groundwater table. Free product is mainly found downgradient of the railyard within the smear zone, where it has migrated towards the river under the influence of groundwater flow. Groundwater in contact with free and residual product in soil becomes contaminated by dissolution of hydrocarbon constituents into the dissolved phase. The plume of dissolved-phase hydrocarbon contamination migrates downgradient, eventually entering the river and impacting surface water and sediment quality. Data indicate that the dissolved hydrocarbon plume attenuates rapidly with increasing distance from areas of free and residual product in soil and that removing free product from the soil and groundwater will protect surface water. Subsurface soils underlying the former Maloney Creek channel are composed of sand and gravel, generally overlain by a thin layer of silt. The former Maloney Creek channel area consists of a deeper smear zone continually hydrologically connected to surrounding soils to the north and south of the wetland, and a shallower zone with intermittent hydrologic contact with the surrounding soil. The deeper sand and gravel is contaminated with high concentrations of TPH, however, the biologically active portion of sediments within the wetland (upper 10 cm) is largely unaffected except during very high groundwater conditions. These sporadic, high groundwater events may introduce contaminants from underlying smear zone soil into shallow wetland sediment, but if this does occur it appears to result in concentrations of less than 500 mg/kg in the biologically active zone.

Downstream bedload transport of sediment occurs during periods of heavy surface runoff. At these times, contaminated sediment may be mobilized and trapped upstream of the culvert. This is the likely source of the contamination noted in the surface sediment in this area. Sediment trapped here has filled in an old plunge pool. The decreasing concentrations at depth in older, deeper sediment suggest that the hydrocarbon contamination degrades or dissociates from the sediments over time. Discharges from the period of railyard operations when oily contamination was evident in the channel are no longer observed in the former Maloney Creek channel or its associated wetlands.

4.4 Exposure Assessment

This section identifies potential human and ecological exposures to contaminated media at the site. Consistent with WAC 173-340-350(1), this section identifies exposure scenarios that will assist in the selection of a cleanup action. Cleanup actions developed in this Final FS must "protect human health and the environment (including, as appropriate, aquatic and terrestrial ecological receptors)" (WAC 173-340-350(8)(c)(i)(A)). In order to evaluate cleanup actions, the cleanup standards must be determined. As outlined in WAC 173-340-700(5), in order to set the cleanup standards applicable to cleanup actions, the following issues must be determined:

- Nature of the contamination
- Potentially contaminated media
- Current and potential land and resource uses
- Current and potential receptors
- Current and potential pathways of exposure.

The nature of contamination and impacted media were described previously in Section 3. This section describes current and potential receptors and pathways of exposure, based on current and potential land and resource uses. Figure 4-3 is a conceptual site model illustrating potential exposure pathways present at the site.

4.4.1 Current and Potential Land and Resource Uses

Cleanup levels must derive from reasonable maximum exposures, defined as the "highest exposure that is reasonably expected to occur at a site under current and potential future site use" (WAC 173-340-708(3)(b)). This section identifies the current and future potential uses of resources where contaminated media are known or suspected to be present. The resources under consideration here are land, groundwater, surface water and sediment. The land resource may be divided into railyard and off-railyard areas.

4.4.1.1 Railyard

Most of the railyard property is currently zoned "Industrial" by the Town of Skykomish. The depot area (south of Railroad Avenue, between 3rd and 5th Street) is zoned "Public" and is within the locally-designated "Historic Commercial" area. This zoning designation is in accordance with land use planning under chapter 36.70A of the RCW (Growth Management Act). The railyard is currently used as industrial property by BNSF, and the most likely future use of the property is industrial. Trespassing is prohibited on the railyard and the general public is only permitted to cross the yard using the public right-of-way (5th Avenue). The depot building and property is currently not open to the general public. If it is opened in the future to the general public, such as for historic preservation purposes, potential exposures would be comparable to a commercial property. In response to the community's request, BNSF installed a fence along the former Maloney Creek to reduce trespassing from the residential areas south of the yard. The BNSF railyard property is "industrial property" for purposes of GMA and MTCA (RCW 70.105D.030(2)(f) and WAC 173-340-200).

4.4.1.2 Off-Railyard – Developed Property

The current land uses of impacted off-railyard properties are residential, commercial (restaurants, hotels, stores), municipal (town offices and garages), and educational (Skykomish School). Some of the properties (notably the town garages) may meet the requirements for designation as industrial property. However, for the purposes of this exposure assessment, the highest beneficial use of the developed properties off of the railyard is assumed to be residential. In addition to human health, ecological receptors must be protected as part of cleanup actions.

4.4.1.3 Off-Railyard – Undeveloped Property

Undeveloped property exists to the south of the railyard along sections of the former Maloney Creek channel and along the south bank of the South Fork Skykomish River. These areas of undeveloped property are generally wooded. The narrow strip along the South Fork Skykomish River serves as part of the King County Department of Natural Resources flood-control dike for the South Fork Skykomish River. Future development in this area is unlikely.

A portion of the former Maloney Creek channel and surrounding wooded areas exist off railyard property. There are no known development plans for this area, and due to the proximity of this land to the railyard and other residences, no development is foreseen. However, the highest potential land use for these areas remains residential.

As these areas currently are vegetated with non-cultivated plants, and may support animal life, they are potential habitat for ecological receptors as discussed in Section 2.

4.4.1.4 Groundwater

Groundwater contaminated with TPH and PAHs exists under the railyard and both developed and undeveloped off-railyard properties. Generally, the highest beneficial use of groundwater is as a source of drinking water (WAC 173-340-720(1)(a)). However, shallow groundwater in the impacted area of the Skykomish site is not a current source of potable water in Skykomish, nor will it likely be used as a source of potable water in the future.

WAC 173-340-720(2) sets forth criteria for determining whether the highest beneficial use of groundwater is potable water. Of these criteria, two are met at this site.

- ***The groundwater does not serve as a current source of drinking water* – WAC 173-340-720(2)(a)*.***

  Shallow groundwater is not currently used as a source of potable water in Skykomish. The public water supply wells for the Town of Skykomish are located approximately 0.5 mile upgradient of historic site operations and are screened about 200 feet bgs in fractured rock, presumably at the surface of the bedrock layer underlying the uppermost alluvial aquifer.

- ***The department determines it is unlikely that hazardous substances will be transported from the contaminated groundwater to groundwater that is a current or potential future source of drinking water at concentrations that exceed groundwater quality criteria* WAC 173-340-720(2)(c), WAC 173-200).**

  As stated above, current drinking water wells for Skykomish are located upgradient of the impacted groundwater plume. Based on gauging performed over at least 10 years, groundwater flow in the upper aquifer underlying the site is consistently toward the South Fork Skykomish River. Locally reversed gradients along the shoreline were observed during two pre-RI gauging events (October 1990 and December 1991). This is most likely due to transient increases in water levels in the river; the reversed gradient extended only slightly into the residential area near the river – approximately 100 to 150 feet. Further, based upon our knowledge of groundwater flow in river basins, it is correct to assume that groundwater flows toward the river.

> In addition, the drinking water wells are screened to approximately 200 feet bgs. Five deep (35 to 40 feet bgs) monitoring wells have been installed at the site; none of these have ever had detectable levels of TPH. Well DW-5, located near the recovery system and screened below the LNAPL layer, has been sampled 10 times between 1993 and 1997; TPH has never been detected. Based on this data, the plume of dissolved TPH attenuates within a short distance (less than 25 feet) below the LNAPL plume. Therefore, because the drinking water wells are located upgradient of site impacts and are screened much deeper than any known groundwater contamination beneath or downgradient of the site, it is impossible that hazardous substances in groundwater underlying the site would be transported to the vicinity of the public water supply wells.

WAC 173-160-171(3) provides an additional regulatory requirement that makes the use of groundwater in the vicinity of the Skykomish site unlikely. WAC 173-160-171(3) requires that wells shall not be located within certain minimum distances of known or potential sources of contamination, including septic systems. The minimum setback specified in WAC 173-160-171(3)(b) is 50 feet from a septic tank, septic holding tank, septic containment vessel, septic pump chamber, and septic distribution box and 100 feet from the edge of a drain field. It is estimated that the commercial and residential portions of the site are all subject to this setback requirement, as the property owners all use septic systems for wastewater management. These regulatory requirements, along with the availability of public water supply, make use of shallow groundwater in the vicinity of the site as a potential source of drinking water highly improbable.

Other potential users of groundwater are industry, businesses and agriculture. In order to extract groundwater for these uses, groundwater wells are required. There are no known existing groundwater extraction wells for agriculture in Skykomish, nor are there industrial processes with high water demand which may desire groundwater extraction to support these processes. Siting for wells to be used for industrial, commercial, and agricultural is also required to meet the setback requirements in WAC 173-160-171(3). As such, there is no current or reasonable potential future human use of groundwater in Skykomish. However, since the criterion listed in WAC 173-340-720(2)(b) is not applicable to the site, in cannot be determined that groundwater is not a potential future source of drinking water.

Despite the unlikelihood of human use of groundwater in Skykomish, cleanup actions for groundwater in Skykomish must prevent direct or indirect violations of surface water, sediment, soil, or air cleanup standards (WAC 173-340-720(1)(c)). As groundwater discharges to the South Fork Skykomish River and, at times, to the former Maloney Creek channel, highest beneficial use of these water bodies must be protected; that is, groundwater must be protected as a potable water source.

4.4.1.5 Surface Water

WAC 173-340-730(1)(a) states that cleanup standards for surface water (South Fork Skykomish River and former channel of Maloney Creek) are "based on estimates of highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions." WAC 173-201A defines the Skykomish River as a Class AA river. Characteristic uses of Class AA rivers include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish, wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment), commerce and navigation. As discussed above, the water supply for Skykomish comes from wells upgradient of the town, not from the South Fork Skykomish River. However, this does not preclude downstream use of the river for any of these purposes.

4.4.2 Potential Receptors

For the purposes of this exposure assessment, receptors and receptor activities are identified based on the highest beneficial use of each resource, as required in WAC 173-340-708(3)(b). This section discusses receptors that may be present at the site, based on the beneficial uses identified in the previous section, and observed land and water uses in the Skykomish area.

4.4.2.1 Residents

The highest beneficial use of most of the railyard is industrial. However, trespassers have been observed on the railyard and have the potential to contact surface soil. Trespassers are assumed to visit the railyard only briefly (in transit across the railyard) and are typically not frequenting areas where access is limited by fencing.

Residential use is the highest beneficial use of property off the railyard. Current and future residents of the Town of Skykomish may garden or landscape in the surface soil (i.e., off railyard property), and may have basements that extend into the impacted subsurface soil. Residents do not typically excavate to subsurface soil.

4.4.2.2 Industrial Railyard Workers

Industrial railyard workers are typically not engaged in construction work that would involve excavation on the railyard. However, these workers may directly contact surface soil during day-to-day maintenance activities.

4.4.2.3 Construction and Utility Workers

Construction and utility workers engaged in excavation work on or off the railyard have the potential for exposure to surface soil, subsurface soil, and groundwater.

4.4.2.4 Recreational Users of the South Fork Skykomish River

Humans use the South Fork Skykomish River for recreational purposes, such as rafting, kayaking, fishing, and boating. Thus, the potential exists for human receptors to contact contaminated surface water and sediments of the South Fork Skykomish River, and to ingest fish from the river.

4.4.2.5 Terrestrial Ecological Receptors

Under WAC 173-340-7490(2), a terrestrial ecological evaluation must be performed unless conditions allowing exclusion of such evaluation are met. Ecology has determined that a site-specific terrestrial ecological evaluation must be performed. A full terrestrial ecological evaluation was completed and submitted to Ecology on March 26, 2004, and it is included as Appendix D. The TEE concluded that TPH risks to soil invertebrates are present throughout the site, and developed a site-specific cleanup level (SSCL) of 1,870 mg/kg TPH. The TEE also found that, while risks are potentially present on the railyard the pathway is incomplete, and therefore the SSCL would not apply to the railyard. BNSF completed the TEE at Ecology's direction, but continues to respectfully disagree with the agency's policy of treating developed residential areas as "contiguous undeveloped land" under WAC 173-340-7490(1)(c)(ii).

4.4.2.6 Ecological Receptors in the South Fork Skykomish River

The South Fork Skykomish River is habitat for fish, shellfish, and sediment-dwelling organisms, as discussed in Section 2.2.6. These are the most sensitive users of the surface waters near the site. Other potential downstream receptors (e.g., water users) encounter very low contaminant concentrations, due to the dilution that occurs within the river. Downstream receptors typically involve larger organisms (i.e., livestock), which tend to be less sensitive to low-level contaminant exposures. Cleanup actions to protect in-stream organisms will protect downstream water users.

4.4.2.7 Ecological Receptors in Former Maloney Creek Channel/ Wetlands

Ecological receptors in wetlands are present in and around the former Maloney Creek channel. Fish use the wetland and ditches connected to the wetland. The wetland characteristics, habitat and potential ecological receptors are characterized in Section 2.2.6 and Appendix B.

The same assumptions cited above for the South Fork Skykomish River apply to the former Maloney Creek channel. The ecological receptors in the creek are considered the most sensitive receptors, and scenarios evaluating these receptors will adequately address potential impacts to other downstream receptors.

4.4.3 Transport Mechanisms

Figure 4-3 depicts the mechanisms (shown with purple arrows) by which contaminants (summarized in Section 4.2) can be transported and thereby lead to a potential exposure to the receptors described in Section 4.4.2. These mechanisms are summarized below.

4.4.3.1 Surface Soil to Water

Contaminants in surface soil may be mobilized (dissolved or sorbed to soil particles) by stormwater. The stormwater may then infiltrate to groundwater, or may travel over the surface, generally to storm drains, which in turn, lead to the South Fork Skykomish River. During flood events there is potential of free product being carried to the ground surface by groundwater. This would only occur if the groundwater rose above the ground surface during a flood, and even then, is only likely to occur close to the barrier wall. If this occurred, there would be potential for oil to be carried away with the flood waters. There is no evidence that this has ever occurred anywhere within the Site.

4.4.3.2 Free Product to Water

Free product moves in the direction of groundwater flow under potentiometric forces (i.e., hydraulic gradient). Contaminants enter the dissolved phase of groundwater after leaching from soil or free product or following infiltration of contaminated stormwater. The dissolved phase contaminants are then transported with the movement of groundwater. Groundwater at the site moves toward, and discharges to, the South Fork Skykomish River.

4.4.3.3 Soil, Groundwater, and Free Product to Indoor Air

Contaminants sorbed to surface soil (e.g., on the railyard) can be transported by wind. Wind-blown transport of lead and arsenic from soil to air is a complete exposure pathway, and will be evaluated further in this document. As shown on Figure 4-3 and discussed in Section 3.6, volatilized contaminants may be present in ambient air or may accumulate in confined spaces. See Section 2.4.3 regarding interim actions being taken by BNSF to control dust.

4.4.4 Potential Receptor Exposures

This section discusses the potential for receptors to encounter IHSs via one of the exposure or transport mechanisms identified previously. Figure 4-3 depicts these potential receptor exposures (highlighted in green).

4.4.4.1 Industrial Worker Exposures (on Railyard)

Routine railyard industrial workers are typically engaged in maintenance work and have the potential for contact with contaminated surface soil on the railyard. Direct contact, inhalation and incidental ingestion are the potential means of industrial worker contact with surface soil. Exposure to volatilized contaminants in outdoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Railyard industrial workers are unlikely to be involved in excavation work that could lead to contaminated subsurface soil and groundwater exposures. Further, exposure to contaminated storm water flow is considered a negligible exposure pathway.

4.4.4.2 Construction and Utility Worker Exposures (On and Off Railyard)

Construction and utility workers may be exposed to contaminated surface soil, subsurface soil and groundwater while excavating. Direct contact, inhalation and incidental ingestion are the potential means of worker contact with these contaminated media. Exposure to volatilized contaminants in outdoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Exposure to contaminated stormwater flow is considered a negligible exposure pathway.

4.4.4.3 Residential Exposures

Residents of the Town of Skykomish may contact contaminated surface soil off the railyard via direct contact or inhalation of soil transported off the railyard by wind. Exposure to volatilized contaminants in indoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Residents who enter the railyard (trespassers) and come into contact with surface soil have the potential for occasional and very minor short-term exposures to surface soils. Residents who conduct redevelopment work on their homes may be exposed to contaminated subsurface soils, groundwater, vapors and free petroleum product. However, deep excavation work is typically contracted out to commercial workers.

4.4.4.4 Terrestrial/Ecological Exposures

Terrestrial receptors have the potential for exposure to contaminated groundwater at the riverbank, where groundwater discharges to the South Fork Skykomish River. Deep roots of plants or terrestrial receptors drinking water near the potential groundwater discharge locations in the South Fork Skykomish River or former Maloney Creek channel may ingest groundwater.

Groundwater may recharge the former Maloney Creek channel during prolonged periods of heavy precipitation coupled with a rise in groundwater table. During these conditions, aquatic organisms have the potential to come into contact with contaminated groundwater.

4.4.4.5 Recreational User Exposures

Recreational users of the South Fork Skykomish River have the potential to come into contact with contaminated groundwater and free product at the riverbank (direct contact and incidental ingestion) where groundwater discharges to the South Fork Skykomish River. Further, recreational users of the river may contact surface water that has been impacted by contaminated groundwater (and free product LNAPL) discharges to the river. Exposure to contaminated surface water further away from the riverbank is a minor risk as the fast-moving surface water flow quickly dilutes the upland discharges to inconsequential contaminant concentrations.

4.5 Summary

The information presented in this section serves as the foundation for development of cleanup standards and cleanup action alternatives under MTCA. As presented in Section 5, cleanup levels are developed for the IHSs based on their potential for migration to other media and for exposure to various human and ecological receptors.

Figure 4-3 illustrates the complete human and ecological conceptual site model. This figure illustrates how the IHSs can potentially affect human health and ecology by migrating through soil, stormwater, groundwater, and surface water to potential receptors. In summary, complete exposure pathways are summarized in the following sections by media. They are summarized by media because cleanup levels are developed for each receptor by media in Section 5.1. The cleanup actions that will mitigate these exposure pathways are described in the following sections of this report.

4.5.1 Soil

The following human populations have the potential for exposure to soil:

- Industrial Worker (on railyard) to surface soil
- Construction and Utility Workers (on and off the railyard) to surface and subsurface soil
- Residents (on railyard) to surface soil
- Residents to subsurface soils (off the railyard while excavating)
- Residents (on and off railyard) through the soil to outdoor air by exposure to vapors or windblown particulates.

In addition,

- Terrestrial receptors have the potential for exposure to soil
- IHSs in soil can migrate to groundwater; therefore, cleanup levels are developed in Section 5 for concentrations of soil that protect groundwater.

As such, in Section 5, cleanup levels are developed for human health, ecology, and soil concentrations that protect groundwater.

4.5.2 Groundwater

The following summarize potential receptors to IHSs in groundwater:

- Construction and Utility Workers (on and off the railyard to groundwater while excavating)
- Residents (off the railyard to groundwater while excavating)
- Receptors to sediment due to the transport mechanism of groundwater to sediment
- Aquatic receptors to surface water due to the transport mechanism of groundwater to surface water
- Recreational users of the South Fork Skykomish River and Maloney Creek due to the transport mechanism of groundwater to surface water.

As such, in Section 5, cleanup levels are developed for human health, groundwater concentrations that protect sediment, and groundwater concentrations that protect surface water.

4.5.3 Sediment

The potential receptors to IHSs in sediments are biota that dwell in, and feed on and from, the sediment.

4.5.4 Surface Water

No IHSs other than TPH have been detected in surface water; however, surface water (specifically South Fork Skykomish River and Maloney Creek) directly affects recreational, terrestrial, and aquatic receptors. To ensure that the health of these receptors is protected, groundwater IHSs are used to calculate cleanup levels for these receptors.

Cleanup levels are developed for human health and ecological receptors in Section 5.

5 Cleanup Standards

MTCA provides the framework for evaluating and selecting cleanup actions, as described in Section 1.1. Within this framework are threshold requirements that must be met by all cleanup actions. The threshold requirements for cleanup actions, as defined in WAC 173-340-360(2)(a), are to:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal law
- Provide for compliance monitoring.

Other MTCA requirements for cleanup actions, as identified in WAC 173-340-360(2)(b), are to use permanent solutions to the maximum extent practicable, to provide for a reasonable restoration time frame, and to consider public concerns raised on the draft cleanup action plan during the public comment period. WAC 173-340-360(2)(c) through (h) identifies additional minimum requirements for cleanup actions. The potential for human health and ecological exposures to the IHSs at the site were evaluated in Section 4. This section develops cleanup standards for the site that protects these human health and environmental receptors. This section also identifies the state and federal laws that are applicable to the site and cleanup actions at the site. As described in Section 1.1, under MTCA, cleanup standards consist of the following:

- The concentration of a hazardous substance that protects human health and the environment (cleanup level)

- The location on the site where the cleanup level must be attained (point of compliance)

- Other regulatory requirements that apply to a cleanup action because of the type of action and/or the location of the site.

Each of these is discussed below, to the extent necessary. Subsequent sections of this FS identify and evaluate alternative means of achieving site cleanup.

5.1 Indicator Hazardous Substances

IHSs in addition to TPH were identified through a detailed screening process, as described in Section 3.8 and Appendix G. The IHSs applicable to different media, in addition to TPH, are also summarized in Section 3.8 and include lead, arsenic, and some PAHs. Cleanup standards are developed later in this section for comparison to site concentrations, and in many cases the cleanup levels will be the same as the screening levels used to select the IHSs in Appendix E.

5.2 Cleanup Levels

Cleanup levels under MTCA are defined as the concentrations of hazardous substances that are protective of human health and the environment under exposure conditions (e.g., the exposure scenarios developed in Section 4). Cleanup levels are developed for IHSs in media that pose a threat to human and ecological receptors, as summarized in Section 4.4. The relevant IHSs were identified in Section 3.8 and Appendix G for soil, groundwater, sediment, and surface water. Ecology has requested that applicable MTCA cleanup levels be compiled for all 16 PAHs, PCBs, lead and arsenic for all media for completeness although many of the PAHs, PCBs, lead and arsenic were not identified as IHS for some or all media based on the screening in Section 3.8 and Appendix G.

MTCA provides three methods for developing cleanup levels for soil, groundwater and surface water:

1) Method A defines cleanup levels for 25 common site chemicals and is generally designated for routine cleanups

2) Method B determines cleanup levels at sites using a site-specific risk assessment with cancer risk levels established at 10^{-6} for individual carcinogens and 10^{-5} for total site risk, and non-cancer risk at or below a hazard index of 1

3) Method C determines cleanup levels for specific site uses (i.e., industrial) using site-specific risk assessment when Method A and B levels are technically impossible to achieve.

Since the cleanup for the site is not considered routine, Method A values will not be used for this site. Method B cleanup levels are applicable to all sites and will be used at this site. Although the railyard is zoned for industrial use, the off-railyard areas are zoned residential, commercial, municipal, and educational; therefore, Method C cleanup levels will not be used. Method B will be used to develop cleanup levels for soil, groundwater and surface water for all areas of the site.

MTCA also requires that cleanup levels for each media be at least as stringent as the concentrations established under applicable state and federal law. The applicable state and federal standards for each media will be identified in the following subsections. Figure 5-1 illustrates the general approach to setting Method B cleanup levels at the site.

Sediment cleanup standards are defined under MTCA in WAC 173-340-760, which requires compliance with WAC 173-204 (Sediment Management Standards [SMS]). Under WAC 173-204-520(1)(d), freshwater sediment cleanup screening levels and minimum cleanup levels are determined on a case-by-case basis consistent with the intent of the SMS, which is to “eliminate adverse effects on biological resources and significant health threats to humans” (WAC 173-204-100(2)).

Cleanup levels are set for soil, groundwater, sediment, and surface water. For each of the environmental media, potential exposures to human health and the environment were evaluated in Section 4. Those exposures include the potential migration of IHSs from one media to another. For example, soil cleanup levels must not only protect the people who may come into direct contact with the soil, but also ensure that the ground water cleanup levels are not exceeded. For each of those potential exposure pathways, including the exposure to other media, protective concentrations must be developed (refer to Figure 5-1 for the relationship between cleanup levels for the various media). The cleanup level is the most stringent of those concentrations.

5.2.1 Soil

Consistent with the potential complete exposure pathways discussed in Section 4.4, cleanup levels are developed for human and ecological (terrestrial) receptors in this section. In addition, cleanup levels are developed for soil for two transport mechanisms: soil to groundwater and soil to air. The soil cleanup levels are established in accordance with WAC 173-340-740.

Under Method B, soil cleanup levels must be at least as stringent as each of the following concentrations:

- Concentrations established under applicable state and federal laws
- Concentrations that protect human health
- Concentrations that protect the environment (terrestrial ecological receptors)
- Concentrations that protect ground water quality
- Concentrations that protect air quality.

5.2.1.1 Concentrations that Protect Human Health

The establishment of soil cleanup levels that are protective of human health depends on the reasonable maximum exposure expected to occur under both current and future site use conditions. MTCA defines “reasonable maximum exposure” as the highest exposure that can be reasonably expected to occur for a human or other living organisms at a site under current and potential future site use [WAC 173-340-200]. As described in Section 4.4.1, land use across the site varies. The rail yard is currently used as industrial property by BNSF, and the most likely future use of the property is industrial. The highest beneficial use of off rail yard properties is residential. The regulation allows for the establishment of soil cleanup levels based on two types of land use: unrestricted land use and industrial land use. Unless a site qualifies as an industrial property, soil cleanup levels must be based on unrestricted land use. See WAC 173-340-745(1).

At the site, although the rail yard is an industrial land use, the surrounding areas are residential, commercial, and recreational. Consequently, soil cleanup levels will be based on unrestricted land use.

Soil cleanup levels protective of human health were determined using Equations 740-1, 740-2 and 740-3 (WAC 173-340-740) based on a soil direct contact exposure pathway.

PAHs

Values for the PAHs were obtained from the CLARC v3.1 (Ecology, 2001a).

Total PCBs

Method B values for PCB mixtures are not available. However, the Method A Soil Cleanup Level for total PCBs is 1 mg/kg, based on applicable federal law.

Metals

For arsenic, the MTCA Method B cleanup level is the Ecology background concentration of 20 mg/kg. The MTCA Method B value for lead will be the cleanup level that is based upon preventing unacceptable blood lead levels and calculated by the IEUBK model (250 mg/kg).

Total Petroleum Hydrocarbons

Ecology prepared a technical memorandum (Ecology, 2004) that sets forth the various TPH cleanup levels applicable to the site and documents their derivation. The Method B soil TPH cleanup levels for unrestricted land use are based on the *Worksheet for Calculating Soil Cleanup Level for Direct Contact Pathway: Method B – Unrestricted Land Use (MTCATPH10.xls)* spreadsheet tool provided on Ecology's website was used to perform the calculations required by Equation 740-3 for petroleum mixtures. Petroleum hydrocarbon fractionation data obtained from EPH/VPH analysis of soil samples was used to perform the calculations. A technical memorandum documenting the procedures used for establishing the EPH/VPH dataset is included as Appendix H. See Appendix I for information regarding other site-specific input parameters for the four-phase model.

Iterations of the model were made for each sample to ensure that the back-calculated TPH concentration satisfied four sub-criteria:

1) Hazard index = 1
2) Total cancer risk =1 x 10^{-5}

3) Cancer risk due to benzene = 1 x 10^{-6}
4) Cancer risk due to cPAHs = 1 x 10^{-6}.

The median TPH concentration was selected as the cleanup level for a specific soil zone. Cleanup levels based on direct contact and developed by Ecology for the vadose and smear zone soil are 2,130 and 2,765 mg/kg TPH (by EPH/VPH method), respectively. Ecology assumed TPH was present at half the detection limit for TPH fractions that were not detected. Ecology also assumed direct contact by a child ingesting 200 mg of soil per day for 6 years, and an acceptable cancer risk of 1 in 100,000.

5.2.1.2 Concentrations that Protect the Environment

Terrestrial Ecological Evaluation

The establishment of soil cleanup levels that are protective of the environment requires a terrestrial ecological evaluation (TEE) under certain circumstances. The regulation establishes a tiered process for evaluating potential risks to terrestrial ecological receptors. This process is set forth in WAC 173-340-7490 through 173-340-7494. WAC 173-340-7491 provides for specific exclusions from the TEE requirements. Certain site circumstances provide an exclusion from any further ecological evaluation at a site because the contaminants either have no pathway to harm the plants or animals, e.g., they are under buildings or deep in the ground; or there is no habitat where plants or animals live or forage near the contamination; or finally, the contamination does not occur at concentrations higher than what is found naturally occurring in the area. Ecology has determined that residential areas around the railyard are "contiguous undeveloped property" such that the site does not qualify for an exclusion. At Ecology's direction, BNSF prepared a site-specific TEE per WAC 173-340-7493. This evaluation is included in Appendix D along with subsequent, related Ecology correspondence dated April 23, 2004.

Ecology has determined the following soil cleanup level necessary to protect terrestrial invertebrates, such as earthworms: 1,870 mg/kg NWTPH-Dx. A separate site-specific value was not developed for plants because there are no available toxicity reference values. For protection of wildlife (mammalian herbivores such as shrews and avian predators such as owls), the MTCA default value of 6,000 mg/kg NWTPH-Dx may be appropriate for areas of the site where this exposure pathway is of concern. Ecology did not require a soil cleanup level for non-petroleum contaminants.

Environmental Effects

Ecology's December 10, 2004 technical memorandum sets forth a TPH concentration in soil of 175 mg/kg NWTPH-Dx and VPH/EPH calculated using the four-phase model that results in no adverse effects in the propagation of wildlife, fish, and other aquatic life. This cleanup is based on the groundwater-to-surface water pathway, groundwater cleanup level of 700 μg/L NWTPH-Dx. The 700 μg/L NWTPH-Dx groundwater cleanup level is, in turn, based upon whole effluent toxicity testing (WET testing) as discussed below in Section 5.2.4.2.

Sediment Recontamination

As discussed in Section 5.2.2.2, groundwater concentrations must not exceed 208 μg/L NWTPH-Dx and VPH/EPH to protect aquatic organisms in sediment. Using the four-phase model, Ecology calculated the soil concentration needed to ensure that groundwater meets 208 μg/L NWTPH-Dx and VPH/EPH (Ecology, 2004). The median value resulting from calculations performed using the VPH/EPH data set is 22 mg/kg NWTPH-Dx and VPH/EPH.

5.2.1.3 Soil Concentrations that Protect Groundwater

Ecology's December 10, 2004 memorandum sets forth the following cleanup level for TPH in soil to protect groundwater – 77 mg/kg VPH/EPH. This value is based on four-phase model calculations to yield a soil TPH concentration that is protective of groundwater to drinking water quality (i.e., hazard index of one).

Ecology has also determined that a vadose zone soil cleanup level protective of groundwater is equal to the MTCA default residual saturation value of 2,000 mg/kg NWTPH-Dx (Ecology, 2004). This value is based on preventing groundwater contamination by gravity flow of fresh diesel from the vadose zone to the groundwater table.

5.2.1.4 Soil Concentrations that Protect Air

Metals

Constituents in soil that could impact air include wind-blown arsenic and lead to outdoor air. Arsenic and lead are identified as IHSs for soil. As discussed in Section 4, a potential exposure pathway that must be addressed is particulate dispersion and subsequent inhalation of these compounds. However, the MTCA Method B cleanup levels shown in Table 5-1 based on direct contact are also protective of this exposure pathway. Therefore, the most stringent soil cleanup levels for lead and arsenic are 250 and 20 mg/kg, respectively.

TPH

As set forth in Ecology's December 10, 2004 technical memorandum, the cleanup level for TPH in soil to protect air is 2,900 mg/kg. This value was derived using the four-phase model and the average VPH/EPH composition of the six available vadose zone samples.

Selected Soil Cleanup Level

Ecology has determined that the lowest soil cleanup level concentration is 22 mg/kg NWTPH-Dx and VPH/EPH and, hence, is the soil TPH cleanup level for the site. MTCA allows for use of the practical quantification limit (PQL) as the cleanup level if the cleanup levels derived under Method B are lower than the PQLs achievable by the laboratory analytical method used to measure concentrations. The PQL for VPH/EPH is 5 mg/kg for each hydrocarbon fraction in soil or sediment. For a total of 12 hydrocarbon fractions, the PQL is 60 mg/kg. The PQL for NWTPH-Dx is 25 mg/kg for petroleum hydrocarbons consisting primarily of diesel fractions. However, the NWTPH-Dx method also indicates 100 mg/kg is the expected PQL for a heavy oil product (Ecology, 2004). The manner in which PQLs and method detection limits will be handled during compliance monitoring has not yet been determined. Thus, 22 mg/kg VPH/EPH is the lowest value of the above soil cleanup levels.

5.2.2 Groundwater

As summarized in Section 4.4, cleanup levels are developed for human receptors in this section. In addition, cleanup levels are developed for two transport mechanisms: groundwater to sediment and groundwater to surface water. The groundwater cleanup levels are established in accordance with WAC 173-340-720.

Under Method B, groundwater cleanup levels must be at least as stringent as each of the following concentrations:

- Concentrations established under applicable state and federal laws
- Concentrations that protect human health
- Concentrations that protect sediment quality
- Concentrations that protect surface water quality.

5.2.2.1 Concentrations that Protect Human Health

The establishment of groundwater cleanup levels that are protective of human health depends on the classification of groundwater as either potable (a current or potential source of drinking water) or non-potable. The classification of groundwater depends on the highest beneficial use expected to occur under both current and future site use conditions. Although site groundwater is not considered a source of potable water, the highest beneficial use of water must be protected as a potable source, as groundwater recharges to the South Fork Skykomish River and potentially to the former Maloney Creek channel.

Groundwater cleanup levels that protect human health through the groundwater ingestion pathway can be calculated by using MTCA Method B and also by considering drinking water standards established under applicable state and federal laws. These include:

- MCLs established under the Safe Drinking Water Act (SDWA)
- Maximum contaminant level goals (MCLGs) for noncarcinogens established under the SDWA
- Secondary MCLs established under the SDWA
- MCLs established by the state board of health.

The MTCA Method B criteria for PAHs, PCBs, arsenic and lead were obtained from the CLARC v3.1 table (Ecology, 2001a).

Per WAC 173-340-720(4)(b)(iii)(C), Ecology's *Worksheet for Calculating Method B Potable Ground Water Cleanup Levels (MTCATPH10.xls)* was used to perform the calculations required by Equation 720-3 for petroleum mixtures. Ecology performed model runs using the entire VPH/EPH groundwater dataset. Iterations of the model were made to ensure that the back-calculated TPH concentration satisfied four sub-criteria:

1) Hazard index = 1
2) Total cancer risk =1 x 10^{-5}
3) Cancer risk due to benzene = 1 x 10^{-6}
4) Cancer risk due to cPAHs = 1 x 10^{-6}.

Ecology derived a TPH cleanup level of 477 µg/L VPH/EPH in groundwater that would be protective of human health based on potable use. The limited groundwater VPH/EPH dataset for the site contains very few detected TPH fractions. As a result, this cleanup level is skewed by TPH fractions that have never actually been detected in groundwater (where half of the detection limit is used as input in the model) and by the assumed distribution of these TPH fractions that have never been detected in groundwater. During the remedial design process and the initial phases of long-term groundwater monitoring, additional EPH/VPH groundwater data will be collected and this cleanup level can be refined, as appropriate.

5.2.2.2 Concentrations that Protect Organisms in Sediment

Ecology has set forth the cleanup level for TPH in groundwater to protect sediments as 208 µg/L NWTPH-Dx and VPH/EPH (Ecology, 2004).This value was calculated using the EPA Equilibrium Partitioning Model for Sediment, assuming a hydrocarbon distribution derived from a sediment sample analyzed by VPH/EPH methodology. This concentration protects against sediment recontamination above the numeric sediment cleanup level of 40.9 mg/kg NWTPH-Dx (See Section 5.2.3).Concentrations that Protect Beneficial Uses of Surface Water

Because groundwater discharges to the Skykomish River and the former Maloney Creek channel, groundwater cleanup levels must also be sufficiently stringent to ensure that groundwater does not cause surface water to exceed cleanup levels established for surface water based on human health protection. As presented in Section 5.2.4, 500 µg/L NWTPH-Dx based on fish consumption and 477 µg/L VPH/EPH based on potable water use are protective of surface water.

5.2.2.3 Selected Groundwater Cleanup Level

The most stringent criteria for TPH in groundwater, 208 µg/L NWTPH-Dx and VPH/EPH, is based on protection of aquatic organisms in sediment (refer to Table 5-1). However, since some of the cleanup levels in Table 5-1 are lower than practical quantitation limits (PQLs), cleanup levels for groundwater and surface water are compared to the PQLs. The published PQL is 50 µg/L per VPH EC range. Historically, a PQL of 20 µg/L per EPH EC range has been achieved. A PQL of 250 µg/L is established in the NWTPH-Dx method for petroleum hydrocarbons consisting primarily of diesel fractions. However, the method also indicates 500 µg/L is the expected PQL for a heavy oil product. The application of PQLs and method detection limits will be addressed in a compliance monitoring plan, as required by MTCA.

5.2.3 Sediment

As summarized in Section 4.4, cleanup levels are developed for ecological receptors including fish, shellfish and sediment-dwelling organisms in this section. The IHSs in sediments at the site include lead, PAHs and TPH.

Sediment cleanup standards are defined under MTCA in WAC 173-340-760, which requires compliance with WAC 173-204 (Sediment Management Standards [SMS]). Under WAC 173-204-520(1)(d), freshwater sediment cleanup screening levels and minimum cleanup levels are determined on a case-by-case basis consistent with the intent of the SMS, which is to "eliminate adverse effects on biological resources and significant health threats to humans" (WAC 173-204-100(2)). Sediment quality standards are determined within the range set by the sediment cleanup objective of no adverse effects at the minimum cleanup levels (WAC 173-204(4)).

No chemical specific cleanup criteria have been defined for freshwater sediments (WAC 173-204-520(1)(d)). Procedures for setting cleanup levels in Puget Sound marine sediments using sediment toxicity bioassays are defined in WAC 173-204-570. An approach similar to the procedures defined for marine sediment was applied at this site, using site-specific acute and chronic sediment toxicity bioassays on a suite of three species (Microtox®, *Hyalella azteca*, and *Chironomus tentans*) analogous to the marine sediment procedures. The bioassay results are presented in Appendix A and can be used to define the area of impacted sediments requiring cleanup.

Based on the bioassay results in Appendix A, Ecology has derived a sediment TPH value of 40.9 mg/kg NWTPH-Dx for use in back-calculating a groundwater cleanup level protective of sediment dwelling organisms (see Section 5.2.2.2) (Ecology, 2004). Thus, 40.9 mg/kg NWTPH-Dx is the numeric sediment cleanup level. However, Ecology has determined that bioassay pass/fail results may be used in lieu of or in combination with chemical analyses of sediments (Ecology, 2004) to define the area of sediment requiring cleanup. This performance based cleanup level will be referred to as "the bioassay cleanup level for sediment" throughout the remainder of this document. PQLs for sediment are the same as those reported for soil in Section 5.2.1.5. The application of PQLs and method detection limits will be addressed in a compliance monitoring plan, as required by MTCA.

5.2.4 Surface Water

The surface water cleanup levels are established in accordance with WAC 173-340-730.

Under Method B, surface water cleanup levels must be at least as stringent as each of the following concentrations:

- Concentrations established under applicable state and federal laws
- Concentrations that protect human health
- Concentrations that protect the environment (aquatic ecological receptors).

5.2.4.1 Concentrations that Protect Human Health

The establishment of surface water cleanup levels that are protective of human health depends on the reasonable maximum exposure expected to occur under both current and potential future site use conditions. The reasonable maximum exposure for surface water at the site is discussed in Section 4.4 and is based on classification of the Skykomish River as a Class AA River. Therefore, the highest beneficial use of surface water at the site may include water supply, fish and shellfish, wildlife habitat, and recreation.

No IHSs were identified for surface water at the site except for TPH; however, as discussed in Section 4.4, groundwater at the site recharges to surface water. Therefore, it is necessary to establish groundwater cleanup levels protective of surface water, and to consider all groundwater IHSs in doing so. Per

Environmental effects-based concentrations have not been established for the surface and groundwater IHSs at the site. Therefore, WET testing of groundwater obtained from the site was conducted to determine TPH concentrations that are protective of aquatic organisms. WET-testing results are presented in Appendix K. The results concluded that a TPH concentration of 700 µg/L NWTPH-Dx is protective of fresh water organisms. Because the WET-testing measures toxicity associated with all constituents present in groundwater, TPH concentrations are used as a surrogate for all of the IHSs.

5.2.4.3 Concentrations that Protect Organisms in Sediment

Ecology has set forth a maximum permissible surface water TPH concentration that protects aquatic organisms in sediment (Ecology, 2004). This concentration is 208 µg/L NWTPH-Dx and VPH/EPH as discussed above in Section 5.2.2.2.

5.2.4.4 Selected Surface Water Cleanup Level

The most stringent of the human health and environmental effects-based criteria are selected as the cleanup level for each IHS (Table 5-1). For TPH, the most stringent criterion is based on protection of sediment. The PQLs for surface water are the same as reported for groundwater in Section 5.2.2.4. The manner in which PQLs and method detection limits will be handled during compliance monitoring has not yet been determined. Air

Ecology has set forth an air cleanup level of 1,246 $\mu g/m^3$ VPH/EPH based on the indoor air inhalation pathway (Ecology, 2004). This value was calculated using the four-phase model based on a hazard quotient of 1 and a soil concentration of 2,906 mg/kg VPH/EPH in accordance with WAC 173-340-750(3)(b)(ii)(C). Although the air cleanup level is based on indoor air inhalation assumptions, it will also apply to ambient air conditions.

5.3 Points of Compliance

The points of compliance define the locations where the cleanup levels must be attained. The term includes both standard and conditional points of compliance. Points of compliance are established for each environmental medium in accordance with the requirements and procedures set forth in WAC 173-340-720 through 173-340-760. A conditional point of compliance is only available under certain conditions.

For the site, points of compliance for soil, groundwater, sediments, and surface water must be established and evaluated. The requirements pertinent to the establishment of those points of compliance are summarized below. The standard and conditional points of compliance considered in this FS are also summarized below.

5.3.1 Soil

The point of compliance for soil depends on the exposure pathway that the soil cleanup level is based on.

- **Direct Contact.** For soil cleanup levels based on direct contact, the point of compliance is defined as throughout the site from the ground surface to 15 feet below the ground surface.

- **Soil to Groundwater.** For soil cleanup levels based on protection of ground water, the point of compliance is defined as throughout the site. This means that the point of compliance extends throughout the soil profile and may extend below the water table.

- **Soil Protection of Vapor.** For soil cleanup levels based on protection from vapors, the point of compliance shall be established in the soils throughout the site from the ground surface to the uppermost ground water saturated zone (e.g., from the ground surface to the uppermost water table).

- **Protection of the Terrestrial Species.** For soil cleanup levels based on protection of the terrestrial species, the standard point of compliance is defined as throughout the site from the ground surface to 15 feet below the ground surface. For sites with institutional controls to prevent excavation of deeper soil, a conditional point of compliance may be set at the biologically active soil zone. This zone is assumed to extend to 6 feet. A different depth may be established based on site-specific information. Where a cleanup action involves containment of hazardous substances that exceed cleanup levels at the point of compliance, the cleanup action still complies with cleanup standards, provided the requirements specified in WAC 173-340-740(6)(f) are met.

5.3.2 Groundwater

Below, we discuss the standard point of compliance and the conditional point of compliance.

5.3.2.1 Standard Point of Compliance

The standard point of compliance for ground water is throughout the site, from the uppermost level of the saturated zone, taking into consideration the seasonal groundwater fluctuations, and extending vertically to the lowest-most depth that could potentially be affected by the site (WAC 173-340-720(8)(b)).

For the site, a standard point of compliance is evaluated in Alternative "STD" of this Final FS.

5.3.2.2 Conditional Point of Compliance

A conditional point of compliance may also be set for groundwater where it can be demonstrated that it is not practicable to meet the cleanup levels throughout the site within a reasonable restoration timeframe (WAC 173-340-720(8)(c)). Conditional points of compliance may either be set on the property or off the property that is the source of the contamination, subject to several conditions. Off-property points of compliance may be set off property in three specific situations, subject to several conditions specified in WAC 173-340-720(8)(d).

In this Final FS, an on-property conditional point of compliance is evaluated in Alternatives PB1 to 5 and an off-property conditional point of compliance is evaluated in Alternatives SW1 to 4. These conditional points of compliance are summarized below.

On-Property Conditional Point of Compliance

The on-property conditional point of compliance must be set as close as practicable to the source of the hazardous substances, but may not exceed the property boundary. The use of an on-property point of compliance is conditioned on the use of all practicable methods of treatment at the site (WAC 173-340-720(8)(c)). Alternatives PB1 to 5 consider an on-property conditional point of compliance. Each of those alternatives sets the point of compliance at the BNSF property boundary (the railyard).

Off-Property Conditional Point of Compliance

The definition of and the requirements for the off-property conditional point of compliance depend on the location of the BNSF property, which is the source of the contamination to the adjacent surface water. In this case, the BNSF property is located near, but does not abut, surface water. Consequently, the off-property conditional point of compliance must be set as close as practicable to the source of the releases that occurred on BNSF's property, but may not exceed the point where groundwater flows into the South Fork Skykomish River (WAC 173-340-720(8)(d)]).

The establishment of such an off-property conditional point of compliance is conditioned on meeting several requirements, including, but not limited to the following (WAC 173-340-720(8)(d)(ii)):

- Groundwater discharges must be provided with all known available and reasonable treatment methods before being released into the South Fork Skykomish River

- Groundwater discharges must not result in violations of sediment quality values

- The affected property owners between BNSF's property boundary and the South Fork Skykomish River must agree in writing to setting such a conditional point of compliance.

Alternatives SW1 to 4 and BNSF’s preferred alternative consider an off-property point of compliance located at the point of groundwater discharge to the South Fork Skykomish River and the former Maloney Creek channel.

5.3.3 Sediment

The point of compliance is the biologically active zone consistent with WAC 173-760 and 173-204. Given that supplemental, site-specific information has not been obtained, the default point of compliance is the top 10 centimeters. Site-specific conditions, such as recontamination potential from subsurface sediments and/or groundwater, must also be considered in determining points of compliance.

5.3.4 Surface Water

The standard point of compliance for surface water is the point at which hazardous substances are released to the surface waters of the state.

At the site, hazardous substances are released to the surface water as a result of groundwater flows. Therefore, the point of compliance must be established at the point at which hazardous substances are released to the surface waters. At the site, this point is where groundwater emanates from the sediment.

5.3.5 Air

Cleanup levels developed under WAC 173-340-750 must be attained in the ambient and indoor air throughout the site.

5.4 Other Potentially Applicable Requirements

MTCA requires that all cleanup actions comply with applicable state and federal laws (WAC 173-340-360(2)). MTCA defines applicable state and federal laws to include “legally applicable requirements” and “relevant and appropriate requirements.” The information is presented in three tables (Table 5-2, Table 5-3, and Table 5-4) categorized as follows:

- Laws pertaining to establishment of cleanup levels
- Laws pertaining to treatment and disposal activities
- Laws that could affect planning or place restrictions on how cleanup actions may be performed.

The laws and regulations cited in this section pertain to non-hazardous wastes only as no “hazardous waste” exists at the site nor is the generation of any hazardous waste anticipated as part of cleanup. Tables 5-2 through 5-4 do not refer to State Dangerous Waste Regulations (WAC 173-304) or Federal Resource Conservation and Recovery Act Subtitle C regulations (40 CFR 260-268) that regulate the management and disposal of "hazardous waste."

6 Remediation Levels

This section develops and presents the rationale for remediation levels. WAC 174-340-200 defines "remediation level" as a concentration (or other method of identification) of a hazardous substance in soil, water, air, or sediment above which a particular cleanup action component will be required as part of a cleanup action at a site. Other methods of identification include physical appearance or location. A cleanup action selected in accordance with WAC 173-340-360 that includes remediation levels constitutes a cleanup action that is protective of human health and the environment. The remediation levels presented in this section are used in Section 7 to define the extent to which different components of a remedial alternative will be applied as part of an overall cleanup action that achieves cleanup standards.

6.1 Introduction

Remediation levels may be used at sites where a combination of cleanup action components are used to achieve cleanup levels at the point of compliance. Remediation levels may also be used at sites where the cleanup action involves the containment of soils. Remediation levels are not the same as cleanup levels. A cleanup level defines the concentration of hazardous substances above which a contaminated medium (e.g., soil) must be remediated in some manner (e.g., treatment, containment, institutional controls). A remediation level, on the other hand, defines the concentration (or other method of identification such as depth, location, etc.) of a hazardous substance in a particular medium above or below which a particular component of a cleanup action (e.g., soil excavation or containment) will be used. Remediation levels that are expressed as a concentration of a contaminant are, by definition, higher than cleanup levels.

The basis for remediation levels presented herein includes:

- Performance of soil and groundwater treatment systems
- Accessibility of contamination in relation to historical buildings and structures[2] Community disruption and related socioeconomic impacts
- Exposure pathways and risk to receptors.

Table 6-1 summarizes the proposed remediation levels.

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[2] A "building," such as a house, barn, church, hotel, or similar construction, is created principally to shelter any form of human activity. The term "structure" is used to distinguish from buildings those functional constructions made usually for purposes other than creating human shelter. Examples of structures include bridges, fences, tunnels, railroad grades, trolley cars and earthwork (National Park Service, US Department of Interior, 1983).

6.2 Remediation Levels for Soil

The most stringent soil cleanup level for TPH at this site is 22 mg/kg NWTPH-Dx and VPH/EPH as presented in Section 5. This cleanup level is based on protecting aquatic organisms in sediment from contaminated groundwater. All soil that exceeds 22 mg/kg NWTPH-Dx and VPH/EPH must be addressed by at least one component of the final cleanup action (which may include removal, treatment or containment beneath clean soils/structures and institutional controls). The only technology that can attain the soil cleanup level (22 mg/kg NWTPH-Dx and VPH/EPH) everywhere at the site with certainty is excavation, as included in the "STD" alternative described in Section 7. Much of the contamination underlies residential and commercial properties, infrastructure such as roads and utilities, and railroad tracks, and it is desirable to minimize the amount of disturbance in the town and the number of people, buildings, etc. that would need to be temporarily relocated. Also, many buildings in the residential and commercial district (the Developed Zones) are listed on the national and state Registers of Historic Places. Therefore, the majority of the other remedial alternatives developed in Section 7 and BNSF's preferred alternative employ other, less invasive, technologies in combination with excavation to address different site cleanup zones in combination with containment and institutional controls to attain cleanup standards while minimizing disturbance to the town.

Site cleanup zones are defined in Section 7.3.1 to facilitate discussion of cleanup activities in various parts of the site. The cleanup zone terminology is used in this section to distinguish between remediation levels proposed for different portions of the site.

6.2.1 Remove Free Product

A proposed remediation level is the removal of free product, as measured in monitor wells, using excavation. This remediation level is based on accessibility and community disruption issues. This remediation level is appropriate because it contributes to permanence and it is protective of human health and the environment.

6.2.1.1 Accessibility

The accessibility of free product for direct removal is limited by overlying permanent buildings, asphalt or concrete paving, a transcontinental railway and sensitive habitat (i.e., former Maloney Creek channel wetland). Many of the residential, commercial and public buildings in Skykomish are listed on the national and state Registers of Historic Places (see Section 2.3.1). Although it may be technically possible to temporarily relocate structures and buildings to allow access to underlying soils, it is very disruptive to residents, businesses and the school, and there is the risk of damage to historically significant buildings.[3] Similarly, disruption of railroad operations to access soils beneath the rail line is prohibitively costly and disruptive to railroad customers. Access to soils underlying the former Maloney Creek channel is limited because destruction of mature vegetation and ecological habitat would be required. Although habitat can be reconstructed and damage mitigated, it will take many years to restore or mitigate the habitat damaged by cleanup activities.

6.2.1.2 Technical Approach

Excavation is the most certain means to remove free product from the subsurface. Excavation is best-suited to areas where free product is accessible without disturbing a structure or building and areas where the presence of free product would result in groundwater exceeding the cleanup levels at the alternate point of compliance (Skykomish River). Excavation can also be used in areas where the number of buildings to be temporarily located is small relative to the amount of free product present and where the buildings to be relocated are not historically significant.

Where accessibility is an issue, recovery trenches are the proposed remedial technology for recovery and containment of free product. Recovery trenches are a component of several of the remedial alternatives developed in Section 7 and BNSF's preferred alternative (Section 10). They are targeted for use primarily in the NW Developed Zone due to the type of contaminant present, the density of residential and commercial buildings and their historical significance and the low potential for exposure to contamination, and in the Railyard since much of the free product lies beneath the railroad tracks.

6.2.1.3 Protectiveness

The removal of free product helps satisfy the MTCA requirement to remove NAPL and it contributes to the protectiveness of a remedy in three ways.

First, the removal of free product is the most cost-effective means of reducing the mass of petroleum at the site, thereby contributing significantly to permanence. Soil in free product areas contains the greatest petroleum mass per unit of soil volume. As a result, excavation focuses on areas where the greatest contribution to permanence or mass removal of a remedy can be achieved.

Second, the removal of free product will contribute to the effectiveness of less intrusive remedies such as enhanced bioremediation. The presence of free product hinders the performance of in situ technologies such as enhanced

[3] Note, according to the U.S. Department of the Interior Standards for the Treatment of Historic Properties, buildings should be returned to their original sites or new sites in such a way that the rail-oriented configuration of lots and buildings, streetscape and siting of buildings relative to the street are maintained as much as possible. This is part of the character of the town and the setting for the historical district.

bioremediation. The mass of petroleum associated with free product contributes to an extended restoration timeframe when using enhanced bioremediation. The presence and behavior of free product hinders the bioavailability of petroleum constituents and can contribute to both an increased restoration timeframe and a higher treatment endpoint.

Third, the removal of free product will achieve groundwater concentrations protective of human health. The removal of free product reduces groundwater concentrations to levels protective of human health. Empirical data that were presented in Figure 3-9 demonstrate that exceedances of the groundwater concentration protective of human health (477 µg/L total VPH/EPH) are closely associated with free product. This is consistent with the Concise Explanatory Statement of MTCA where it states, “an infinite amount of diesel fuel can be left in the soil without causing ground water impacts” in reference to a diesel fuel without benzene. The Concise Explanatory Statement also noted that “diesel fuel would be a reasonable conservative approach to heavy oils” since diesel fuel has light aromatics but heavy oil has carcinogenic PAHs. This is also consistent with the leaching test results (see Appendix L), which demonstrated that TPH in the soil at the site does not present an unacceptable carcinogenic or non-carcinogenic risk to drinking groundwater, except where free product (defined in MTCA as “a distinct separate layer” of oil) is present. As a result, the removal of free product results in groundwater concentrations protective of human health. Using this remediation level, further treatment would be required prior to discharge to the Skykomish River to achieve the 208 µg/L NWTPH-Dx and VPH/EPH cleanup level protective of sediment.

6.2.2 Excavate Free Product Where Accessible

The concept of accessibility is further incorporated as a remediation level in some of the cleanup alternatives developed in Section 7 to limit the disturbance of structures, buildings, habitat, etc. as much as possible, while satisfying threshold requirements. The remediation level that is used is “excavate free product where accessible.” This approach eliminates direct conflict between remedial actions and buildings or structures by excavating free product only in those areas that are accessible without physically moving a building or structure. This remediation level incorporates the certainty of excavation of free product while considering accessibility and community impacts.

Examples of this remediation level include Alternatives SW3 and PB1, which call for excavation of free product in the NW Developed Zone “where accessible.” In the former Maloney Creek channel, limiting disruption of habitat is the rationale for incorporating hot-spot removal (free product removal) as a remediation level in Alternatives SW4 and PB3.

This remediation level decreases the risks associated with the direct contact pathway since free product remains only in those areas where the subsurface impacts cannot be physically accessed without significant effort. At some point in the future, if a structure or building is moved, the free product becomes accessible and may be excavated. Since there is some free product left in place, alternatives that use this remediation level will have a more difficult time achieving the groundwater level protective of human health (477 µg/L total EPH/VPH) and the groundwater cleanup level. There will also be the potential for free product to migrate from beneath structures and buildings and recontaminate areas that were already excavated unless physical containment barriers, such as recovery trenches, are used. Excavation of free product where accessible will be complicated by the presence of structures and buildings that will require the use of shoring or sloping, and the use of sloping will reduce the amount of petroleum mass that can be removed.

6.2.3 Remove/Treat Soil to 20,000 mg/kg NWTPH-Dx

This remediation level is included in the FS as an example of a soil remediation level between removal of free product and achieving the cleanup level. This remediation level is incorporated into remedial alternative PB4 to provide another data point by which to compare alternatives in Sections 9 and 10, specifically in the substantial and disproportionate costs analysis. It is this analysis of the remedial alternatives where the appropriate choice between remediation levels and cleanup levels is achieved.

The use of the 20,000 mg/kg NWTPH-Dx level increases the protectiveness of groundwater for human health. This remediation level does increase the permanence of the remedy and it also increases the certainty that enhanced bioremediation will achieve the groundwater cleanup level of 208 µg/L NWTPH-Dx (diesel plus motor oil) prior to discharge to the river. The evaluation of remedial alternatives will assess whether this increased certainty is cost-effective and the SEPA analysis associated with the Cleanup Action Plan will determine whether the impacts to the built and natural environment are acceptable.

6.2.4 Remove Soil to 2,000 mg/kg NWTPH-Dx

Alternative PB5, included at Ecology's request, consists of excavation of soil in all of the site cleanup zones to 2,000 mg/kg NWTPH-Dx. This remediation level falls between the soil cleanup level needed to protect organisms in sediment (22 mg/kg NWTWPH-Dx and VPH/EPH) and the direct contact cleanup level (2,130 and 2,765 mg/kg VPH/EPH for vadose and smear zone soils, respectively). This remediation level is equal to MTCA's default residual saturation for diesel, and therefore is protective of groundwater.

6.2.5 Direct Contact (Human)

Remediation levels proposed for protection of human direct contact with soils and airborne contaminants are based on concentration, depth, land use and location. These remediation levels are necessary when the proposed remedy to achieve the cleanup standard uses containment and institutional controls or when the cleanup action does not completely address all of the potential exposure pathways at all locations.

6.2.5.1 Developed Zones

Contamination in the Developed Zones consists of petroleum in smear zone soil and groundwater and as free product in the smear zone and discontinuous contamination of surface soil with lead. All of the remedial alternatives (Section 7) include excavation of accessible, near surface metals in the Developed Zones to a depth of two feet bgs. This soil zone has a high likelihood of disturbance, and therefore potential for exposure, resulting from typical residential activities including, but not limited to:

- Mowing, raking, sweeping
- Children/pets digging
- Gardening
- Tree planting
- Re-sodding
- Irrigation system installation
- Paving/install sidewalk
- General landscaping
- Deck foundation.

Additionally, alternatives SW4, PB3, and PB4 offer additional protection to residents by achieving direct contact cleanup levels for smear zone soil in the upper four feet of soil in the NW Developed Zone. The smear zone direct contact cleanup level is 2,765 mg/kg VPH/EPH or 3,400 mg/kg NWTPH-Dx[4]. The smear zone direct contact cleanup level is used as a remediation level because TPH impacts in the NW Developed Zone are limited to the smear zone and are the result of free product migration and groundwater transport.

6.2.5.2 Railyard

Contamination in the Railyard Zone consists primarily of lead and arsenic in the surface soil, petroleum hydrocarbons in vadose and smear zone soil, groundwater contamination in the smear zone, and free product. All of the remedial alternatives in Section 7 remove near surface metals-impacted soils from the upper two feet of soil and backfill the excavation with a clean fill cap. This two-foot depth remediation level eliminates the airborne particulate

[4] Calculated by multiplying by 1.25 factor developed through correlation of NWTPH-Dx and VPH/EPH soil data, as presented in Section 3.

exposure pathway and protects against direct contact exposure by trespassers in accessible areas. Alternatives SW4, PB3, PB4, STD and BNSF's preferred alternative also include excavation of near surface TPH-impacted soils to the vadose zone direct contact cleanup level of 2,130 mg/kg VPH/EPH or 2,600 mg/kg NWTPH-Dx[5] in the upper two feet of soil.

BNSF considers a two-foot depth remediation level appropriate because exposure to subsurface contamination on the railyard can successfully be prevented using institutional controls with a high degree of assurance. For example, railroad employees routinely receive health and safety training as required by WISHA, OSHA and the FRC. Operational procedures can be developed to ensure workers are properly trained, or are required to bring in properly trained individuals to conduct any track maintenance work that requires disturbance of soil to depths greater than two feet bgs.

6.2.5.3 Levee

Several of the alternatives (SW4, PB3, PB4 and BNSF's preferred alternative) include excavation of the levee to the smear zone direct contact level of 3,400 mg/kg NWTPH-Dx. Since soil impacts in the levee are found in the smear zone, and not the vadose zone, this remediation level is also protective of the direct contact pathway. Removal to this concentration is greater than that needed to protect the river (i.e., excavation area extends beyond area identified with biological impacts to sediments) and to satisfy the groundwater cleanup level, as shown in Figure 6-1.

6.2.6 Terrestrial Ecological Exposure

As discussed in Section 5 and Appendix D, the TPH cleanup level based on protection of terrestrial ecological exposure to soil biota in areas other than the railyard zone is 1,870 mg/kg NWTPH-Dx. The conditional point of compliance for this exposure pathway specified by MTCA is 6 feet bgs, based on a generic estimate of the biologically active zone. At Skykomish, the upper 12 inches, or one foot, of soil is a reasonable estimate of the soil zone depth where the majority of biological activity occurs (i.e., soil mixing by earthworms, moles, ants, etc.) (Ecology, 1999; Sutter, 2000; TEE, Appendix D). A remediation level depth of one foot bgs for removal of soil in the accessible areas of the developed zones, as well as the former Maloney Creek channel, where the TEE cleanup level is exceeded will protect terrestrial species when combined with clean soil backfill and institutional controls and monitoring.

[5] Calculated by multiplying by 1.25 factor developed through correlation of NWTPH-Dx and VPH/EPH soil data, as presented in Section 3.

6.2.7 Soil to Air

A soil cleanup level of 2,900 mg/kg VPH/EPH is established in Section 5 based on protection of the indoor air pathway. This cleanup level applies to the developed areas of the site, since these are the areas with unrestricted land use and where residential/commercial buildings overlie the contamination. This level serves as a remediation level beneath buildings in the Developed Zones where the remedial alternative results in remaining soil concentrations that exceed 2,900 mg/kg VPH/EPH. When this level is exceeded beneath a building, it will trigger cleanup action components that address the soil to vapor pathway. These cleanup action components may consist of monitoring, vapor barriers or venting, for example.

7 Development of Remedial Alternatives

This section describes the remedial alternatives that can meet the cleanup standards presented in Section 5 and remediation levels in Section 6. To develop remedial alternatives, individual cleanup technologies were first screened to identify technologies that are implementable and effective at the site. This screening is described in detail in Appendix M and summarized in Section 7.1.

Using the results of the technology screening, technologies that are implementable and effective at the site were grouped into remedial alternatives. Section 7.3 describes the approach used to group individual cleanup technologies and develop the resulting remedial alternatives presented in Section 7.4.

In Section 7.4, the remedial alternatives for the site are described. Section 7.4.1 summarizes how each technology (regardless of alternative) would be implemented at the site. Section 7.4.2 summarizes each alternative.

7.1 Technology Screening

This section summarizes the results of the screening process for individual cleanup technologies that should be suitable for cleaning up contaminated soil, groundwater at the site. Technologies suitable for cleaning up sediment are included with the discussions about contaminated soil. Surface water cleanup was not considered separately in this screening evaluation because cleanup actions designed for sediments, soil and groundwater must also protect surface water. A detailed description of the screening process is presented in Appendix M.

Table 7-1 identifies the cleanup technologies screened and determined to be effective and implementable or to hold promise of being effective and implementable in the context of physical and chemical conditions at the site. In Section 7.4, these technologies are grouped into remedial alternatives that address all of the contamination at the site.

7.1.1 Metals in Soil

For metals in soil, the technology screening determined that appropriate response actions were containment or removal. Containment would be achieved by capping while removal would be achieved by excavation. If metals-impacted soils were removed they would either have to be treated *ex situ* or disposed of. *Ex situ* technologies retained for further consideration are soil stabilization and cement incorporation. The only disposal option considered, placing the material in a commercial landfill, was retained.

7.1.2 Petroleum Hydrocarbons in Soil

In addition to containment and removal, *in situ* treatment technologies were retained for petroleum hydrocarbons in soil. As with metals in soil, containment would be achieved by capping and removal would be by excavation. *In situ* treatment would be achieved through bioventing. Excavated soils could be treated *ex situ* by thermal desorption or cement incorporation. Disposal for excavated petroleum impacted soils would be by placing the materials in a commercial landfill.

7.1.3 LNAPL

Technologies retained for further consideration that address LNAPL contain, extract, treat *in situ*, or reuse the LNAPL. Containment would be attained by placement of a slurry wall or permeation grouting. LNAPL extraction technologies that have been retained are excavation, skimming, and recover trenches. Removed LNAPL could then be reused by recycling as an off-specification fuel. Alternatively, LNAPL could be treated *in situ* by flushing (*in situ* or hot water/steam) or by *in situ* oxidation.

7.1.4 Dissolved Petroleum Hydrocarbons in Groundwater

Dissolved petroleum hydrocarbons in groundwater could be treated by containment, extraction (and *ex situ* treatment or discharge), or *in situ* treatment. Containment could be achieved through the use of a slurry wall and extraction could be achieved through pumping. Once extracted the water could be treated *ex situ* with bioreactors, by phase separation, precipitation, filtration, carbon adsorption, or oxidation. Once treated the water could be discharged under an NPDES permit or re-injected into the subsurface. The *in situ* technologies retained for further consideration are enhanced aerobic biodegradation, chemical oxidation, and natural attenuation.

7.2 Bench-Scale Testing of Cleanup Technologies

Few *in situ* cleanup technologies are considered potentially effective for contaminants identified at the site and limited performance data are available for these technologies and contaminants. To determine the potential effectiveness of these technologies, bench-scale testing was performed for the following cleanup technologies:

- *In situ* flushing using hot water mixed with surfactant and polymer
- *In situ* biological treatment
- *In situ* chemical oxidation using ozone.

The scope of this testing was described in the *Bench Testing Work Plan* (RETEC, 2003e). This testing commenced in May 2003 and complete results are provided in the *Bench-Scale Cleanup Technology Testing Report* (RETEC, July 1, 2004). The tests were designed to measure the potential effectiveness of these three technologies at this site. *Ex situ* technologies (e.g., excavation) do not require bench scale testing to determine their potential effectiveness.

The following subsections provide summaries and excerpts from the Bench-Scale Cleanup Testing Report on the application of the three *in situ* technologies in light of the treatability data. A full analysis and all analytical data referenced appear in the Bench-Scale Testing Report (RETEC, July 1, 2004).

7.2.1 Results for Flushing with Surfactant and Polymer

Surfactant flushing was relatively successful at removing petroleum from the soil columns, while the combination of surfactant flushing and biopolishing was more successful. The combination of technologies achieved soil cleanup levels for direct contact (2,130 mg/kg EPH/VPH) developed by Ecology but was above the soil cleanup level for protection of groundwater (22 mg/kg NWTPH-Dx and EPH/VPH) developed by Ecology. The final EPH/VPH concentrations were 163 mg/kg in SP1 and 255 mg/kg in SP5.

These surfactant flushing tests were performed at temperatures of 60ºC, which is achievable in the field only by using a combination of heating techniques, such as hot water injection and electrical resistance heating. As such, this approach would not be cost-effective. However, due to the positive results of the test, it was believed that successful removal of petroleum may occur at lower temperatures (e.g. ~ 45 ºC). In addition, the success of the biopolishing portion of the test suggested that surfactant-enhanced bioremediation showed promise as a cost-effective technology for the site.

The Draft Final FS (RETEC, 2004) considered surfactant enhanced flushing to be an appropriate technology for application at the site. However, after additional evaluation, BNSF has determined that the surfactant enhanced flushing technology is not sufficiently developed and proven to reliably recover the type of highly viscous LNAPL found at this Site. Other site-specific factors that limit the viability and effectiveness of the technology are the shallow depth of groundwater and the permeability of the vadose and smear zone soil.

BNSF believes that while surfactant-enhanced flushing appears to have potential as an effective, *in situ* technology for remediating poorly accessible areas, the technology is not currently developed to a point for use within the challenging operational constraints at Skykomish, and carries a high risk of not achieving performance objectives. Shallow groundwater and high

LNAPL viscosity may severely limit the ability of the technology to achieve Ecology, BNSF and the community expectations. Bench testing has shown that even under idealized conditions, achieving numeric cleanup levels is unlikely and there are no existing pilots or full-scale testing at other similarly sites to suggest that a more limited objective of removing mobile LNAPL with certainty.

7.2.2 Results for Biological Treatment

A full range of biological treatment studies was conducted for two soil samples. One sample was collected from the NE Developed Zone where diesel is the primary petroleum compound and the second sample was collected from the NW Developed Zone where bunker C and diesel are present (zones are defined in Section 7.6.4 of this FS). The results for the NW Developed Zone are considered representative of the Former Maloney Creek Zone. Limited testing was also performed for a soil sample collected from the far east end of the Railyard.

7.2.2.1 NE Developed Zone

Significant reductions in petroleum levels were noted during biodegradation testing for soil from the NE Developed Zone. The final concentrations were well below direct contact cleanup levels for both the nutrient-amended and the unamended flasks.

The final EPH/VPH soil concentrations from the nutrient-amended flasks were evaluated for protection of groundwater using the 4-phase model. These were the only EPH/VPH data available even though the unamended flasks performed better according to the NWTPH-Dx data. In accordance with WAC-173-340-720(9)(e)(v), those substances or fractions that have not been detected in soil in the NE Developed Zone or on the Railyard in the vicinity of the NE Developed Zone were excluded from the analysis.

Using half of the detection limits for the other undetected samples results in a HI of 1.5 for the nutrient-amended sample and 1.38 for the nutrient-amended duplicate sample. These results are above the cleanup level HI of 1, but the vast majority of the risk (0.92 of the HI) is based on half of the detection limit for the following petroleum ranges: aromatic EC >8-10 range and aromatic EC>10-12. These ranges are highly amenable to biodegradation suggesting that half of the detection limit is an unreasonable assumption. In total, only 0.37 to 0.42 of the HI is based on detected concentrations.

Based on these data and past experience, an appropriate compliance monitoring program will demonstrate that enhanced bioremediation will achieve groundwater cleanup levels in the NE Developed Zone. BNSF proposes to use the empirical demonstration (WAC 173-340-747(9)) to demonstrate compliance with soil concentrations protective of groundwater.

7.2.2.2 Former Maloney Creek Zone

Bioremediation is also being considered for the Former Maloney Creek Zone. Biodegradation performance is assumed to be similar to the MW-45 biodegradation testing due to the similar petroleum composition. Using the MW-45 treated soil data, soil concentrations protective of groundwater can be achieved through bioremediation alone. Based on a review of data on Figures 3-4 and 3-11 of the Draft FS/EIS (RETEC, 2003), location 2A-B-8 is the only sample in the vicinity of the Former Maloney Creek Zone that exceeds the initial diesel concentration in MW-45. These results suggest that a hot spot removal near 2A-B-8 followed by enhanced bioremediation is likely to satisfy Method B groundwater criteria and prevent significant disruption to the wetland.

7.2.2.3 NW Developed Zone

The use of biodegradation as a standalone cleanup approach was considered potentially viable for areas of the NW Developed Zone where free product was not present. Due to the high initial concentration, the sample from the NW Developed Zone did not achieve cleanup levels. However, if we apply the removal rates achieved in this biodegradation test for the EPH/VPH ranges, the 4-phase model indicates that the direct contact cleanup level for unrestricted land use can be achieved for initial soil concentrations below about 7,000 mg/kg diesel-range hydrocarbons according to the initial sample ratios between analyses (see Table 2-2 data). Based on Figures 3-4 and 7-2, only four soil samples outside of the defined free product areas exceed this concentration in the NW Developed Zone (5-W-4, 1A-W-3, 2A-W-1, and 2A-W-2), and these samples are all within 70 feet of the edge of a free product plume. These data indicate that direct contact cleanup levels for soil (2,130 mg/kg TPH) are achievable throughout the NW Developed Zone when enhanced bioremediation is used in conjunction with free product removal.

7.2.3 Summary of Bench-Scale Results for Chemical Oxidation with Ozone

Chemical oxidation with ozone was considered as an option for soil and groundwater treatment in the Levee that would minimize short-term impacts to the Skykomish River. Treatment with ozone showed some promise at removing petroleum impacts from the subsurface. The doses and durations used in the bench test were selected to be cost competitive with excavation. While these doses and durations were effective at reducing the total EPH/VPH concentrations they did not achieve cleanup levels. Since this test was not successful, it does not appear cost-effective to use ozone. Excavation of the Levee will provide immediate and complete removal of petroleum impacts and will allow achievement of groundwater levels protective of sediment.

7.3 Approach to Developing Remedial Alternatives

This section describes the approach used to develop site-wide remedial alternatives, using the individual cleanup technologies discussed in Section 7.1 and the cleanup levels discussed in Section 5. The remedial alternatives are described in Section 7.4.3 and evaluated in detail in Section 8. The approach to developing the suite of remedial alternatives presented herein was performed in phases, as described below:

- Subdivide the site into "cleanup zones" based on exposure pathways, land use, and distribution and chemical composition of hazardous substances (Section 7.3.1)
- Consider standard and conditional POCs for each affected media (Section 7.3.2)
- Consider soil remediation levels based on exposure pathways (Section 6)
- Combine individual cleanup technologies from Section 7.1 into a suite of remedial alternatives that meets cleanup standards (i.e., cleanup levels at various POCs) and remediation levels.

Each of these phases is described in more detail below. The resulting remedial alternatives are presented in Section 7.4.

7.3.1 Site Cleanup Zones

The concept of site cleanup zones was developed to facilitate the evaluation of remedial alternatives. The zones are based on exposure pathways, land use, and distribution and chemical composition of hazardous substances at different parts of the site. The zones are defined as follows:

1) **Aquatic Resource Zones –** The South Fork Skykomish River and Levee and the former Maloney Creek channel (and associated wetland) are considered Aquatic Resource Zones due to the potential for ecological and recreational exposures, the presence of contaminated groundwater that affects sediment and surface water, and the lack of potential future development, such as housing. The Aquatic Resource Zones are noted in the orange hatching on Figure 7-1.

2) **Developed Zones –** The Developed Zones have been or are likely to be developed for residences, commercial buildings, streets, and public institutions, such as the school, city hall, and community center. These zones are primarily affected by petroleum contaminants in the groundwater and surrounding subsurface soil.

Three Developed Zones were defined based on location and the different types of petroleum affecting the zones: the Northwest (NW) Developed Zone, the South Developed Zone, and the NE (NE) Developed Zone (Figure 7-1). The NW Developed Zone and the South Developed Zone are affected by petroleum plumes that consist of a mixture of diesel and bunker C and are separated by the Railyard Zone. These two developed zones are noted in the pink hatching pattern on Figure 7-1. The NE Developed Zone is affected by a petroleum plume primarily composed of diesel fuel. Smear zone soil data from 1B-W-1, 1C-W-1, and 2A-W-6 indicate that 85 percent to 90 percent of the petroleum present in this Zone is in the diesel range. The greater diesel content in the NE Developed Zone indicates that petroleum in this Zone is more soluble and more biodegradable than the petroleum present in the NW and South Developed Zones. Therefore, different cleanup technologies may be applied to the NE Developed Zone than the NW and South Developed Zones. The NE Developed Zone is noted in purple hatching on Figure 7-1.

3) **Railyard Zone –** The Railyard Zone has historically been used for industrial purposes and should continue as an industrial site for the foreseeable future. It includes BNSF property with surface and subsurface soil impacts. It also includes small areas immediately adjacent to the BNSF property: two with surface soil metal impacts, and one with surface and subsurface soil TPH impacts. The Railyard Zone is noted in blue hatching on Figure 7-1.

Figure 7-1 provides a clear representation of the locations of these zones. Figure 7-2 illustrates the basis for the areal extent of these zones by overlaying all known and suspected areas of soil, groundwater, and sediment impacts. The extent of TPH soil impacts illustrated on Figure 7-2 is based on the 20 mg/kg TPH-diesel contour for surface, vadose, and smear zone soil impacts. This contour was used to represent the maximum extent of impacts exceeding cleanup levels for purposes of the FS as it closely approximates the areas that exceed the cleanup level for all TPH.

7.3.2 Points of Compliance

Section 5.3 presents the standard and conditional POCs used to develop and evaluate the remedial alternatives. The POCs are the locations where cleanup levels would be achieved and are considered part of the cleanup standards and are summarized in Table 7-2. Site-wide remedial alternatives were developed to meet cleanup standards for the following three POCs: (1) off-property, conditional groundwater POC at the points of discharge to surface water (SW1 to SW4); (2) on-property, conditional groundwater POC at the property boundary (PB1 to PB5); and (3) the standard POCs (STD).

7.4 Description of Remedial Alternatives

The approach outlined in Section 7.3 is used in this section to develop a suite of remedial alternatives. Individual cleanup technologies were first selected for each cleanup zone based on the nature and extent of contamination, land use and exposure pathways. The technologies selected for each cleanup zone are described in Section 7.4.1.6. Institutional controls are applicable to some extent in all cleanup zones; therefore, they are discussed in context of all cleanup zones in Section 7.4.1.7.

After grouping technologies by cleanup zone, they were grouped based on their ability to comply with cleanup standards and attain remediation levels. As described in Section 5, compliance with cleanup standards includes attaining the cleanup levels at specific POCs. Soil, sediment and surface water POCs are the same for all alternatives. However, the standard and two conditional POCs for groundwater (defined in Section 5.3) were used to develop the remedial alternatives. The groundwater POCs were used to name the alternatives in Section 7.4.2.

In addition to meeting cleanup levels at the POCs, alternatives were selected based on achieving remediation levels (Table 7-3). Remediation levels mostly apply to soil and sediment cleanup; however, a remediation level for free product removal from groundwater is also included. All alternatives meet the remediation levels, as explained in Section 7.4.2, in addition to meeting the cleanup levels at the POCs.

7.4.1 Detailed Description of Remedial Approaches by Cleanup Zone

The site-wide remedial alternatives presented in Section 7.4.2 use different combinations of cleanup technologies within each cleanup zone, as illustrated in Table 7-4. To limit repetitious text, all cleanup technologies applicable to each cleanup zone are described separately, by cleanup zone, in the following six subsections (as listed on Table 7.4).

For example, the technologies for cleaning up the South Developed Zone include natural attenuation and excavating free product and TPH in the surface soil and the smear zone. Some site-wide remedial alternatives use all of these technologies, whereas others use only a few of the technologies (Table 7-4). The following five subsections demonstrate how each cleanup technology would be implemented in each cleanup zone and describe all remedial approaches. Section 7.4.2 describes how the remedial alternatives combine these different cleanup technologies in a way that meets site-wide cleanup standards and remediation levels.

7.4.1.1 Levee and South Fork Skykomish River Aquatic Resource Zone

This zone incorporates the area downgradient of the existing barrier wall and the locations of petroleum impacts to the bank and sediment of the South Fork Skykomish River. The majority of this zone includes the floodwater control levee that was designed by the USACE in 1951 and is currently managed by the King County Department of Natural Resources, Rivers Section.

The cleanup technologies for this zone include:

- Removing surface sediment
- Enhanced bioremediation
- Excavation.

These technologies are described in the following subsections. All activities on the levee would be coordinated with King County, which manages the levee for purposes of local water control.

Remove Surface Sediment

This technology involves the excavation of the upper 4 inches (10 centimeters) of sediment to achieve cleanup levels in the biologically active zone. It is estimated that an area about 725 feet long and 20 feet wide exceeds the cleanup level (Figure 7-3). Including overexcavation to a depth of 1 foot, 540 cubic yards (cy) of sediment is expected to be removed. Surface sediment removal would not occur until soil and groundwater impacts within the levee have been addressed. Sediment removal activities would be designed to comply with ARARs, such as Ecology's water quality standards (including anti-degradation) and the Federal Clean Water Act and Engendered Species Act.

Two of the site-wide remedial alternatives (SW3 and PB2) include excavation of free product from within the levee. For these alternatives, removal of surface sediment would be limited to the free product seep areas since this is where bioassay failures occurred. These alternatives minimize disruption to the shoreline habitat. This sediment removal area is about half the area that exceeds cleanup levels for an excavation volume of 270 cy.

A temporary cofferdam or deflector will be placed in the river to keep surface water away from the sediment excavation. An access ramp to allow dam placement and excavation will be created by removing about 6 feet of clean fill from the top of the levee in a 50-foot-wide area near the east end of the levee. Excavation would be performed using a track-mounted excavator. Difficulties are to be expected due to the presence of cobbles and boulders. Excavated sediment will be immediately removed from the river channel via an off-road dump truck to a stockpile area on the railyard. The excavation will be backfilled with coarse-grained soil, similar to what was excavated.

This work would be performed in late summer during low water conditions to minimize impacts on water and protected fish species. The construction window for the South Fork of the Skykomish River and its tributaries between Sunset Falls and Alpine Falls would allow in-water cleanup activities to occur between July 1st and August 31st (WDFW, pers. comm., 2003c). This construction window may be extended based on site-specific permitting.

Enhanced Bioremediation

Enhanced bioremediation is not an effective cleanup technology by itself in the Levee Zone due to the presence of bunker C/diesel free product and significant soil impacts. The purpose of this technology is to address dissolved-phase groundwater impacts that could continue to migrate through the levee under some of the site-wide alternatives due to the presence of free product or significant soil impacts in the Levee Zone or the NW Developed Zone. Bench-scale testing of this technology has been performed and is described in detail in the Bench-Scale Cleanup Technology Testing Report (RETEC, 2004), and in Section 7.2 of this FS. This testing provides information about potential treatment endpoints that can be achieved with this technology.

Enhanced bioremediation will be implemented using air-sparging techniques. A single row of air sparging wells will be installed across the area that exceeds the groundwater cleanup level of 208 µg/L. These wells will be installed through the top of the levee and, as a result, will require that the levee be cleared of brush and trees (Figure 7-4). Aboveground power lines along West River Road will be shielded, as necessary, during drilling and trenching activities. Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation, and air will be injected at a rate of 2 to 3 standard cubic feet per minute (scfm) per well. Compressed air will be supplied using positive displacement blowers located in the vicinity of the levee. These blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in a trench on top of the levee.

Excavation

Excavation includes the removal of free product or contaminated soil from between the existing barrier wall and surface sediment in the South Fork Skykomish River (Figure 7-5). All brush on the levee will be removed prior to excavation. A temporary cofferdam or deflector will be placed in the river to keep soil and contamination away from surface water. Power poles and lines along West River Road and the levee will be temporarily relocated during construction activities. Access for dam construction and clearing will be created by cutting an entry in the east side of the levee, as described for surface sediment excavation and by creating a ramp on the west end of the levee. A temporary road will have to be constructed west of the schoolyard to allow traffic to circulate and to provide emergency access to residences on the west end of West River Road. The abandoned residence on West River Road (the second residence east of the school yard) could be demolished so that a road might be constructed to connect Railroad Avenue to West River Road. If this is not possible, an alternate means of access to the west end of West River Road will need to be established, or the residents may need to be vacated during excavation activities.

The excavation will start on the east end of the levee, closest to the bridge. Clean soil will be excavated from the top of the levee and placed in trucks for temporary stockpiling on the railyard. Impacted soil will then be loaded into trucks for temporary stockpiling prior to treatment or disposal. As the excavation proceeds to the west, clean overburden soil might be immediately placed as backfill in previously excavated areas.

Streets and aboveground utilities will be returned to their current or historic character after disturbance, while restoring the same dimensions and materials above ground. The final design will be a result of discussion and planning with the Town of Skykomish. The Secretary of the Interior's Standards for the Treatment of Historic Properties do not 'apply' to the cleanup action because there is no grant-in-aid involved (see 36 CFR Part 68) but the Standards are 'relevant and appropriate' under MTCA to the extent the cleanup will affect historic buildings, sites, structures or districts.

The free product excavation is estimated to be 9,380 cy, with 4,870 cy requiring treatment or disposal. Excavation to 3,400 mg/kg NWTPH-Dx would generate 29,690 cy of soil with 15,990 cy requiring treatment or disposal while excavation to 2,000 mg/kg NWTPH-Dx would generate 32,480 cy of soil with 17,200 cy requiring treatment or disposal. Excavation to the cleanup level would generate 39,610 cy of soil, with 20,630 cy requiring treatment or disposal.

For all site-wide alternatives except SW1, SW2, and PB1, the barrier would be excavated since excavation of free product would occur in both the Levee and NW Developed Zones.

Excavation would be performed in late summer during low water conditions to prevent discharges to surface water and to satisfy the "fish window" that is intended to protect threatened species. The "fish window" for the South Fork of the Skykomish River and its tributaries between Sunset Falls and Alpine Falls is July 1st through September 15th. It is assumed that some water in the excavation will be managed to remove any free product that accumulates and to allow collection of excavation verification samples from the bottom of the excavation. Soil confirmation sample analysis will be performed with an on-site laboratory or using 48-hour turnaround at a fixed facility.

7.4.1.2 Former Maloney Creek Aquatic Resource Zone

This zone includes the ditch and wetland areas located north of the Old Cascade Highway, and is associated with storm drainage through the former Maloney Creek channel. The zone also includes any surface sediment impacted areas between the culvert and Maloney Creek on the south side of the Old Cascade Highway. This zone is considered separately due to the potential for groundwater discharge to surface water during high water events and due to the presence of a wetland. In addition, Coho salmon, a threatened species, have been noted in this storm water drainage. Cleanup in this zone will be closely coordinated with cleanup in the South Developed Zone and on the southern edge of the Railyard Zone.

The cleanup technologies for this zone include:

- Remove surface sediment
- Natural attenuation
- Enhanced bioremediation
- Excavation.

These technologies are described in the following subsections.

Remove Surface Sediment

The technology involves the excavation of the upper 4 inches (10 centimeters) of sediment to achieve cleanup levels in the biologically active zone. It is estimated that the full wetland area exceeds the sediment cleanup level including a small area on the downgradient side of the culvert (Figure 7-6). Assuming an excavation depth of 1 foot with over excavation, a total of 1,740 cy of sediment will be removed if excavation is to cleanup levels. A temporary cofferdam or deflector will be placed in the channel to keep soil and contamination away from surface water. Work will be performed in the summer to minimize the likelihood of precipitation. A bypass pump and hose will be used to pump any collected surface water around the excavation area.

Due to the high value of forested wetland, including the presence of mature trees, excavation of all impacted surface sediment would cause significant damage to the habitat. As a result, several alternatives have been developed that include removal of some surface sediment in strategic locations. For these alternatives, the excavation volume is assumed to be one half of the total removal volume or approximately 870 cy. For other alternatives, no excavation of surface sediment is proposed in this zone to avoid impacting the habitat.

Natural Attenuation

Natural attenuation might be used as the primary petroleum treatment method in the Former Maloney Creek Aquatic Zone due to the presence of the wetland habitat and petroleum constituents at moderate concentrations (per Figure 3-11, only boring 2B-SD-5 has NWTPH-Dx concentrations above 3,200 mg/kg). Free product present on the adjacent South Developed Zone at MW-39 would be removed to accelerate natural attenuation. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Enhanced Bioremediation

Enhanced bioremediation is a viable *in situ* cleanup alternative for the Former Maloney Creek Aquatic Zone, and it will minimize adverse impacts on wetland habitat. Bench-scale testing of this technology has been performed and is described in detail in the Bench-Scale Cleanup Technology Testing Report (RETEC, 2004), and in Section 7.2 of this FS.

Bioremediation will target the more soluble and toxic components of TPH and soil TPH concentrations in the smear zone do not significantly exceed cleanup levels. Enhanced bioremediation will be implemented using air sparging techniques. Air sparging wells will be installed across the area that exceeds the soil direct contact cleanup level in the smear zone. These wells will be installed to completely cover this area, as illustrated in Figure 7-7. Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation. Air will be injected at a rate of 2 to 3 scfm per well. Some wells might need to be angle-bored to minimize impacts to the wetland. The adverse impacts of drilling and operating wells in the wetland will be less significant (both in intensity and duration) than the impacts of excavating in the wetland.

Air bubbling up through the wetland represents a less negative impact to the habitat than excavation of surface sediment or soil. Compressed air will be supplied using positive displacement blowers located on the railyard in the vicinity of the former Maloney Creek channel. The blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches to the maximum extent possible; however, in order to minimize impact to the wetland habit, much of the piping might be completed aboveground.

Excavation

Excavation includes the removal of all soil exceeding a remediation level of 2,000 mg/kg NWTPH-Dx or the cleanup level from the zone, including surface sediment in the former Maloney Creek channel and the wetland areas (Figure 7-8). All brush and trees will be removed prior to excavation. A temporary dam will be placed in the channel to keep surface water away from the excavation and work will be performed in the summer to minimize the likelihood of precipitation. A bypass pump and hose will be used to pump any collected surface water around the excavation area. Disturbance of the wetland area will require mitigation by creating equal or higher value wetlands. This mitigation will occur at the existing wetland and possibly at another, as-yet undetermined location within the Maloney Creek watershed.

Impacted surface sediment will be removed first. Any clean soil between the surface impacts and the smear zone will be excavated and placed in trucks for temporary stockpiling on the railyard. Impacted soil will then be loaded into trucks for temporary stockpiling prior to treatment or disposal. As the excavation proceeds, clean soil will be used as backfill in previously excavated areas. The total excavation volume is estimated to be 10,750 cy, with 10,020 cy requiring treatment or disposal based on the 2,000 mg/kg NWTPH-Dx RL. The excavation volume is estimated to be 21,320 cy, with 18,190 cy requiring treatment or disposal to achieve the cleanup level.

The estimated maximum depth of excavation is 10 feet. Excavation will include sloping sidewalls. Some excavation water will be managed to remove any free product that accumulates and to allow collection of excavation verification samples from the bottom of the excavation. Soil analysis will be performed with an on-site laboratory or using 48-hour turnaround at a fixed facility.

7.4.1.3 Northeast Developed Zone

The NE Developed Zone has been developed for residences, commercial buildings, streets, and institutions such as city hall. The NE Developed Zone is affected by a petroleum plume in smear zone soil and groundwater that is primarily composed of diesel fuel, generally greater than 75 percent. This petroleum is less viscous, more soluble, and more biodegradable than the petroleum present in the NW and South Developed Zones. An oil column was historically located in the vicinity of MW-21 where free product is present indicating that bunker C might be present in the immediate vicinity of MW-21 although there are no soil data to confirm this. Otherwise, the majority of the impacts appear to be associated with diesel fueling activities that occurred about 150 feet to the south of MW-21.

Cleanup technologies for this zone include:

- Natural attenuation
- Enhanced bioremediation
- Excavation.

These technologies are described in the following subsections.

Natural Attenuation

Natural attenuation in the NE Developed Zone has the potential to significantly reduce soil and groundwater concentrations due to the high percentage of diesel. Diesel-range hydrocarbons are soluble and biodegradable and would be expected to attenuate in a reasonable timeframe. Soil direct contact criteria are only exceeded in a small area and groundwater currently appears to attenuate to cleanup levels prior to discharging to the South Fork Skykomish River. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Enhanced Bioremediation

Enhanced bioremediation is considered a viable alternative for the NE Developed Zone because the primary petroleum constituent is diesel. Bench-scale testing of this technology has been performed and is described in detail in the Bench-Scale Cleanup Technology Testing Report (RETEC, 2004), and in Section 7.2 of this FS.

Enhanced bioremediation has been implemented at multiple sites to achieve groundwater cleanup levels where thin accumulations (less than 2 feet) of diesel free product have been present. This is likely due to both the solubility and biodegradability of diesel constituents. RETEC's database of bench-scale testing data (Appendix M) indicates that soil concentrations of diesel are reduced, on average, by 90 percent due to the application of enhanced bioremediation techniques.

Air sparging wells will be installed across the area that exceeds the soil direct contact cleanup level in the smear zone and the groundwater cleanup level. Air sparging wells will be installed to completely cover the area of free product when free product is not flushed or excavated, as illustrated in Figure 7-9. Otherwise, a single row of air sparging wells will be used in this area. One or two additional rows of sparging wells will intersect the groundwater plume downgradient to the north depending on the desired restoration timeframe and accessibility of public and private property. The locations of air sparging rows have been selected to avoid generating vapors that could cause nuisance odors beneath inhabited buildings; vapor extraction will be included as a contingency should nuisance odors become a problem.

Wells will be installed at 25-foot spacing in each row, with the top of the well screen 10 feet below the low water table elevation. Air will be injected at a rate of 2 to 3 scfm per well. Compressed air will be supplied using positive displacement blowers located on the railyard near the depot. The blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches located on BNSF property and public right-of-ways.

Excavation

Excavation includes either the removal of free product, the removal of free product and soil exceeding the 2,000 mg/kg RL, or the removal of all free product and all soil exceeding the cleanup level (Figure 7-10). For the free product-only excavation approach, the objective would be to excavate as much free product as possible without significantly impacting roads or utilities. This would limit the excavation to between Railroad Avenue and the BNSF property boundary in the vicinity of MW-21.

Two or three residences will need to be temporarily relocated to excavate all free product and contaminated soil above the RL in this zone while 5 or 6 residences and a telephone switching station will need to be temporarily relocated to excavate to the cleanup level. Use of shoring might be necessary to protect some structures and buildings. Utilities are also present, including a telephone switching station and associated fiber optics cables. A 2-inch water line is present on both Railroad Avenue and 3rd Street. Overhead power is present on the north side of Railroad Avenue and will need to be moved during excavation. All utilities will need to be protected or temporarily rerouted to facilitate excavation. A bypass road will be necessary to maintain access to residences east along Railroad Avenue.

Site clearing includes removal of asphalt paving, landscaping (including some large trees), and relocation or demolition of the residences. A significant thickness of clean soil exists in the vadose zone that will be excavated and stockpiled adjacent to the excavation area. Impacted soil will be loaded into trucks for temporary stockpiling prior to treatment or disposal. The total soil excavation volume for accessible free product is estimated to be 8,490 cy, with 3,320 cy requiring treatment or disposal. The soil excavation volume for all soil exceeding cleanup levels is estimated to be 66,450 cy with 27,470 cy requiring treatment or disposal. The soil excavation volume for all soil exceeding the 2,000 mg/kg NWTPH-Dx RL is estimated to be 28,830 cy with 12,380 cy requiring treatment or disposal. The estimated maximum depth of excavation is 17 feet.

7.4.1.4 South Developed Zone

The South Developed Zone affects two residences and involves petroleum in surface soil, smear zone soil and groundwater that is composed of mixed bunker C and diesel. These impacts appear to be limited in extent. Free product present in MW-39 is more viscous than free product noted elsewhere on the site and appears to be coincident with a previous channel of Maloney Creek that may have been affected by railyard operations. Cleanup of this zone will have to be closely coordinated with cleanup of the Former Maloney Creek Aquatic Zone.

The cleanup technologies for this zone include:

- Natural attenuation
- Excavation.

These technologies are described in the following subsections.

Natural Attenuation

Natural attenuation in the South Developed Zone would only be used following free product excavation. The high viscosity of the product in MW-39 suggests that limited residual impacts will remain after free product removal. In addition, the free product appears to be associated with an earlier channel of Maloney Creek that is now backfilled. As a result, the impacts are suspected to be limited to this earlier channel and complete removal of this limited area may be possible. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Excavation

Due to the limited extent of impacts and the viscous nature of the free product, excavation is considered a viable cleanup technology for this zone. The approach to excavation might have to be altered based on the cleanup technology used at the Former Maloney Creek Aquatic Zone.

Excavation includes either free product excavation, excavation to soil RLs of 2,000 and 3,400 mg/kg NWTPH-Dx, or the complete removal of all free product and soil exceeding cleanup levels (22 mg/kg NWTPH-Dx) (Figure 7-11). Little to no clearing will be necessary for free product excavation, as it is primarily located in a grass area. The garage associated with one residence might need to be temporarily relocated or demolished and reconstructed to facilitate soil excavation. Utilities affected include services to the residences. All utilities will be temporarily disconnected or rerouted, as necessary.

A limited thickness of clean soil exists in the vadose zone that will be excavated and stockpiled adjacent to the excavation area. Impacted soil will be loaded into trucks for temporary stockpiling prior to treatment or disposal. The soil volume for excavating free product is estimated to be 690 cy, with 280 cy requiring treatment or disposal. The soil volume for excavating to the 3,400 mg/kg NWTPH-Dx RL is 4,520 cy, with 4,340 cy requiring treatment or disposal while the soil volume for excavating the 2,000 mg/kg NWTPH-Dx RL is 4,870 cy, with 4,670 cy requiring treatment or disposal. The soil volume for excavating all contaminated soil is 18,700 cy, with 16,320 cy requiring treatment or disposal.

7.4.1.5 Northwest Developed Zone

The NW Developed Zone has multiple residences, commercial buildings, streets, and institutions such as the school and community center. The zone is primarily affected by petroleum contaminants in the smear zone soil and groundwater and the petroleum consists of a mixture of diesel and bunker C. This is the largest and most developed zone at the site and includes several large or historic (Washington Heritage Register and National Register of Historic Places) buildings, such as Maloney's General Store, the Skykomish

Hotel and the School. This zone also has a very shallow smear zone that extends to within about 2 feet of ground surface in some areas, is very close to the levee and the South Fork Skykomish River.

Free product is present in this zone as two narrow bands between the railyard and the levee. The petroleum appears to originate in the vicinity of the former oil sump that was used to transfer bunker C from railcars to the aboveground 100,000 gallon oil storage tank on a 30-foot steel tower. This interpretation is based on free product thickness measurements, the location of oil seeps to the river, soil and groundwater data, known or suspected petroleum sources, and lithologic controls.

Interim actions have been performed in the NW Developed Zone that include (1) installation of free product skimming wells in 1996; (2) construction of a free product barrier wall in 2001; and (3) installation of new skimming wells and pumps, and upgrades to existing wells and pumps in 2002. These systems are effectively containing and capturing free product at the downgradient boundary of the NW Developed Zone and preventing migration from this zone into the levee and the South Fork Skykomish River, as evidenced by monitoring data from wells located at the ends of the barrier wall and product recovery.

In addition to these existing, interim measures, the cleanup technologies for this zone include:

- Surface soil excavation
- Natural attenuation
- Free product recovery trenches
- Enhanced bioremediation
- Excavation.

These technologies are described in the following subsections.

Surface Soil Excavation

Lead-contaminated soil (250 mg/kg) was noted at seven sample locations within the NW Developed Zone (Figure 7-12). The locations are isolated and are not contiguous with the railyard. The source(s) of this lead is unknown (RETEC, 2002a). The lead soil exists in yards near residential or commercial properties and in the schoolyard. Because the source and distribution of the lead in soil is unknown, estimating excavation volume is difficult. Assuming 2-foot-deep excavations, 400 cy of soil will be excavated from throughout town using a backhoe. The excavated soil will be placed in trucks and transported to stockpiles on the railyard. The soil will be shipped to an off-site landfill by truck or rail. These areas will be backfilled and restored to pre-excavation conditions. Given the shallow excavation, no significant impacts to utilities, buildings, or structures are expected.

Natural Attenuation

Natural attenuation in the NW Developed Zone would only be effective following free product removal. Once the free product is removed, natural attenuation will help address the residual soil and groundwater impacts. In each case where residual impacts remain in the NW Developed Zone, enhanced bioremediation will be implemented in the Levee Zone to protect people and animals that use the South Fork Skykomish River. Natural attenuation will address groundwater concentrations in the NW Developed Zone in the long term. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Free Product Recovery Trenches

Recovery trenches provide a minimally intrusive means to remove free product from the subsurface. The use of trenches relies on the hydraulic gradient to transport free product to the trenches. Trenches would be excavated using bioslurry techniques to 5 feet below the low water table. The trench backfill material would be designed to be compatible with native soil conditions and an impermeable barrier would be placed on the downgradient wall of the trench to prevent free product from escaping beyond the trench. Sumps will be placed in the trench at about 50-foot spacing.

Proposed locations of recovery trenches are illustrated in Figure 7-13. Excavation of these trenches will require work on public and private property and associated removal of pavement, landscaping or other features. Berms will be constructed around the trenching area to prevent loss of bioslurry overflows. Temporary mixing equipment, tanks, and pumps will be required near the excavation areas to supply bioslurry. Trench backfill material, impermeable barrier material, and sump material will also be stockpiled near the work area. Excavated material will be transported to the railyard for stockpiling prior to off-site shipment for disposal via rail or truck. The work surfaces will be replaced to pre-trenching conditions.

Electrically-driven skimmer pumps will be placed in vaults at each sump location and an electric control panel will be located nearby. No other aboveground features will be present. The skimming pumps will likely remain in operation for at least 10 years and may need to remain in operation for over 30 years.

Enhanced Bioremediation

Enhanced bioremediation is not an effective cleanup technology by itself in the NW Developed Zone due to the presence of bunker C/diesel free product and significant soil impacts. This technology would only be used once the free product has been addressed by excavation. The purpose of this technology is to address residual soil and groundwater impacts to the maximum extent practicable. Bench-scale testing of this technology has been performed and is described in detail in the Bench-Scale Cleanup Technology Testing Report (RETEC, 2004), and in Section 7.2 of this FS.

Enhanced bioremediation will be implemented using air sparging techniques. Air sparging introduces oxygen to the soil and groundwater to stimulate aerobic biodegradation in the vicinity of the air sparge wells and to other areas as the oxygenated groundwater migrates downgradient. Multiple rows of air sparging wells will be installed across the zone (Figure 7-14). These wells will be installed on public and private property. The locations of the sparging wells have been selected to minimize nuisance odors near inhabited buildings; vapor extraction will be retained as a contingency to address these odors should they become a concern. Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation. Air will be injected at a rate of 2 to 3 scfm per well. Compressed air will be supplied using positive displacement blowers located on the railyard. These blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches to connect the equipment on the railyard with the air sparging wells.

All work surfaces will be replaced to pre-cleanup conditions. A flush-with-grade monument will be present at each wellhead. All other equipment and activities will occur on the railyard.

Excavation

Excavation in the NW Developed Zone includes one of the following (Figure 7-15):

1) Excavation to remove free product, where accessible
2) Excavation to remove all free product
3) Excavation of shallow smear zone impacts
4) Excavation to a soil RL of 20,000 mg/kg NWTPH-Dx
5) Excavation to a soil RL of 2,000 mg/kg NWTPH-Dx
6) Complete excavation of all free product areas and all soil exceeding cleanup levels.

These six scenarios are discussed individually below; however, all excavation work would occur during low water conditions to maximize access to impacted smear zone soil. Clean overburden soil will be stockpiled as close to the excavation as possible and will be used as clean backfill. Impacted soil will be hauled to the railyard and stockpiled for on-site treatment or hauling to an off-site landfill via rail or truck. All utilities will need to be protected or temporarily rerouted to facilitate excavation. Various bypass roads will be necessary during excavation to maintain access to residences, businesses and public facilities. Site clearing includes removal of asphalt paving, landscaping (including some large trees), and relocation or demolition of several buildings and structures.

- **Excavation to remove free product, where accessible –** Excavation to remove free product, where accessible, is intended to minimize disruption to the community while removing a significant amount of free product. The long-term environmental benefit of this approach is questionable due to the patchwork of excavation that will occur (Figure 7-19). Accessibility is generally defined as anywhere a building is not present. As a result, excavation will still disrupt traffic and utilities. For the purpose of the FS, it is assumed that excavations will be sloped up to the sides of buildings that remain. Based on this approach, approximately 43,520 cy of soil will be excavated with 19,280 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation to remove all free product –** Excavation to remove all free product will require the temporary relocation and replacement or demolition and reconstruction of about eight buildings and temporary structural support to allow excavation underneath several other structures and buildings (Figure 7-19). These buildings include private residences, the hotel, the depot, the post office, the stove shop, the community center, and the teacher's cottage. Based on this approach, approximately 68,160 cy of soil will be excavated with 38,070 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation of shallow smear zone impacts –** Excavation of shallow smear zone impacts is intended to remove contaminated soil to a depth of 4 feet bgs in accessible areas (those areas not already covered by a structure or building). Cleanup to this depth will enable routine work in residential yards and public utility work without future exposure to contaminated soil. This work will disrupt traffic and utilities, but could be phased to allow residents to remain in their homes. Based on this approach, approximately 10,430 cy of soil will be excavated with 2,640 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation to soil RLs of 20,000 and 2,000 mg/kg NWTPH-Dx –** Both of these scenarios require the temporary relocation and replacement or demolition and reconstruction of about 11 buildings and temporary structural support to allow excavation underneath several other buildings (Figure 7-19). The buildings affected by these excavations would include private residences, the hotel, the depot, the post office, the stove shop, the community center, the teacher's cottage, the school and portions of the motel. Based on the excavation to the soil RL of 20,000 mg/kg NWTPH-Dx, approximately 139,550 cy of soil will be excavated with 86,310 cy requiring treatment or disposal. Based on the excavation to the soil RL of 2,000 mg/kg NWTPH-Dx, approximately 159,440 cy of soil will be excavated with 97,820 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions and all buildings will be replaced or rebuilt.

- **Excavation to remove all soil above cleanup levels –** This scenario requires the temporary relocation and replacement or demolition and reconstruction of about 30 buildings and temporary structural support to allow excavation underneath several other buildings (Figure 7-19). Additional buildings affected by this excavation would include numerous private residences and the remainder of the motel. Based on the excavation of all soil exceeding cleanup levels, approximately 253,590 cy of soil will be excavated with 126,590 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions and all buildings will be replaced or rebuilt.

7.4.1.6 Railyard

The Railyard Zone has historically been used for industrial purposes and will continue as an industrial site for the foreseeable future. It includes BNSF property with surface and subsurface soil impacts. It also includes small areas immediately adjacent to the BNSF property: two with surface soil metals impacts, and one with surface and subsurface soil TPH impacts. The railyard has an active main line with two sidings and two other active sidings south of the main line area. Both passenger and cargo trains use the main line and sidings; approximately one train per hour passes the site.

All alternatives except one leave the rail lines in place and use *in situ* remedies to address these impacts, due to the expense and disruption associated with moving the main line. One alternative relies on excavation, as it is the only technology currently considered effective enough to result in a permanent removal of all contaminated soil throughout the site. Fiber optics, electrical, and signal lines are present within the Railyard Zone. Any crossing of the rail lines will require horizontal boring.

The cleanup technologies for this zone include:

- Excavate surface soil
- Capping
- Skimming free product
- Free product recovery trenches
- Natural attenuation
- Enhanced bioremediation
- Excavation.

These technologies are described in the following subsections.

Excavate Surface Soil

Lead, arsenic, and TPH exceed the direct-contact cleanup criteria in several locations on the railyard. The impacted areas will be excavated to 2 feet below grade and will be capped with clean soil or ballast to prevent direct contact by site workers and trespassers. Based on the excavation outlines illustrated on Figure 7-16, it is estimated that 5,700 cy are associated with metals and an additional 6,600 cy are associated with TPH. Metals-impacted soil will be excavated in all site-wide alternatives to prevent exposure via dust. Soil exceeding cleanup levels will remain in place across much of the site; dermal contact will be prevented by a protective layer of clean soil (or ballast on the railyard).

Soil will be excavated using a backhoe or excavator. The excavated soil will be placed in trucks and transported to stockpiles on the railyard. The soil will be shipped to an off-site landfill by truck or rail. The excavated area will be lined with a woven-fabric, indicator layer to separate the subsurface-impacted soil from the clean-cap material.

Capping

A permeable cap may be used to protect the following pathways on the railyard.

- **Windblown Transport:** A cap may be used to eliminate the potential for contaminated soil being blown from the railyard by wind. Several alternatives for this Zone include excavating all contaminated soil in the upper two feet, and backfilling the area with 2 feet of clean fill. Therefore, a permeable cap overlying TPH impacts greater than 2 feet in depth is proposed.

- **Direct Contact:** A cap is proposed to prevent people or wildlife from coming into direct contact with the contaminated material at the railyard. Several alternatives include excavation of the upper two feet of soil in areas where contamination exceeds the direct contact cleanup levels. The excavated soil will be replaced with clean fill. This clean fill is, in effect, a permeable cap.

Skimming Free Product

For site-wide alternatives with a conditional groundwater POC at the South Fork Skykomish River, aggressive free product removal on the railyard contributes little to no benefit to the protection of human health and the environment although it reduces the restoration time frame for groundwater on the railyard. For other alternatives, installation of skimming wells will remove free product up to the BNSF property boundary (alternative SW1) and at free product plumes within the railyard (alternatives SW2, SW3, SW4, and PB1). These wells will be installed at 50-foot centers at the downgradient edge of the free product plumes. Wells will be installed using standard drilling techniques and the wells will be screened across the range of water table fluctuation. The pumps will be housed in above-ground structures protected by bollards.

Free Product Recovery Trenches

Recovery trenches provide a minimally intrusive means to remove free product from the subsurface. The use of trenches relies on the hydraulic gradient to transport free product to the trenches. Trenches would be excavated using bioslurry techniques to 5 feet below the low water table. The trench backfill material would be designed to be compatible with native soil conditions and an impermeable barrier would be placed on the downgradient wall of the trench to prevent free product from escaping beyond the trench. Sumps will be placed in the trench at about 50-foot spacing.

Proposed locations of recovery trenches are illustrated in Figure 7-17. Due to the location of free product on the railyard, recovery trenches are considered primarily for the downgradient zone/property boundary. Berms will be constructed around the trenching area to prevent loss of bioslurry overflows. Temporary mixing equipment, tanks, and pumps will be required near the excavation area to supply bioslurry. Trench backfill material, impermeable barrier material, and sump material will also be stockpiled near the work area. Excavated material will be stockpiled on the railyard prior to off-site shipment for disposal via rail or truck. The work surfaces will be replaced to pre-trenching conditions.

Electric skimming pumps will be placed in vaults at each sump location and an electric control panel will be located nearby. No other aboveground features will be present. The skimming pumps will likely remain in operation for a period exceeding 10 years.

Natural Attenuation

Natural attenuation in the Railyard Zone would only be used following free product removal. Because of the presence of oil-range petroleum throughout this zone, skimming wells and pumps, recovery trenches, excavation, or flushing will be used to remove the free product prior to relying on natural attenuation. Once the free product is removed, natural attenuation will help address the residual soil and groundwater impacts. Natural attenuation will be effective in this zone due to the distance between the railyard and the primary downgradient ecological receptor, the South Fork Skykomish River. Compliance with groundwater cleanup levels at the BNSF property boundary could be accelerated with enhanced bioremediation. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected since aerobic degradation is anticipated to be the primary method of petroleum degradation.

Enhanced Bioremediation

Enhanced bioremediation is not an effective cleanup technology by itself in the Railyard Zone due to the presence of bunker C/diesel free product and significant soil impacts. This technology will only be used once the significant impacts have been addressed by recovery trenches or excavation. Enhanced bioremediation will be implemented as a groundwater containment remedy using air sparging techniques. Bench-scale testing of this technology has been performed and is described in detail in the Bench-Scale Cleanup Technology Testing Report (RETEC, 2004), and in Section 7.2 of this FS. As a containment remedy, enhanced bioremediation will include a single row of air sparging wells located near the downgradient zone/property boundary (Figure 7-18). This row will stretch across the whole area where groundwater exceeds the remediation level (208 µg/L EPH/VPH).

Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation, and air will be injected at a rate of 2 to 3 scfm per well. Compressed air will be supplied using positive displacement blowers located on the railyard. These blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches to connect the equipment on the railyard with the air sparging wells.

All work surfaces will be replaced to pre-cleanup conditions. A flush-with-grade monument will be present at each wellhead. All other equipment will be restricted to a small equipment pad.

Excavation

Excavation in the Railyard Zone includes either: (1) excavation of free product at the two southern free product plumes; (2) excavation to a soil RL of 2,000 mg/kg NWTPH-Dx; or, (3) the complete excavation of all free product areas and all contaminated soil above cleanup levels (Figure 7-19). These three scenarios are discussed individually below; however, all scenarios would occur during low water conditions to maximize access to impacted smear zone soil. Clean overburden soil will be stockpiled as close to the excavation as possible and will be used as clean backfill. Impacted soil will be stockpiled on the railyard for on-site treatment or hauling to an off-site landfill via rail or truck. All utilities will need to be protected or temporarily rerouted to facilitate excavation. Little to no site clearing is required on the railyard although excavation of all contaminated soil will require temporary relocation of rail lines.

- **Excavation to Remove Free Product at the Two Southern Plumes –** This scenario is intended to maximize free product removal while avoiding disruption of railyard activities. This scenario will be used in conjunction with flushing to address the inaccessible free product areas. Accessibility is generally defined as anywhere a building or active rail line is not present. For the purpose of the FS, it is assumed that excavations will be sloped to maintain the stability of surface structures and rail lines. Based on this scenario, approximately 3,950 cy of soil will be excavated with 2,900 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation to a Soil RL of 2,000 mg/kg NWTPH-Dx and Excavation of All Contaminated Soil –** These scenarios are each only included in one remedial alternative. The excavations will require the temporary relocation and replacement of active rail lines to provide complete site access for excavation. Based on the excavation to a soil RL of 2,000 mg/kg NWTPH-Dx, approximately 185,340 cy of soil will be excavated with 129,980 cy requiring treatment or disposal. Based on the excavation of all soil exceeding cleanup levels, approximately 258,400 cy of soil will be excavated with 235,430 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

7.4.1.7 Institutional Controls (All Cleanup Zones)

Institutional controls are an essential component of any cleanup action, including the Preferred Alternative presented in Section 10. Even with the STD alternative (excavation of all soils to cleanup levels in all cleanup zones), institutional controls would be required for several years until the excavation work was completed and groundwater conditions stabilize. Institutional controls are legal or administrative measures designed to limit or control activities that could result in inadvertent exposure to contamination before, during, and after a cleanup action, particularly if contaminant residues are likely to remain above cleanup levels for an extended period of time. For many of the alternatives evaluated herein, soil and groundwater are likely to remain at concentrations above cleanup levels in the NE and NW Developed Zones for an extended period of time. These impacts will not present a threat to human health and the environment if institutional controls are properly utilized. For many of the alternatives presented in this FS, soil and groundwater will also remain at concentrations above cleanup levels for an extended period of time on the Railyard where institutional controls will also be used. For the Skykomish cleanup, institutional controls will be designed to:

- Ensure access by BNSF or Ecology to remedial systems (e.g., cleanup or monitoring equipment) before, during and after active cleanup operations

- Protect residents, visitors, property owners and construction workers from exposure to hazardous substances on site during and after active cleanup operations.

A common form of institutional control that satisfies these objectives is a Restrictive Covenant that limits or restricts the use of a property. The Covenant is said to "run with the land" as provided by law and is binding on all current and future property owners and tenants. BNSF is currently negotiating agreements with individual property owners that include restrictive covenants. An example of such a covenant is provided in Appendix Q.

Another common form of institutional control is a local ordinance or a state rule or regulation. Local government, using its police powers, can limit the installation of groundwater wells in contaminated areas and can require proper management of soil and groundwater generated during excavation or drilling in contaminated areas. Including this type of condition to an existing permit system for grading would create an additional layer of protection to ensure that contaminated soil or groundwater are properly managed. It is currently envisioned that Town's existing grading permit requirements for private property, and its existing permit system for work in public areas such as public rights-of-way and utility corridors, would be amended to control excavation and drilling in contaminated areas and that BNSF would be responsible for properly managing soil and groundwater generated during construction projects through agreements with the Town and/or individual property owners. Ecology already has a rule prohibiting new wells in contaminated zones.

The institutional controls would place controls or limitations on the use of contaminated groundwater and/or soils for certain properties. The controls alert property owners and/or anyone who would be conducting subsurface work (utility installations) of precautions that must be taken when working with certain soils and/or groundwater. The controls would specify at what soil depth special planning and management must be followed. Shallow non-contaminated soils would not be affected by the controls, and therefore typical activities such as gardening and plantings would not require any special actions by property owners. Utility installations, construction activities or other such actions that may be desired by property owners would be allowed, the controls simply state precautions and procedures that must be followed when the activities involve contaminated soil and/or groundwater. The controls do prohibit the use of impacted groundwater. Appendix Q provides a specific example of the type of institutional controls that are currently being considered by property owners in Skykomish.

The SW and Preferred Alternatives will meet the groundwater cleanup level at the point where groundwater discharges to surface water. Therefore, long term institutional controls (anticipated to be in place much longer than 10 years) would be required on properties throughout the NW Developed Zone and the NE Developed Zones. As discussed in Section 10.8, five year reviews and ongoing technology development may result in remedial options that can be implemented at a later time to reduce or eliminate long-term institutional controls.

7.4.2 Description of Site-Wide Remedial Alternatives

This section provides a summary description of each site-wide remedial alternative. More specific information regarding how each cleanup technology would be implemented in each cleanup zone is described in Section 7.4.1.

Site-wide remedial alternatives were developed to meet cleanup standards for the following three POCs: (1) off-property, conditional groundwater POC at the points of discharge to surface water (SW1 to SW4); (2) on-property, conditional groundwater POC at the property boundary (PB1 to PB5); and (3) the standard POCs (STD). Remedial alternative STD represents the most permanent alternative, and it meets cleanup levels at the standard POCs for all media. A No Action alternative is not presented in the tables but is retained in the text to satisfy SEPA requirements.

Table 7-3 summarizes how the groundwater POCs were combined with soil, sediment, and groundwater cleanup and remediation levels to develop the remedial alternatives. The matrix provides a basis for understanding the alternative development process and comparing the alternatives with respect to compliance with cleanup standards. Section 6 of this FS discusses remediation levels that would be applicable to each of these alternatives. Please refer to Section 6 for specific remediation levels to each alternative.

All of the alternatives in this FS (except No Action) can achieve cleanup standards and protect public health and the environment. Thus, the bulk of this document analyses the trade-offs between restoration time frame and degree of permanence (which includes cost), and minimizing adverse impacts to the built and natural environment. BNSF's preferred alternative, a combination of technologies and alternatives developed herein and selected based on the analysis presented in Sections 8 and 9, and on public and agency comments to date, and on public and agency comments to date, is described in Section 10.

Table 7-4 provides a matrix that illustrates which remedial approaches were selected for each medium in each cleanup zone. Table 7-5 further expands this matrix by providing a summary description of the remedial approach for each zone for each site-wide remedial alternative.

7.4.2.1 Alternatives with the Off-Property, Conditional Groundwater Point of Compliance

The alternatives in this section were developed to meet an off-property, conditional groundwater POC (i.e., groundwater must achieve cleanup levels before discharging to the River or Maloney Creek). The SW alternatives will improve groundwater at the site but will not meet groundwater cleanup levels between BNSF property and the River. Per WAC 173-340-720 (8)(d)(ii), the affected property owners between the railyard and the surface water body must agree in writing to the use of the conditional point of compliance. The alternatives are discussed from left to right on Table 7-5 as you proceed through the discussions below. In general, more aggressive alternatives are more costly than less aggressive alternatives, thereby reducing restoration time and increasing permanence.

Alternative SW1

The cleanup technologies that combine to make up Alternative SW1 are listed on Table 7-5. Together these remedial approaches satisfy the minimum requirements of MTCA by removing free product, satisfying groundwater cleanup standards before reaching points of discharge, and providing containment and institutional controls to prevent dermal contact with soil off the railyard (Figure 7-20). This alternative permanently addresses the higher risk pathways of:

- Groundwater and oil discharges to the South Fork Skykomish River
- Contaminated surface soil that might cause dust or be a direct contact concern.

This alternative also minimizes short-term impacts to the community and the environment while relying on a long restoration timeframe and institutional controls to achieve cleanup.

This alternative consists of the following actions:

- Enhanced bioremediation in the Levee Aquatic Resource Zone

- Monitored natural attenuation in the Former Maloney Creek Aquatic Resource Zone

- Monitored natural attenuation in the Northeast Developed Zone

- Excavation of free product, surface soil with greater than 2,600 mg/kg NWTPH-Dx, and monitored natural attenuation in the South Developed Zone

- Excavation of surface soil with metals exceeding their cleanup levels, maintenance of the barrier wall and recovery system, and monitored natural attenuation in the Northwest Developed Zone

- Excavation of surface soil with metals exceeding their cleanup levels, capping, removal of free product by skimming, and monitored natural attenuation in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

Natural attenuation is used in the Former Maloney Creek Aquatic Zone to minimize the potential for habitat damage while attempting to restore soil and groundwater that is moderately impacted by petroleum.

Sediment impacts in the Levee Zone and the former Maloney Creek channel will be addressed by natural recovery to avoid damage to the habitat and to maximize the net environmental benefit of the habitat.

Alternative SW2

The cleanup technologies that combine to make up Alternative SW2 are listed on Table 7-5. Alternative SW2 builds on SW1 by adding the following elements:

- Free product recovery trenches in the NW Developed Zone to supplement the existing barrier wall and skimming system

- More aggressive free product recovery on the railyard by replacing skimming wells with recovery trenches at the property boundary and adding skimming wells to remove free product from the interior of the railyard.

A plan view illustrating the SW2 site-wide remedial alternative is provided in Figure 7-21. This alternative provides some additional short-term protectiveness but does not significantly shorten the long restoration time frame.

Alternative SW3

The cleanup technologies that combine to make up Alternative SW3 are listed on Table 7-5. Alternative SW3 provides the following additional actions relative to SW2:

- Excavating free product in the levee to reduce the time frame required to eliminate seeps
- Removing impacted surface sediment associated with the free product removal in the levee noted above
- Implementing enhanced bioremediation in the NE Developed Zone to achieve soil and groundwater cleanup levels
- Excavating free product, where accessible, in the NW Developed Zone.

A plan view illustrating the SW3 site-wide remedial alternative is provided in Figure 7-22. This alternative provides additional short-term protectiveness in the Levee Aquatic Zone, reduces the time frame to permanently remove free product in the NW Developed Zones, and accelerates groundwater cleanup in the NE Developed Zone.

Alternative SW4

The cleanup technologies that combine to make up Alternative SW4 are listed on Table 7-5. Alternative SW4 is evaluated with a conditional groundwater POC at the River and Maloney Creek. This alternative provides additional cleanup actions as follows:

- Excavating the levee to a soil remediation level (3,400 mg/kg NWTPH-Dx) that is protective of groundwater
- Removing all contaminated surface sediment in the South Fork Skykomish River
- Removing impacted surface sediment in the former Maloney Creek channel to the extent that it does not significantly damage the wetland
- Implementing enhanced bioremediation in the former Maloney Creek channel to address soil impacts and reduce the potential for recontamination of sediment
- Excavating all soil to a RL of 3,400 mg/kg NWTPH-Dx from the South Developed Zone

- Excavating all free product in the NW Developed Zone
- Excavating shallow smear zone impacts in the NW Developed Zone to 4 feet bgs to reduce the likelihood of direct contact by residents and public utility workers
- Excavating surficial soil with TPH concentrations greater than the direct contact cleanup level (2,600 mg/kg TPH-Dx) on the railyard in addition to metals exceeding their cleanup levels.

A plan view illustrating the SW4 site-wide remedial alternative is provided in Figure 7-23. This alternative accelerates cleanup in the Levee Aquatic Resource Zone and removal of free product, and it more permanently addresses direct contact risks.

7.4.2.2 Alternatives with the On-Property, Conditional Groundwater Point of Compliance

The alternatives in this section were developed to meet on-property conditional groundwater POC (i.e., groundwater must achieve cleanup standards as close as practicable to the source without exceeding the BNSF property boundary). Each of the PB alternatives will clean up groundwater from BNSF property to the River. The alternatives are discussed from left to right on Table 7-5 and as you proceed through the discussions below.

Alternative PB1

The cleanup technologies that combine to make up Alternative PB1 are listed on Table 7-5. Alternative PB1 removes free product, complies with groundwater cleanup standards, protects the South Fork Skykomish River and Maloney Creek, and provides containment and institutional controls to prevent dermal contact with soil off the railyard (Figure 7-24). This alternative consists of the following actions:

- Enhancing bioremediation in the Levee Aquatic Resource Zone
- Excavating surface metals, capping, skimming free product, recovering free product with recovery trenches, and monitoring natural attenuation in the Railyard Zone.

These actions permanently address the higher risk pathways of:

- Groundwater and oil discharges to the South Fork Skykomish River
- Contaminated surface soil that might be inhaled as dust or might be a direct contact concern.

The alternative also looks to address impacts beyond the property boundary by:

- Excavating the South Developed Zone to remove contaminated soil to an RL of 3,400 mg/kg NWTPH-Dx
- Excavating free product from the NW Developed Zone where accessible
- Excavating surface soil with metals exceeding their cleanup levels
- Implementing enhanced bioremediation in the NW Developed Zone
- Monitoring Natural Attenuation in the Former Maloney Creek Aquatic Resource Zone and the Northeast Developed Zone
- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

A plan view illustrating the PB1 site-wide remedial alternative is provided in Figure 7-24.

Alternative PB2

The cleanup technologies that combine to make up Alternative PB2 are listed on Table 7-5. Alternative PB2 builds on PB1 by adding the following elements:

- Excavating free product in the levee
- Removing impacted surface sediment associated with the free product removal in the levee noted above
- Implementing enhanced bioremediation in the NE Developed Zone
- Excavating free product and using enhanced bioremediation of groundwater at the property boundary to restore groundwater quality in the NW Developed Zone
- Using free product recovery trenches for the interior free product plumes on the Railyard rather than skimming pumps.

A plan view illustrating the PB2 site-wide remedial alternative is provided in Figure 7-25.

Alternative PB3

The cleanup technologies that combine to make up Alternative PB3 are listed on Table 7-5. Alternative PB3 builds on PB2 by adding the following elements:

- Excavating free product and impacted soil to an RL of 3,400 mg/kg TPH-Dx in the levee
- Removing all contaminated surface sediment in the South Fork Skykomish River
- Removing contaminated surface sediment from the Former Maloney Creek channel to the extent that it does not significantly damage the wetland habitat
- Implementing enhanced bioremediation in the Former Maloney Creek Channel to address soil impacts and reduce the potential for recontamination of sediment
- Excavating all free product in the NW Developed Zone
- Excavating shallow smear zone impacts in the NW Developed Zone to 4 feet bgs to reduce the likelihood of direct contact by residents and public utility workers
- Excavating surface soil with TPH concentrations greater than the direct contact cleanup level (2,600 mg/kg TPH-Dx) on the Railyard in addition to metals, exceeding their cleanup levels.

A plan view illustrating the PB3 site-wide remedial alternative is provided in Figure 7-26.

Alternative PB4

The cleanup technologies that combine to make up Alternative PB4 are listed on Table 7-5. Alternative PB4 provides additional action relative to PB3 as follows:

- Excavating all free product and soil impacts to an RL of 3,400 mg/kg NWTPH-Dx in the levee
- Removing all contaminated surface sediment in the former Maloney Creek channel
- Excavating free product in the NE Developed Zone in addition to enhanced bioremediation

- Excavating all free product and impacted soil to an RL of 20,000 mg/kg NWTPH-Dx
- Excavating the two southern free product areas on the railyard.

A plan view illustrating the PB4 site-wide remedial alternative is provided in Figure 7-27.

Alternative PB5

The cleanup technologies that combine to make up Alternative PB5 are listed on Table 7-5. Alternative PB5 is similar to the STD alternative and includes excavation to a soil RL of 2,000 mg/kg NWTPH-Dx in all zones. Surface soil and sediment removal activities are the same as those proposed for PB4. A plan view illustrating the PB5 site-wide remedial alternative is provided in Figure 7-28.

7.4.2.3 Standard Point of Compliance Alternative (STD)

This alternative is included to satisfy the MTCA requirement that one remedial alternative be included in the FS that achieves cleanup levels for all media at standard POCs. Due to the physical and chemical properties of the petroleum impacts at Skykomish, this alternative relies primarily on excavation of all free product and all impacted soil.

Figure 7-29 shows the layout of these excavations for free product, soil, and sediment. The excavations will be performed to remove all free product, all soil above cleanup levels, and all sediment above cleanup levels. The River and Maloney Creek would be restored, the levee would be rebuilt and structures, buildings, roads and utilities would be replaced or rebuilt.

8 MTCA Evaluation of Remedial Alternatives

This section evaluates each of the remedial alternatives with respect to threshold and other requirements for cleanup actions set forth in MTCA, Ch. 70.105D (WAC 173-340-360). The requirements of MTCA against which the alternatives are evaluated are first described in Section 8.1. The action and No Action alternatives are evaluated against MTCA requirements in Section 8.2 to 8.10, including a summary of the alternatives evaluated in Section 8.1. The alternatives are then evaluated on a comparative basis using the MTCA requirements in Section 9. BNSF's preferred alternative is described and evaluated in the same manner in Section 10.

8.1 Requirements for Remedial Alternatives

Cleanup actions selected under MTCA must meet several requirements that address multiple factors in addition to the overarching goal of protecting human health and the environment. These requirements include threshold requirements and "other requirements" per WAC 73-340-360(2)(a) and (b) and as summarized in the following subsections. WAC 173-340-360(2)(c) through (h) minimum requirements were considered in developing the alternatives. The remedial alternatives are evaluated against these requirements in Sections 8.2 to 8.10. The final selection of a cleanup action will be based on the requirements of WAC 173-340-360(2). This comparative analysis is provided in Section 9.

8.1.1 Threshold Requirements

WAC 173-340-360(2)(a)) lists four threshold requirements for cleanup actions. All cleanup actions must:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring

All of the alternatives presented in Section 7.3.2.1 (except No Action) are designed to meet these threshold requirements, as described below.

8.1.1.1 Protect Human Health and the Environment and Comply with Cleanup Standards

The SW alternatives protect human health and the environment by meeting cleanup standards for groundwater at a conditional point of compliance where groundwater discharges to the South Fork Skykomish River (Table 8-1). Free product will be removed, petroleum discharges to the river will be eliminated, and surface soil contamination of the rail yard and the NW Developed Zone will be removed. Upland soil and groundwater between the rail yard and river will continue to exceed cleanup levels. Protection is achieved through containment (protective soil cap), institutional controls, and a long-term maintenance and monitoring program. MTCA evaluations of the SW alternatives are presented in Sections 8.2 to 8.5.

The PB alternatives meet groundwater standards at the railyard property boundary, another potential conditional point of compliance. Free product will be removed, petroleum discharges to the river and Maloney Creek will be eliminated, surface contamination on the rail yard and the NW Developed Zone will be removed and groundwater between the rail yard and river will be restored. MTCA evaluations of the PB alternatives are presented in Sections 8.6 to 8.9.

Subsurface soil on and off the rail yard will continue to exceed cleanup levels. Protection with respect to this material is achieved through containment, institutional controls and a long-term maintenance, inspection and monitoring program

The standard (STD) alternative achieves protection by meeting cleanup levels throughout the site for all media (sediment, groundwater, soil and surface water). Sediment cleanup is attained through some combination of natural recovery, removal, and enhanced bioremediation. All free product and contaminated soil is removed. Groundwater is restored to drinking water quality through natural attenuation following free product and soil removal. No long-term maintenance, inspection and monitoring program is required. MTCA evaluation of the STD alternative is presented in Section 8.10.

8.1.1.2 Comply with State and Federal Laws

Compliance with applicable state and federal laws is ensured, in part, through selection of the numeric cleanup levels (Section 5) that protect air, groundwater, surface water, and soil quality. Aside from cleanup levels, compliance must also be ensured in the manner by which prospective remedial alternatives are implemented. As described in Section 5, there are numerous laws and associated regulations that influence how any particular remedial action is implemented. Permitting by federal agencies, substantive standards promulgated by state and local agencies, best management practices, workplace safety, and off-site waste disposal practices are just a few of the aspects that must be formally addressed in the design and implementation phases of a cleanup action to ensure compliance with applicable laws. None of the alternatives possess features that cannot be designed and implemented in full compliance with these laws.

8.1.1.3 Provide for Compliance Monitoring

Compliance monitoring refers to the collection, analysis, and reporting of environmental data to determine the short and long-term effectiveness of the cleanup action and whether protection is being achieved in accordance with the cleanup objectives. Compliance monitoring plans are developed in conjunction with the Cleanup Action Plan and typically involve standard field techniques and laboratory analytical methods. All of the remedial alternatives presented in Section 7 include comprehensive compliance monitoring plans that fulfill the requirements of WAC 173-340-410.

8.1.2 "Other Requirements"

Under MTCA, alternatives that meet the threshold requirements described above must also meet the following "other requirements" (WAC 173-340-360(2)(b)):

- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration time frame
- Consider public concerns.

As the remedial alternatives were all designed to meet threshold requirements (except for No Action), the evaluation of remedial alternatives presented in this section focuses primarily on these other requirements that are described below. Table 8-2 is a compilation of relevant evaluation outcomes for each of the "Other Requirements" of cleanup actions under MTCA.

8.1.2.1 Use Permanent Solutions to the Maximum Extent Practicable

MTCA specifies that, when selecting a cleanup action, preference shall be given to actions that are "permanent to the maximum extent practicable." Multiple approaches to cleanup are possible for this site. Selecting one that is permanent "to the maximum extent practicable" requires the weighing of costs and benefits. MTCA defines this balancing as a "substantial and disproportionate cost analysis" (WAC 173-340-360(3)(e)). The analysis can be both quantitative (e.g., degree of hazardous substance volume or mass reduction, costs) and qualitative (e.g., overall protectiveness, implementability, consideration of public concerns). Section 9 presents a substantial and disproportionate cost analysis for the remedial alternatives presented in this FS. The alternatives span a broad range of costs and have widely varying impacts on the community and environment. Often, however, the alternatives afford only incremental or minor degrees of protection and permanence.

One important measure of permanence is the degree to which an alternative reduces the mass or toxicity of contamination present. All of the alternatives (except No Action) remove soil contaminated with metals and thus are equivalent in this regard. Hydrocarbons (in soil and as free product) are the major contaminants at the site, and removal or treatment of hydrocarbons is a useful measure of permanence with which to differentiate the alternatives.

In Section 9, an “equivalent soil volume” removed or treated is calculated for each alternative as a surrogate for hydrocarbon mass and permanence. An equivalent volume is a normalized or weighted volume based on the level of contamination and is determined as follows:

- Free product soil volume multiplied by a weighting factor of 40 (for mixed diesel and Bunker C free product areas)
- Diesel free product soil volume and impacted soil volume between 20,000 mg/kg NWTPH-Dx and free product multiplied by a weighting factor of 25 (for mixed diesel and Bunker C areas)
- Impacted soil volume between 3,400 mg/kg and 20,000 mg/kg NWTPH-Dx multiplied by a weighting factor of 11.7
- Impacted soil volume between 2,000 mg/kg and 20,000 mg/kg NWTPH-Dx multiplied by a weighting factor of 11
- Impacted soil volume between 20 mg/kg and 2,000 mg/kg NWTPH-Dx multiplied by a weighting factor of 1.

Soil containing metals was assigned a weighting factor of 1.

8.1.2.2 Provide for a Reasonable Restoration Time Frame

A reasonable restoration time frame is another requirement for evaluating alternatives. MTCA places a preference on those alternatives that, while equivalent in other respects (e.g., permanence, implementation risks to the community and environment, costs) can be implemented in a shorter period of time. Thus, while all of the alternatives (except No Action) attain cleanup standards, they vary in the time required to do so.

8.1.2.3 Community Concerns

Community concerns are considered by Ecology in the selection of cleanup actions and are formally obtained during required Public Notice and Participation periods per WAC 173-340-600. Earlier versions of the FS have undergone formal public comment to solicit comments from the community on the proposed remedial alternatives; these concerns have been considered in preparing the preferred alternative in Section 10 and in revising the FS to.

Issues of particular interest and concern to the community of Skykomish include the prospects for significant disruptions and disturbances (e.g., noise, traffic, temporary relocation of residents and buildings) that could attend a cleanup action. In addition, the community has expressed concerns over the potential duration and effectiveness of cleanup actions, protection of the environment, protection of public health, public facilities such as the school, water supply, septic waste treatment and disposal, the local economy, and property values. While some of the socio-economic concerns of the community are not directly addressed through MTCA, the alternatives presented in this document span a range of actions that attempt to balance the concerns already expressed by the community with other MTCA factors such as permanence, effectiveness, restoration time frame, and avoiding or mitigating adverse impacts on the built and natural environment.

8.2 No Action Alternative

This alternative includes continued use of the existing barrier wall and associated free product skimming system. This system (wall and skimmers) is collecting free product at the site at the leading edge of the plume and should ultimately result in the cessation of seeps to the South Fork Skykomish River. A dust suppressant will continue to be applied to metals-impacted surface soils on the railyard to minimize airborne exposures. Oil recovery booms will continue to be maintained along the River to recover oil. Long-term groundwater monitoring will also be performed. The alternative will not restore groundwater or sediment quality in Maloney Creek and the River. Further, the alternative will not fully protect people or ecological receptors from exposure to surface or subsurface contamination. The No Action alternative will effectively satisfy the MTCA requirement to collect free product.

No Action would not significantly affect the built environment. No roads, buildings or utilities would be physically damaged or disrupted. The long-term presence of contamination could deter future investment in the built environment and the community. The natural environment would continue to be significantly and adversely impacted by the contamination present.

8.3 Evaluation of Alternative SW1

Alternative SW1 consists of:

- Enhancing bioremediation in the Levee Aquatic Resource Zone
- Monitoring natural attenuation in the Former Maloney Creek Aquatic Resource Zone
- Monitoring natural attenuation in the NE Developed Zone
- Excavating free product, excavating surface TPH and monitoring natural attenuation in the South Developed Zone

- Excavating surface metals, maintaining the barrier wall and recovery system, and monitoring natural attenuation in the NW Developed Zone

- Excavating surface metals, capping, skimming free product, and monitoring natural attenuation in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

Protection of human health is achieved in the short-term (less than 1 year) through excavation of surface soil containing metals and implementation of institutional controls. Soil exceeding the cleanup level remains in place across much of the site and is isolated from the ground surface by a protective layer of clean soil (or ballast on the railyard). Threshold requirements are met after groundwater and sediment achieve cleanup standards, a process likely to take more than 30 years to complete.

SW1 is implementable from both a technical and administrative standpoint. Further, short-term risks during implementation are minor and manageable using standard methods and procedures for protecting workers and the community. Access agreements to private property are needed for monitoring.

Protection of human health is achieved by removal/disposal of surface soil containing metals. Isolation of soil exceeding cleanup levels and institutional controls to prevent exposures to contaminated media (soil, free product, and groundwater) is not permanent. In the long term groundwater will achieve protective concentrations due to the removal of free product. However, protection with respect to these media is achieved through long-term maintenance, inspection and monitoring.

Figure 8-1 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.4 Evaluation of Alternative SW2

Alternative SW2 consists of:

- Enhancing bioremediation in the Levee Aquatic Resource Zone

- Monitoring natural attenuation in the Former Maloney Creek Aquatic Resource Zone

- Monitoring attenuation in the NE Developed Zone

- Excavating free product, excavating surface TPH and monitoring natural attenuation in the South Developed Zone

- Installing free product recovery trenches, excavating surface metals and monitoring natural attenuation in the NW Developed Zone

- Excavating surface metals, capping, skimming free product, recovering free product with trenches and monitoring natural attenuation of groundwater in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

The MTCA evaluation of Alternative SW2 is nearly equivalent to that for SW1 because of the minor technical differences between the two alternatives. With SW2, free product removal time decreases because of the greater number and density of free product recovery elements (trenches and well-based recovery equipment).

Access agreements to private property are needed to service and monitor free product recovery equipment.

As with SW1, protectiveness of human health is achieved by removal/disposal of surface soil containing metals. Isolation of subsurface soil exceeding cleanup levels and institutional controls to prevent exposures to contaminated media (soil, free product and groundwater) are effective but lack permanence and long-term protectiveness, as defined by MTCA.

Figure 8-2 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.5 Evaluation of Alternative SW3

Alternative SW3 consists of:

- Excavating free product, excavating sediment to cleanup levels and enhancing bioremediation in the Levee Aquatic Resource Zone
- Monitoring natural attenuation in the Former Maloney Creek Aquatic Resource Zone
- Enhancing biodegradation in the NE Developed Zone
- Excavating free product, excavating surface TPH, and monitoring natural attenuation in the South Developed Zone
- Excavating free product where accessible, excavating surface metals and monitoring natural attenuation in the NW Developed Zone
- Excavating surface metals, capping, skimming free product, recovering free product with trenches and monitoring natural attenuation in the Railyard Zone
- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

This alternative increases permanence and protectiveness over the previous alternatives (SW1 and SW2) by excavating free product in the NW Developed Zone (where accessible), excavating free product in the levee, removing contaminated sediments from the South Fork Skykomish River, and free product treatment in the NE Developed Zone using enhanced bioremediation. Free product remaining after excavation is prevented from reaching the South Fork Skykomish River by the existing barrier wall and passive recovery systems (trenches and skimmers) or with new recovery trenches placed in the vicinity of the existing barrier wall.

Access agreements are needed to excavate and monitor on private property. Disruption to the community occurs as a result of excavation work near homes and other infrastructure. Temporary road and utility service disruptions are likely.

This alternative reduces the restoration time frame relative to previous alternatives for attainment of sediment and groundwater cleanup levels at the off-property, conditional point of compliance at the levee. While increasing protectiveness and permanence with respect to free product removal, soil and groundwater are likely to remain above cleanup levels across most of the site in the long-term. As with SW1 and SW2, protection is ensured through institutional controls.

Figure 8-3 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.6 Evaluation of Alternative SW4

Alternative SW4 consists of:

- Excavating soil to 3,400 mg/kg NWTPH-Dx and free product, excavating sediment to cleanup levels and enhancing bioremediation in the Levee Aquatic Resource Zone

- Enhancing bioremediation and excavating sediment to remediation levels in the Former Maloney Creek Aquatic Resource Zone

- Enhancing bioremediation in the NE Developed Zone

- Excavating all soil above 3,400 mg/kg NWTPH-Dx in the South Developed Zone

- Excavating free product, surface metals, and soil in the shallow smear zone that exceeds 3,400 mg/kg NWTPH-Dx and monitoring natural attenuation in the NW Developed Zone

- Excavating surface metals and surface soil that exceeds 2,600 mg/kg NWTPH-Dx, capping, skimming free product, recovering free product using trenches and monitoring natural attenuation in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

This alternative increases permanence and effectiveness over the previous alternative (SW3) by excavating all free product in the NW Developed Zone, removing shallow soil contamination in the NW Developed Zone (where accessible), removing near-surface, TPH-contaminated soil in the railyard and more aggressively attending to sediment impacts at the Former Maloney

Creek. Excavation is used at the levee to remediate free product and soil contamination.

Access agreements are needed to excavate and monitor on private property. Disruption to the community occurs as a result of excavation work near homes and other infrastructure. Temporary road and utility service disruptions are likely.

This alternative reduces restoration time frames (relative to the previous alternatives), primarily with respect to attainment of cleanup levels at the Aquatic Resource Zones. Actions in the Former Maloney Creek have significant impacts on the natural environment and may outweigh any benefit from restoration measures more aggressive than natural recovery.

Protectiveness and permanence are increased in the NW Developed Zone in that free product removal efficiency is greater. Nevertheless, soil and groundwater are likely to remain above cleanup levels across most of the site in the long-term. As with SW1, SW2 and SW3, protection is ensured through institutional controls.

Figure 8-4 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.7 Evaluation of Alternative PB1

Alternative PB1 consists of:

- Enhancing bioremediation in the Levee Aquatic Resource Zone
- Monitoring natural attenuation in the Former Maloney Creek Aquatic Resource Zone
- Monitoring natural attenuation in the NE Developed Zone
- Excavating soil above a RL of 3,400 mg/kg NWTPH-Dx in the South Developed Zone
- Excavating free product where accessible, excavating surface metals and enhancing biodegradation in the NW Developed Zone

- Excavating surface metals, capping, skimming free product, recovering free product with trenches and monitoring natural attenuation in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

Alternative PB1 protects human health and the environment and meets cleanup standards through a combination of sediment natural recovery, excavation, enhanced bioremediation, passive free product recovery, isolation of subsurface contaminated soil and institutional controls.

Excavation of metals contaminated surface soil, accessible free product in the NW Developed Area, and soil in the South Developed Zone can be accomplished within a 2-year planning horizon. These elements of Alternative PB1 are both permanent and protective. Remaining soil in excess of cleanup levels is isolated below a protective clean soil layer and cannot be contacted except under controlled circumstances (as stipulated in institutional controls). While effective, these measures are not considered permanent and protective under MTCA.

Enhanced bioremediation promotes restoration of groundwater quality between the railyard and the point at which groundwater discharges to the South Fork Skykomish River. This will likely require a restoration time frame of greater than 30 years in the NW Developed Zone. The results provided in the Bench-Scale Testing Report (RETEC, 2004) indicate enhanced bioremediation is anticipated to be both permanent and effective as the hydrocarbon contaminants are biodegradable, the technology is well developed, and system components are reliable.

Figure 8-5 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.8 Evaluation of Alternative PB2

Alternative PB2 consists of:

- Excavating free product, excavating sediment to remediation levels (3,400 mg/kg NWTPH-Dx) and enhancing bioremediation in the Levee Aquatic Resource Zone

- Monitoring natural attenuation in the Former Maloney Creek Aquatic Resource Zone

- Enhancing biodegradation in the NE Developed Zone

- Excavating soil above a RL of 3,400 mg/kg NWTPH-Dx in the South Developed Zone

- Excavating all free product, excavating surface metals and enhancing biodegradation in the NW Developed Zone

- Excavating surface metals, capping, skimming free product, recovering free product with recovery trenches within the areas of free product, and enhancing biodegradation in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

Alternative PB2 builds on provisions of PB1 by increasing the amount of enhanced bioremediation for developed areas north of the railyard and by increasing the permanence and effectiveness of soil and sediment cleanup actions at the levee through selective removal (excavation) and grouting. PB2 addresses all free product, not just accessible free product.

The removal of soil and free product at seep locations reduce the time required to restore sediment quality to protective levels. The greater enhanced bioremediation infrastructure, particularly in the NE Developed Zone, reduces the time required to restore groundwater quality. The complete removal of free product in the NW Developed Zone reduces the restoration timeframe for both soil and groundwater.

Figure 8-6 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.9 Evaluation of Alternative PB3

Alternative PB3 consists of:

- Free product excavation, excavating sediment to cleanup levels, soil to a RL of 3,400 mg/kg NWTPH-Dx, and enhancing bioremediation in the Levee Aquatic Resource Zone
- Enhancing biodegradation and excavating sediment to remediation levels in the Former Maloney Creek Aquatic Resource Zone
- Enhancing biodegradation in the NE Developed Zone
- Excavating soil above a RL of 3,400 mg/kg NWTPH-Dx in the South Developed Zone
- Excavating free product, excavating surface metals to CULs, excavating the shallow smear zone to 3,400 mg/kg NWTPH-Dx, and enhancing biodegradation in the NW Developed Zone
- Excavating surface metals and soil with NWTPH-Dx greater than 2,600 mg/kg, capping, recovering free product with trenches, and enhancing biodegradation in the Railyard Zone
- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings

Alternative PB3 builds on provisions of PB2 primarily by reducing the restoration time frame for the Aquatic Resource Zones. More aggressive action is also taken at the levee to restore sediment and soil and groundwater quality at both the Levee and the former Maloney Creek.

Actions in the Former Maloney Creek have significant impacts on the natural environment and may outweigh any benefit from restoration measures more aggressive than natural recovery.

Figure 8-7 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.10 Evaluation of Alternative PB4

Alternative PB4 consists of:

- Excavating the smear zone to a soil RL of 3,400 mg/kg NWTPH-Dx, excavating sediment to cleanup levels, and enhancing bioremediation in the Levee Aquatic Resources Zone

- Enhancing biodegradation and excavating sediment to cleanup levels in the Former Maloney Creek Aquatic Resource Zone

- Excavating free product and enhancing biodegradation in the NE Developed Zone

- Excavating soil above a RL of 3,400 mg/kg NWTPH-Dx in the South Developed Zone

- Excavating soil to a RL of 20,000 mg/kg NWTPH-Dx, excavating surface metals and the shallow smear zone and enhancing biodegradation in the NW Developed Zone

- Excavating free product at the two southern plumes, surface metals and TPH, capping, and enhancing biodegradation in the Railyard Zone

- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

Alternative PB4 meets cleanup standards in off-railyard areas in approximately 10 years, except for soil and groundwater in the NW Developed Zone. All free product and residual product are removed by excavation. Sediment is removed to cleanup levels at the South Fork Skykomish River and in the former Maloney Creek channel.

Federal (Nationwide 38) permitting is required for sediment removal along the levee.

This alternative, while technically feasible, is very disruptive to the community and environment given the extended reach of cleanup operations in the NW Developed Zone. Residents would need to be temporarily displaced during excavation near homes. Residual contamination above soil cleanup levels would remain, thereby necessitating institutional controls to ensure protection.

Figure 8-8 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal from long-term remediation activities is also provided on the figure.

8.11 Evaluation of Alternative PB5

Alternative PB5 consists of:

- Excavating the smear zone to a soil RL of 2,000 mg/kg NWTPH-Dx and excavating sediment to cleanup levels
- Excavating to a soil RL of 2,000 mg/kg NWTPH-Dx and excavating sediment to cleanup levels in the Former Maloney Creek Aquatic Resource Zone
- Excavating to a soil RL of 2,000 mg/kg NWTPH-Dx in the NE Developed Zone
- Excavating soil above a RL of 2,000 mg/kg NWTPH-Dx in the South Developed Zone
- Excavating soil to a RL of 2,000 mg/kg NWTPH-Dx and, excavating surface metals in the NW Developed Zone
- Excavating soil to a RL of 2,000 mg/kg NWTPH-Dx in the Railyard Zone
- Air quality monitoring where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings.

Alternative PB5 would likely achieve cleanup levels immediately after excavation was performed. Although numeric soil cleanup levels are below 2,000 mg/kg NWTPH-Dx, compliance monitoring would likely provide the empirical demonstration that soil is protective of groundwater that would allow removal of institutional controls.

While technically feasible and possessing a significant level of permanence, the PB5 alternative requires the removal or destruction and replacement of a significant number of homes and infrastructure, including the main rail line and a telecommunication switching station and associated fiber optics cables. This disruption includes the likelihood that the Skykomish School would be closed for one or more semesters. These are major short-term and possibly long-term consequences for the community.

Excavation of sediment in the levee and former Maloney Creek channel will result in short-term attainment of cleanup levels for soil and sediment at the expense of the existing natural habitat. Sediment and soil removal below the stream high water marks will require federal permitting (Nationwide 38).

Figure 8-9 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal rates from long-term remediation activities is also provided on the figure.

8.12 Evaluation of Standard Alternative (STD)

Alternative STD consists of:

- Excavating the smear zone and excavating sediment to cleanup levels in the Levee Aquatic Resource Zone
- Excavating the smear zone and excavating sediment to cleanup levels in the Former Maloney Creek Aquatic Resource Zone
- Excavating free product and the smear zone in the NE Developed Zone
- Excavating all soil above cleanup levels in the South Developed Zone
- Excavating all soil above cleanup levels in the NW Developed Zone
- Excavating all soil above cleanup levels in the Railyard Zone.

The standard alternative requires excavation of all free product and soil exceeding cleanup levels and is, therefore, the only alternative that meets the cleanup standard without the need for institutional controls. While technically feasible and possessing the maximum levels of permanence protectiveness of all alternatives, the standard alternative requires the removal or destruction and replacement of all homes and infrastructure in identified excavation areas, including the main rail line and a telecommunication switching station and associated fiber optics cables. This disruption includes the likelihood that the Skykomish School would be closed for one or more semesters. These are major short-term and possibly long-term consequences for the community.

Excavation of sediment in the levee and former Maloney Creek channel will result in short-term attainment of cleanup levels for soil and sediment at the expense of the existing natural habitat. Sediment and soil removal below the stream high water marks will require federal permitting (Nationwide 38).

Figure 8-10 provides an estimate of the extent of groundwater impacts above cleanup levels and the extent of free product after the active remediation phase. Active remediation includes excavation and enhanced bioremediation and is generally completed within 5 to 10 years after cleanup activities commence. Active remediation is distinct from long-term remediation activities which include enhanced bioremediation (for containment purposes), free product recovery trenches, and natural attenuation. An estimate of petroleum removal rates from long-term remediation activities is also provided on the figure.

8.13 Summary of Remedial Alternatives Evaluation

This section summarizes the evaluation of remedial alternatives provided in Sections 8.2 to 8.12 in terms of MTCA requirements and the overall environmental impact analysis.

Table 8-3 provides a summary of the remedial alternatives, including the cleanup action proposed for each cleanup zone and the associated costs. Costs are based on the detailed calculations provided in Appendix N.

8.13.1 No Action

The No Action alternative does not satisfy MTCA threshold requirements for meeting cleanup standards.

No Action would not significantly affect the built environment. No roads, buildings or utilities would be physically damaged or disrupted. The long-term presence of contamination could deter future investment in the built environment and the community. The natural environment would continue to be significantly and adversely impacted by the contamination present.

8.13.2 Standard Alternative

The Standard Alternative removes all material from the site that exceeds cleanup levels. Following excavation, groundwater returns to protective levels by natural attenuation. While technically feasible and achieving a high level of protectiveness and permanence, this alternative would cause severe disruption to the community and local ecology. Residents would be displaced for at least several months depending on how the excavation work is phased. Houses and other buildings would be moved or demolished and utilities would need to be moved or demolished and ultimately replaced. The main track of the BNSF rail line would need to be moved. The wetland ecology of the former Maloney Creek channel would be destroyed. Restoration measures at the former Maloney Creek channel could eventually create a biologically healthy ecology; however, the restoration of a wetland area with diverse and robust wetland ecology equivalent to what exists today cannot be ensured.

This alternative would yield a high level of protection through permanent removal of contamination from the site. Short-term risks could be managed with engineering controls commonly practiced at construction and hazardous material cleanup projects. While there was significant public support for the Standard Alternative specifically during the public comment on the Draft FS/EIS, and there was more broad support for the concept of completing the cleanup as quickly as possible, there was also substantial public opposition to moving or demolishing historic buildings such as the school.

8.13.3 SW Alternatives

The SW alternatives are designed for a conditional point of compliance where groundwater discharges to surface water (South Fork Skykomish River). Adoption of any SW alternative and a conditional point of compliance at the River require the agreement of affected property owners. Approximately 30 properties are affected by contaminated groundwater (see Appendix O).

MTCA Evaluation Summary

As a group, the SW alternatives focus on groundwater cleanup through removal of free product and *in situ* bioremediation of groundwater before it affects the South Fork Skykomish River and former Maloney Creek. The need for and duration of bioremediation of groundwater depends on the effect removing free product has on reducing groundwater impacts to the River. Alternatives SW1 and SW2 will require long-term bioremediation of groundwater in the levee because they rely on passive recovery of free product upgradient of the barrier wall in the NW Developed Zone. Alternatives SW3 and SW4 ultimately transition from enhanced bioremediation to natural attenuation. Both offer more permanent and effective removal of free product and associated smear zone soil in the NW Developed Zone.

Soil cleanup is achieved, in all cases, by removing surface soil exceeding cleanup levels and applying institutional controls to protect against exposures to contaminated soil remaining at depth. Air quality will be monitored in all cases where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings. As mentioned above, SW3 and SW4 remove greater quantities of smear zone soil contamination than SW1 and SW2. Contaminated soil remaining at depth is isolated under a protective layer of clean overburden soil. The institutional controls protect against exposures to this material by obligating BNSF to assist property owners and other affected entities (e.g., utilities, the town of Skykomish) with managing contaminated soil and groundwater from construction work. The town and/or Ecology could adopt regulatory prohibitions on drilling any new wells where public water is available.

All of the SW alternatives protect human health and the environment. Alternatives SW3 and SW4 are more permanent than SW1 and SW2 through removal of greater amounts of material, particularly in the NW and South Developed Zones (Table 7-2).

8.13.4 PB Alternatives

The PB alternatives assume a conditional point of compliance for groundwater located at the BNSF property boundary rather than at the River.

MTCA Evaluation Summary

As with the SW alternatives, the PB alternatives focus on attainment of the groundwater cleanup standard through removal of free product and either natural attenuation, enhanced bioremediation or a combination of the two. The need for and duration of bioremediation of groundwater depends on the effect of removing free product has on reducing groundwater impacts at the BNSF property boundary.

All of the PB alternatives achieve soil cleanup by removing surface soil and subsurface soil to varying degrees after which institutional controls are invoked to protect against exposures to remaining contaminated soil at depth. Contaminated soil remaining at depth after the cleanup actions is isolated under a protective layer of clean overburden soil. Air quality will be monitored in all cases where soil exceeding 2,900 mg/kg (total VPH/EPH) is present beneath buildings. The institutional controls protect against exposures to this material by obligating BNSF to assist property owners and other affected entities (e.g., utilities, the town of Skykomish) with managing contaminated soil and groundwater from construction work. Alternatives PB3 and PB4 achieve greater permanence with respect to soil cleanup by removing or treating substantially greater amounts of contaminated soil in the NW Developed Zone (Table 7-2).

Cleanup of the Northeast Developed Zone is more likely to achieve cleanup standards due to the presence of more biodegradable petroleum constituents. Cleanup of the South Developed Zone is more likely to achieve cleanup standards due to the limited source area and the small area of concern.

Alternative PB5 provides the greatest level of permanence for the PB alternatives. Excavation to this extent will likely achieve cleanup levels, including an empirical demonstration that soil is protective of groundwater, in a very short timeframe after excavation is performed. Demonstrating compliance with cleanup levels will allow removal of institutional controls from the site.

All of the PB alternatives protect human health and the environment. Alternatives PB3 and PB4 are more permanent than PB1 and PB2 through removal of greater amounts of material, primarily in the NW Developed Zone (Table 7-2). Alternative PB5 is the most permanent of the PB alternatives.

9 MTCA Remedial Alternative Selection Process

The purpose of the feasibility study as stated in WAC 173-340-350 (8)(a) "is to develop and evaluate cleanup action alternatives to enable a cleanup action to be selected for the site." This section of the FS follows the requirements for selecting cleanup actions. It summarizes how each alternative complies with MTCA's minimum requirements (WAC 173-340-360(2)(a)) and it illustrates how each remedial alternative is consistent with MTCA's "other requirements" (WAC 173-340-360(2)(b)). It is important to remember throughout this section that impacts on the local region, population, and environment are also further evaluated in the environmental documents required by SEPA before Ecology selects a final remedy. Section 10 provides BNSF's preferred alternative which is a combination of these technologies/ alternatives resulting from this evaluation process. Analysis of the No Action Alternative is retained in this section for incorporation in the Final Environmental Impact Statement.

9.1 Threshold Requirements

All cleanup actions shall fulfill the "threshold requirements" as specified in WAC 173-340-360(2)(a). This section describes how all the remedial alternatives presented in the Final FS meet these threshold requirements.

9.1.1 Protect Human Health and the Environment

Cleanup levels that protect human health and the environment are provided in Section 5. Protection can be achieved by excavating all contaminated soil and sediments and attaining these cleanup levels throughout the site, as described in alternative STD, or by containing contaminated soil and groundwater and using institutional controls to minimize long-term exposure. The use of containment and institutional controls is acceptable under MTCA (WAC 173-340-360(2)(e)) as long as the cleanup action meets threshold and other requirements, the institutional controls reduce risk, and the cleanup action does not "rely primarily on institutional controls where it is technically practicable to implement a more permanent cleanup action." At a minimum, each alternative (other than No Action) will remove free product, eliminate discharges of petroleum to surface water, and remove contaminated surface soil.

9.1.1.1 Human Health

Section 5 demonstrates that the risks to human health under existing conditions at the site are the following:

- Direct contact with soil containing concentrations of TPH (based on the sum of EPH/VPH data) greater than 2,130 mg/kg in the vadose zone and 2,765 mg/kg in the smear zone, arsenic above 20 mg/kg, and lead above 250 mg/kg. These numeric criteria are based on a child ingesting 200 grams of soil per day for 6 years.

- The ingestion of groundwater or surface water and aquatic organisms for water containing greater than 477 µg/L TPH (based on the sum of EPH/VPH).

In order to eliminate these risks, each alternative addresses metal impacts in surface soil. The No Action alternative includes the continued application of Soil Sement™. All of the other alternatives include the excavation and capping of all surface metals in soil in both the NW Developed and Railyard Zones. All other soil impacts are not present in surface soil and, therefore, require some form of excavation before there is human exposure. Intermittent exposures to construction workers, utility workers or residents conducting occasional soil excavation can be controlled by institutional controls such as a city-managed grading permit process that includes environmental review to ensure direct contact exposures to subsurface soil are avoided and contaminated soil and groundwater are safely managed. Alternatives SW3 and PB1 include excavation of accessible free product in the NW Developed Zone and alternatives SW4, PB2, PB3, PB4, PB5, and STD include the complete removal of free product from the NW Developed Zone. These alternatives provide more permanent means of protecting residents and utility or construction workers from being accidentally exposed to soil that presents a risk while working in yards or public rights-of-way. Remedial alternatives SW4, PB3, and PB4 include an additional layer of permanence and protectiveness by excavating subsurface soil impacts to satisfy the cleanup levels wherever soil contamination is within 4 feet of the ground surface.

The community currently has a public drinking water supply that is not at risk of contamination from the site. State and local institutional controls prohibit installation of wells within contaminated areas. These include the King County Board of Public Health, *Public Water System Rules and Regulations* (Title 12) and the *Declaration of Covenant for Individual Water Supply*, both managed by the Department of Health; Town of Skykomish Ordinance; and Department of Ecology *Minimum Standards for Construction and Maintenance of Wells*, WAC 173-160. Even though human health risk related to groundwater is already controlled by the existing water supply system and institutional controls, MTCA generally requires that groundwater be cleaned-up to drinking water standards.

Human health cleanup levels for groundwater and surface water are based on restoring the water for use as drinking water. Off-railyard exceedances of the 477-µg/L groundwater cleanup level are concurrent with free product (see Figure 3-9). Alternatives SW4, PB2, PB3, PB4, PB5, and STD aggressively address all free product in all off-railyard areas and achieve the groundwater cleanup level in all off-railyard areas in a relatively short timeframe (<10 years). Alternatives SW3 and PB1 also address free product and achieve the groundwater cleanup level over a longer timeframe (>30 years) in off-railyard areas, but in a manner than creates less disturbance to the community.

9.1.1.2 Environment

Section 5 demonstrates that risks to the environment under existing conditions at the site are the following:

- Sediment in the South Fork Skykomish River that failed bioassay tests due to the presence of product seeps.

- Groundwater discharging to the South Fork Skykomish River and the Former Maloney Creek channel that may cause sediment to accumulate contaminants to levels that would present a risk to aquatic receptors. The groundwater TPH cleanup level is 208 µg/L (as NWTPH-Dx) based on groundwater-sediment interaction.

- Groundwater discharging to the surface water of the South Fork Skykomish River and the Former Maloney Creek channel that would present a risk to aquatic receptors. A groundwater TPH cleanup level of 700 µg/L (NWTPH-Dx) was developed based on WET testing bioassays on water column organisms.

Each alternative (other than No Action) provides groundwater treatment at the levee to treat groundwater to acceptable levels prior to discharge to the South Fork Skykomish River. More aggressive remedies, including free product or soil removal at the levee, are proposed for seven of the ten remedial alternatives. With respect to the former Maloney Creek channel, it is not clear that groundwater above cleanup levels is discharging into the channel, although it may be inferred from the data. Aggressive cleanup is proposed for all alternatives for the South Developed Zone, which is immediately upgradient of the former Maloney Creek channel and would be a source of groundwater that may discharge to the channel during certain times of the year. In addition, active groundwater treatment within the former Maloney Creek channel is proposed for alternatives SW4, PB3, and PB4.

Based on bioassays, some sediment in the South Fork Skykomish River has been identified for cleanup. In addition, a correlation of the bioassay results with TPH concentrations produces a numeric cleanup level of 40.9 mg/kg NWTPH-Dx. Some sediment in the former Maloney Creek channel has also been identified for cleanup based on this cleanup level. Seven of the ten remedial alternatives include actively addressing these sediment impacts in the South Fork Skykomish River while five of the ten alternatives include actively addressing sediment impacts in the former Maloney Creek channel. Less aggressive approaches are included for other alternatives in an effort to avoid or minimize significant adverse environmental impacts that may outweigh the benefits of excavating sediments.

9.1.2 Comply With Cleanup Standards

Cleanup standards consist of both a cleanup level and a point of compliance where the cleanup level must be met (WAC 173-340-700). Per the regulation, "a cleanup level is the concentration of a hazardous substance in soil, water, air, or sediment that is determined to be protective of human health and the environment under specified exposure conditions." For each alternative presented in this Final FS, standard points of compliance are used for all media except groundwater. Cleanup standards applicable to groundwater at the site include:

- For all SW alternatives, groundwater must achieve a cleanup level of 208 µg/L TPH (sum of EPH/VPH) prior to discharging to surface water (South Fork Skykomish River and Former Maloney Creek channel).

- For all PB alternatives, groundwater must achieve a cleanup level of 208 µg/L TPH (NWTPH-Dx) in all areas of town, except the railyard.

- For the STD alternative, groundwater must achieve a cleanup level of 208 µg/L TPH (sum of EPH/VPH) throughout the site, including the railyard.

Only remedial alternatives STD and PB5 can achieve groundwater cleanup levels at the standard point of compliance (i.e., throughout the site, including the railyard and off-railyard properties). STD and PB5 are considered permanent groundwater cleanup actions. Per WAC 173-340-360(2)(c)(ii), the less permanent groundwater cleanup actions shall include "removal [of] free product consisting of petroleum and other light nonaqueous phase liquid (LNAPL) from the groundwater using normally accepted engineering practices" and "ground water containment…to the maximum extent practicable to avoid lateral and vertical expansion of the ground water volume affected by the hazardous substance." All of the SW and PB alternatives address these requirements through the use of barrier walls, skimming pumps, or recovery trenches, all of which are normal engineering practice for removing heavy, viscous free product. More aggressive approaches have been included such as excavation near higher risk areas. Enhanced bioremediation and excavation can effectively remove the diesel-range free product from the

NE Developed Zone. Monitored natural attenuation is proposed in some areas to avoid or minimize significant adverse effects on the built and natural environment.

STD achieves all groundwater, soil, surface water and sediment cleanup levels at the standard points of compliance. It is, therefore, the most permanent alternative considered in this Final FS. Institutional controls are required to ensure compliance with cleanup standards and must be implemented in accordance with WAC 173-340-440. For the STD alternative, institutional controls are required in the short-term (<8 years) to minimize the risk of exposure while the remedy is being implemented. For all of the other alternatives (PB and SW), long-term (10+ years) institutional controls are required to comply with cleanup standards. Institutional controls include restrictive covenants on individual properties and legal or administrative mechanisms. Restrictive covenants require the consent of the property owner of the property with contamination above cleanup levels to which the restrictive covenant is applied. Legal or administrative mechanisms include "zoning overlays, placing notices in local building department records or state lands records, public notices and education mailings." State and local institutional controls already in place prohibit installation of wells within contaminated areas. Additional institutional controls (ordinances and private agreements) can further limit exposure and provide a mechanism for BNSF (or the Town with technical and financial assistance from BNSF) to safely manage contaminated soil and water encountered during construction activities on private and public properties. In this case, the primary technical and financial assistance from BNSF would likely be making a qualified environmental contractor available, without charge, to plan for and manage contaminated soil and groundwater encountered during construction activities. Any of these institutional controls could be removed or modified once the cleanup is completed.

All of the proposed remedial alternatives are intended to comply with cleanup standards. Compliance with cleanup standards would be demonstrated by monitoring during implementation of the cleanup action and over the long-term.

9.1.3 Comply With Applicable Local, State and Federal Laws

Several applicable local, state and federal laws have been incorporated into the cleanup level development process included in this Final FS. These include the Sediment Management Standards (WAC 173-204) and the State Environmental Policy Act (WAC 197-11-400). Additional laws may apply to implementation of the cleanup action. An example is Section 404 of the Clean Water Act that will require permitting and mitigation associated with cleanup actions that impact the South Fork Skykomish River or the wetland at the former Maloney Creek channel. All of the alternatives included in the Final FS can be designed to comply with applicable local, state and federal laws.

9.1.4 Provide for Compliance Monitoring

Compliance monitoring is not a cleanup element that is described in detail during the Final FS process. These provisions are better developed in the Cleanup Action Plan and detailed Compliance Monitoring Plans are developed during Engineering Design of the cleanup action. Compliance Monitoring Plans provide for a monitoring program to ensure that cleanup levels are obtained and include provisions for contingent remedies should the initial remedy fail. All of the alternatives in the Final FS can be designed to provide all phases of compliance monitoring, including protection, performance and conformational monitoring.

9.2 Use Permanent Solutions to the Maximum Extent Practicable

The first of three "other requirements" for selection of cleanup actions under MTCA is the use of permanent solutions to the maximum extent practicable. The procedure for determining whether a cleanup action uses permanent solutions to the maximum extant practicable is provided in WAC 173-340-360(3). This section presents a "disproportionate cost analysis" to compare the relative costs and benefits of all the alternatives. Costs are disproportional to benefits if the incremental cost of an alternative exceeds the incremental benefit achieved with the additional cost. The analysis may be quantitative or qualitative. The analysis begins by ranking alternatives from the most permanent to the least permanent. Once alternatives are ranked from the most permanent to the least permanent, they are evaluated based on seven criteria in WAC 173-340-360(f).

A "permanent cleanup action" achieves cleanup standards without further action at the site, such as long-term monitoring, maintenance or institutional controls (WAC 173-340-200). Section 8.1.2.1 describes a process for quantifying permanence. The measure was termed "equivalent soil volume." An alternative that treats or removes a greater equivalent soil volume may be considered more permanent because it represents a larger reduction in the volume of hazardous substances at the site and a reduced need for long-term monitoring, maintenance or institutional controls. The remedial alternatives are ranked in Figure 9-1 from the most permanent (STD) to the least permanent (No Action).

9.2.1 Protectiveness

Protectiveness of human health and the environment includes the degree to which existing risks are reduced, time required to reduce risk at the site and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.

As discussed in Section 8.1.1.1, all of the remedial alternatives are designed to aggressively address possible human health risk associated with exposure to impacted surface soil. With respect to subsurface soil, alternatives SW4, PB3, and PB4 provide some additional protectiveness from dermal contact relative to the other alternatives by removing all impacts from within 4 feet of ground surface. While human health risk associated with consumption of groundwater is already controlled, alternatives SW3, SW4, PB1, PB2, and PB3 all aggressively address free product in the NW Developed Zone which are the only off-railyard areas that exceed the human health groundwater remediation level of 477 µg/L outside of the NE Developed Zone (diesel impacts). 2A-W-6 has a TPH (sum of EPH/VPH) in excess of the criteria but is just outside the free product plume in the NE Developed Zone; however, this area will be addressed via enhanced bioremediation for the same alternatives listed above (SW3, SW4, PB1, PB2, PB3).

Alternatives SW4, PB3, PB4, and PB5 provide the greatest level of environmental protectiveness by addressing soil and sediment in the Former Maloney Creek channel and by addressing soil, sediment, and free product at the Levee. SW3 and PB2 provide a moderate level of environmental protectiveness by actively addressing sediment and free product at the Levee. SW1, SW2, and PB1 all provide a lower level of environmental protectiveness.

9.2.2 Permanence

Permanence was discussed earlier and the relative permanence of the remedial alternatives was illustrated in Figure 9-1.

9.2.3 Cost

Costs for each remedial alternative were developed as part of the FS process. Figure 9-2 indicates the cost for each alternative with the alternatives ranked by level of permanence. Detailed cost estimates are provided in Appendix N. The largest cost elements are associated with cleanup of the NW Developed Zone, the levee, and the railyard. Cleanup of the other three zones combined contribute on the order of 15 percent or less of total costs. The total project costs range from less than $10 million to over $70 million.

Figure 9-3 illustrates the cost to achieve the increasing levels of permanence. Lower unit costs (total cost divided by total equivalent soil volume) indicate increased cost-effectiveness of the remedial alternative with respect to equivalent soil volume removal or treatment where equivalent soil removal volumes are used as a surrogate for contaminant mass removal and permanence.

9.2.4 Effectiveness over the Long-Term

Long-term effectiveness includes "the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations above cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes." MTCA suggests the use of the use of the following hierarchy of cleanup action components in descending order of long-term effectiveness:

1) Reuse or recycling
2) Destruction or detoxification
3) Immobilization or solidification
4) On- or off-site disposal
5) On-site isolation or containment
6) Institutional controls.

The remedial technologies in the proposed remedial alternatives fit this hierarchy as follows:

1) Reuse or recycling (free product skimming or trenches with free product recovery and recycling)

2) Destruction or detoxification (natural attenuation and enhanced bioremediation)

3) Immobilization or solidification (none)

4) Excavation (requires off-site disposal)

5) Institutional controls.

Based on the suggestion in MTCA, equivalent soil volumes were calculated for each cleanup action component for each alternative (see Appendix P). The volumes were then divided by the hierarchy number and summed for each alternative to derive a normalized equivalent soil volume. The higher normalized equivalent soil volume suggests a higher level of long-term effectiveness. This approach was used to score the alternatives from 0 to 5 points. The other 5 points were scored based on site remediation activities that were most likely to contribute to the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time that hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The resulting scores for long-term effectiveness are provided in Table 9-1. Alternative PB4 ranks highest, followed by STD and PB5.

9.2.5 Management of Short-Term Risks

Impacts from remedial action implementation include vehicle traffic, temporary relocation of residences/buildings, temporary closure of the school and other public facilities, odor, open excavations, and noise, dust and safety concerns associated with extensive heavy equipment activity. The greatest short-term risk to human health is related to safety and general construction activity. As a result, the short-term risks to human health would be greatest for the more permanent alternatives. In all cases, similar measures would be taken to manage risk such as fencing, signage, dust controls, and traffic control.

With respect to short-term risks to the environment, more aggressive remedies in the aquatic resource zones present a greater short-term risk to the environment. So, similar to human health risks, the short-term risks to the environment would be greatest for the more permanent alternatives. In all cases, similar measures would be taken to manage risk such as temporary dams to prevent surface water discharges, angle boring to minimize drilling in sensitive areas, and scheduling work to avoid sensitive species during critical stages.

9.2.6 Technical and Administrative Implementability

Three major administrative concerns with the remedial alternatives are institutional controls, permitting, and relocating residents, businesses, transportation facilities and public facilities such as the school. All SW and PB alternatives require long-term institutional controls on off-railyard properties where soil and/or groundwater will remain above cleanup levels for extended periods of time. Alternatives SW3, SW4, PB2, PB3, PB4, PB5, and STD will treat soil and groundwater to cleanup levels in a shorter timeframe in the NE Developed Zone. Alternatives SW4, PB1, PB2, PB3, PB4, PB5, and STD will achieve cleanup levels in the South Developed Zone. Alternatives PB5, STD, and possibly PB4, will achieve groundwater cleanup levels in the NW Developed Zone. Alternatives PB4 and PB5 will substantially reduce the number of properties with soil above cleanup levels while only alternative STD will result in no properties with soil above cleanup levels in the shortest period of time. The administrative implementability of these alternatives would be proportionate to the number of properties requiring some from of institutional control and the length of time these controls must be enforced.

The second administrative implementability issues relates to permitting and mitigating cleanup actions at the Levee and the former Maloney Creek channel. Permits are required from the US Army Corps of Engineers under Section 404 of the Clean Water Act, and the Endangered Species Act requires the Corps to consult with NOAA-Fisheries and the U.S. Fish and Wildlife Service. In addition, incidental take permits may be required under the Endangered Species Act. Permitting of environmental cleanup activities under this process is expected to take 1 to 2 years. Natural attenuation in the former Maloney Creek channel and enhanced bioremediation or ozone sparging in the Levee would not involve these administrative requirements (as well as the adverse environmental impacts associated with excavating in wetlands and streams). All other approaches would likely require this permit. In addition, any invasive work on or in the Levee will require coordination with King County to ensure the structural integrity of the Levee is not compromised. This applies to all remedial alternatives affecting the Levee.

Finally, the more aggressive remedies (PB4, PB5, and STD) necessarily involve administrative and technical challenges associated with extensive excavation around and under buildings and facilities such as the school, the community center, residences, businesses, the main rail line, streets and utilities. Alternative facilities would be required for students, faculty and staff. Temporary dwellings would be required for residents. Businesses and the community center would have to close or relocate to other buildings that may be available in town. Rail traffic (24 trains/day) might have to be rerouted or temporary alternative routes would have to be constructed through town. Even for some of the less aggressive alternatives (such as SW2, SW3 and PB1) if technologies such as natural attenuation, free product recovery and sparging in the NW Developed Zone prove ineffective, then excavation may be needed near or beneath structures and buildings. In general, however, technical and administrative implementability decreases with increasing permanence.

9.2.7 Consideration of Public Concerns

The public comment process includes review of the Draft FS/EIS and other public meetings and forms hosted by Ecology or BNSF. Public comments on the FS have been received. These comments were incorporated in the development of the preferred alternative in Section 10.

9.2.8 Permanence to the Maximum Extent Summary

As noted at the beginning of this section, the analysis of whether an alternative is permanent to the maximum extent practicable involves the comparison of the alternatives based on the seven evaluation criteria as described above. The goal is to determine whether the incremental cost of an alternative is disproportionate to the incremental benefit relative to the lower cost alternative (WAC 173-340-360(e)(i). A systematic approach was developed to quantify the relative benefit of the alternatives. The total benefit of each alternative was calculated as the sum of ratings for five of the evaluation criteria:

1) Protectiveness
2) Permanence
3) Effectiveness over the long-term
4) Management of short-term risks
5) Technical and administrative feasibility.

Consideration of public concerns is based on the public comment received on the Draft FS/EIS and cost is part of the analysis to determine if the incremental cost of an alternative is disproportionate to the incremental benefit relative to the lower cost alternative. The benefit ratings are provided in Table 9-1 and Figure 9-4 illustrates these benefit ratings and alternative costs.

Figure 9-4 indicates generally comparable levels of benefit for the six most aggressive alternatives. Cost is shown, but not taken into account in regard to the benefit rating on this figure. Benefit is based on the MTCA criteria described above. Figure 9-4 does not take into account restoration time frame of the alternatives (this is shown in Section 9.3).

To further evaluate the ratings, benefit was plotted versus cost in Figure 9-5. Where a tangent to this curve is steeper (closer to vertical) indicates a greater incremental benefit per incremental dollar expended. For example, the Figure 9-5 analysis shows notable benefit gain for the added cost in alternative SW3 over SW2, and PB2 over PB1. Comparatively, alternatives PB4, PB5, and STD show significantly higher costs without significant increases in benefit. This analysis of benefit includes consideration of MTCA items such as a preference for *in situ* and/or technologies that do not require off-site disposal.

MTCA states that the most practicable permanent alternative shall be the “baseline cleanup action” against which other alternatives are compared (WAC 173-340-360(e)(ii)(B)). To evaluate the alternatives using this criterion, the alternative STD was considered the most practicable permanent alternative and the other alternatives were plotted based on the percentage incremental benefit and decrease in cost versus STD (Figure 9-6). To determine the alternative with the most desirable cost-benefit result, move a line, like the hand of a clock with the STD alternative located where the hand attaches to the clock, in a clockwise direction. This analysis shows that alternative PB4 ranks the highest in the cost-benefit analysis, followed closely by alternatives PB2, SW4, and PB3, respectively.

9.3 Provide for a Reasonable Restoration Timeframe

The second of three "other requirements" for selection of cleanup actions under MTCA is a reasonable restoration timeframe. Restoration timeframe is the time it takes to meet cleanup standards; i.e., to meet all cleanup levels in all media at all points of compliance. A cleanup action can meet cleanup standards through the use of treatment, removal or containment, or some combination of these three approaches. Each alternative relies on removal of free product and restoring groundwater before it discharges to surface water. The PB alternatives rely on containment and institutional controls for soil in off-railyard areas while the SW alternatives rely on containment and institutional controls for both soil and groundwater in off-railyard areas.

Estimates of time to remove free product and restoration timeframes for groundwater and soil were generated for each zone and remedial alternative. These estimates assume that containment and institutional controls can be established for off-railyard areas for soil and groundwater for the SW alternatives and for soil for the PB alternatives. Figures 9-7 through 9-9 illustrate the estimated restoration timeframes. These charts present the mid-point from estimated ranges in Table 8-2, as follows:

- "4 years" represents a 3 to 5 year range
- "8 years" represents a 5 to 10 year range
- "15 years" represents a 10 to 20 year range
- "25 years" represents a 20 to 30 year range
- "40 years" represents greater than 30 years.

The procedure for determining whether a cleanup action provides for a reasonable restoration timeframe is provided in WAC 173-340-360(4). The nine factors used to determine whether a cleanup action provides for a reasonable restoration timeframe are provided in the rule and include:

1) Potential risks posed by the site to human health and the environment

2) Practicability of achieving a shorter restoration timeframe

3) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site

4) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site

5) Availability of alternative water supplies

6) Likely effectiveness and reliability of institutional controls

7) Ability to control and monitor migration of substances from the site

8) Toxicity of hazardous substances at the site

9) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

The rule (WAC 173-340-360(4)(c)) also states that: "a longer period of time may be used for the restoration timeframe for a site to achieve cleanup levels at the point of compliance if the cleanup action selected has a greater degree of long-term effectiveness than on-site or off-site disposal, isolation, or containment options".

Figure 9-7 indicates that free product will be removed from all off-railyard areas within 10 years for alternatives SW4, PB2, PB3, PB4, PB5, and STD. Free product will remain on the Railyard for >30 years for most alternatives, except PB5 and STD; these two alternatives would remove free product within a couple of years.

Figure 9-8 indicates that all alternatives achieve cleanup standards for groundwater within 10 years, except for PB1, PB2, PB3, and PB4. This restoration timeframe reflects the different groundwater points of compliance between the SW (points of discharge to surface water) and PB (railyard property boundary) alternatives. Figure 9-9 indicates that only alternatives PB5 and STD achieve soil cleanup levels with 10 years and PB5 will require an empirical demonstration that the soil cleanup level protective of groundwater has been achieved. Alternatives SW3, SW4, PB2, and PB3 achieve soil cleanup levels in all off-railyard zones, except the Northwest Developed Zone, within 20 years. PB4 reduces the restoration timeframe to 10 years for these same zones.

9.4 Consider Public Concerns

The third of the three "Other Requirements" in MTCA is to consider public concerns. The public comment process included public and regulatory agency review of the Draft FS/EIS. With respect to MTCA, specific comments regarding whether the proposed alternatives provide for a reasonable restoration timeframe were considered by BNSF while preparing the preferred alternative described in Section 10.

9.5 SEPA Analysis

An EIS is generally required when one or more of the alternatives in the FS will have probable, significant, adverse environmental impacts. The EIS analyzes the probable significant adverse environmental impacts of each reasonable alternative to clean up the site consistent with MTCA and the reasonable measures that could reduce or mitigate those impacts (WAC 197-11-400). These impacts include short- and long-term impacts, direct and indirect impacts and cumulative impacts.

The EIS process is used to analyze alternatives and possible mitigation measures to reduce the environmental impacts of the proposal. The Draft FS/EIS was an integrated document, consistent with MTCA and SEPA regulations. Ecology decided to separate the Final FS from the EIS in order to expedite publication of the Final FS. A Draft Supplemental EIS is being prepared and will be published with the Draft Cleanup Action Plan for additional public review and comment. The final EIS will be published with the Final Cleanup Action Plan.

9.6 Preferred Alternative Selection

Ecology will choose the cleanup action based on an analysis similar to that presented in this Section 8. The selected cleanup alternative must:

- Satisfy MTCA threshold requirements (Section 9.1)
- Be permanent to the maximum extent practicable (Section 9.2)
- Provide for a reasonable restoration timeframe (Section 9.3)
- Consider public concerns (Section 9.4)
- Minimize environmental impacts through alternative selection and mitigation (Section 9.5).

The selected cleanup alternative may or may not be one of the remedial alternatives presented in this Final FS. It may combine cleanup actions by zone in a manner that better satisfies MTCA requirements or it may use technologies that were retained (Appendix L) but not included in any of the remedial alternatives. For example, a final cleanup action based on SW3 might also include free product and soil excavation in the Levee Zone rather than just free product removal. As another example, a final cleanup action based on PB2 might include permeation grouting to solidify free product under buildings in the NW Developed Zone rather than excavation..

10 Preferred Remedial Alternative

Ecology makes the final selection of cleanup actions based on WAC 173-340-360. Alternative cleanup actions were developed in the draft Final FS that satisfy the following minimum, threshold requirements:

- Protect human health and the environment
- Comply with Cleanup Standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring.

When selecting from among the cleanup action alternatives that satisfy the threshold requirements, Ecology considers the following additional criteria:

- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration timeframe
- Public and agency comments and concerns.

Formal public and agency comments were received on the Draft FS and Draft EIS in September and October 2003, formal comments from Ecology were received on the Preferred Remedial Alternative Memorandum on January 5, 2005, and informal comments have been received by BNSF through a series of technical workshops and open meetings with the public and agencies over an 18 month period prior to the publication of the Draft FS and Draft EIS, and BNSF has received additional input from the community and agencies since October 2003. This input was critical to BNSF in developing its preferred alternative for cleanup as Skykomish.

Other site-specific requirements specified in MTCA for the type of cleanup actions developed in this Final FS are:

- Requirements for Groundwater Cleanup Actions (WAC 173-340-360 (2)(c))

- Requirements for Soil Cleanup Actions for Residential Areas, Schools and Child Care Centers (WAC 173-340-360(2)(d))

- Requirements for Cleanup Actions that use Institutional Controls (WAC 173-340-360(2)(e) and 173-340-440)

- Requirement to prevent or minimize present or future releases and migration of hazardous substances (WAC 173-340-360(2)(f))

- Requirements for Cleanup Actions that use Dilution and Dispersion (WAC 173-340-360(2)(g))

- Requirements for Cleanup Actions that use Remediation Levels (WAC 173-340-360(2)(h)).

Following a discussion of the factors used in selecting the preferred alternative, this section presents a description of the preferred alternative,

10.1 Factors Influencing Selection

Many factors were considered when developing BNSF's preferred remedial alternative. The analysis of alternatives in Section 9 of the FS above describes some new data that allowed additional analysis of the alternatives presented in the Draft FS/EIS and Draft Final FS. Public, Ecology and other agency comments were received on the Draft FS/EIS, and bench-scale testing of several technologies mentioned in the Draft FS/EIS were received and evaluated. Several of the most significant considerations that were used in developing BNSF's preferred alternative are detailed below.

- **Maintain historic character of town –** Many comments were received that expressed concern regarding the potential movement of historic structures to facilitate excavation. Other comments indicated that closing the school for cleanup actions, even if only for a single school year, might jeopardize the future viability of this important public institution and that closing the school would have serious social and economic consequences for Skykomish. The preferred remedy incorporates in situ remedial technologies where historic structures are present and offers a solution that avoids closing the school while classes are in session.

- **Restoration Timeframe –** Many comments expressed the need to achieve cleanup in as short a timeframe as possible. The preferred remedy includes rapid cleanup of the most significant potential human health and environmental exposures (the levee and shallow soil impacts) and overall provides short and reasonable restoration timeframes, particularly for the Aquatic Resource and Developed Zones of the site.

- **Socioeconomics –** A few comments expressed concern with the adverse economic consequences of contamination and a long and disruptive cleanup project. While MTCA and SEPA are not intended to directly address purely economic factors, MTCA and SEPA do require avoiding and mitigating adverse impacts on physical assets of communities and these assets are indirectly related to social and economic consequences of a project, including public and private buildings, streets and sidewalks, utilities such as water and power, open spaces, and natural areas. BNSF's preferred alternative was designed to remove as much contamination as possible, as quickly as possible, while minimizing disruption to the commercial district of town, residential areas and public institutions. BNSF has also initiated direct discussions with the owners of property that is likely to be affected by BNSF's preferred cleanup plan in an effort to address purely economic issues.

- **Technology Testing Data –** Bench-scale testing results of several technologies have become available and are included by reference in this Final FS. These data, which were received earlier in 2004, suggest that enhanced bioremediation of contaminants will be effective in the NE Developed Zone. A significant change occurred following the bench-scale testing report while preparing the pilot test work plan for surfactant flushing. This more detailed analysis of surfactant flushing indicated that flushing is not sufficiently developed and proven to reliably recover the type of highly-viscous LNAPL found at the site.

- **Data Gaps –** Many comments suggested that additional data is needed from the site before Ecology selects a final cleanup action. Ecology has completed an investigation to obtain additional data from the flood control levee east of the 5th Street Bridge, between the river and the NE Developed Zone, within the former Maloney Creek channel, and at the USFS property south of the Old Cascade Highway. The new data will be incorporated into future documents, such as the cleanup action plan and remedial design work plans, as appropriate. In addition, BNSF's preferred alternative includes further characterization of the former Maloney Creek channel.

10.2 Description of Preferred Alternative

BNSF prepared a preferred alternative in May 2004 to present BNSF's then-current thinking regarding how cleanup can proceed at Skykomish consistent with the technical, legal and practical limitations (as expressed in the Draft Final FS and Draft EIS) as well as meet overall needs of the community (as expressed in verbal and written comments). BNSF's May 2004 preferred alternative also reflected technical and policy discussions BNSF and Ecology had over several years. BNSF revised its preferred alternative in late September 2004 based on new technical information about some of the remedial technologies that might have enhanced product recovery under buildings and structures. The preferred alternative presented in this document represents a slight modification from the September 2004 version in order to respond to the final TPH soil cleanup level (22 mg/kg) that Ecology issued on December 10, 2004. Thus, the preferred alternative in this section again represents BNSF's current thinking regarding technical, legal, practical and community issues; however, Ecology will make the final selection of a cleanup action for Skykomish.

BNSF's preferred alternative addresses cleanup in Skykomish by "cleanup zones," as discussed throughout the Draft FS/EIS and final Draft FS. All cleanup zones will be addressed. Significant flexibility exists in implementing the work – a great deal of it can be phased over time to minimize overall disruption of the community. Figure 10-1 provides a schematic of the preferred remedy. The exact nature and extent of phasing will be determined during the remedial action design, with substantial input from elected officials with the Town and the School, affected property owners, and the rest of the community, as well as Ecology and other regulatory agencies. A proposed schedule and sequencing is provided as part of this section.

The principle cleanup standards used in developing BNSF's preferred alternative are:

- **Petroleum in Soil – 22** mg/kg total EPH/VPH and NWTPH-Dx throughout the site to protect groundwater as a potential drinking water source and a current source of recharge to the river
- **Metals in Soil –** 20 mg/kg arsenic and 250 mg/kg lead soil to protect people from direct contact with surface soil
- **Petroleum in Groundwater –** 208 µg/L total EPH/VPH and NWTPH-Dx at the point of groundwater discharge to surface water to protect all beneficial uses of the Skykomish River
- **Petroleum in Sediment –** cleanup will remove sediments from an area defined by bioassay tests on aquatic organisms
- **Free Product –** cleanup will contain and remove all free product.

BNSF's preferred cleanup action for each cleanup zone will use these cleanup standards as well as remediation levels that were discussed previously.

10.2.1 Levee Aquatic Resource Zone

The Aquatic Resource Zone along the river includes the area north of the existing subsurface barrier wall (along West River Road) and the south bank of the South Fork Skykomish River. The majority of this zone includes the floodwater control levee that was designed and built by the U.S. Army Corp of Engineers in 1951 and is currently maintained and managed by the King County Department of Natural Resources, Rivers Section.

The objectives of cleanup of this Zone are to stop free product discharges to the river, remove contaminated sediment that impacts aquatic receptors, and prevent dissolved petroleum in groundwater from contaminating surface water and sediment. In addition, the cleanup of this Zone should not jeopardize the public safety benefits of flood control and may provide an opportunity to enhance the existing river habitat that was impaired when the levee was originally constructed over 50 years ago.

The cleanup level for groundwater (208 μg/L total EPH/VPH and NWTPH-Dx) will protect sediment and surface water where groundwater discharges to the river. The cleanup level for sediment is based on bioassay testing. A remediation level of 3,400 mg/kg NWTPH-Dx will be used to define the extent of soil excavation necessary to protect groundwater.

BNSF's preferred remedy for this Zone includes:

- Excavating surface sediment along and within the South Fork of the Skykomish River at the base of the levee.
- Excavating and rebuilding portions of the levee to remove free product and contaminated soil.
- Long-term monitoring of groundwater quality to ensure compliance with the cleanup standard
- Contingent treatment of groundwater beneath the levee using enhanced biological treatment (e.g., air sparging).

The surface sediment removal area has been defined by bioassay testing. The area is estimated to be 440 feet long and 20 feet wide. This area will likely be removed along with the side slope of the Levee soil excavation. With excavation cut depths of 16 to 17 feet, the side slopes of the excavation will likely extend 24 to 26 feet into the river. A temporary cofferdam or similar barrier will be placed beyond this area, in-river, to prevent surface water from entering the excavation area.

Soil will be removed to address free product and to remove soil with concentrations above 3,400 mg/kg NWTPH-Dx. Excavation to this remediation level will remove soil above direct contact criteria and with the potential to impact groundwater to above the cleanup level. Additional details regarding the need to address power lines and construct a temporary access road west of the school were provided in Section 7.4.

An air sparging system will be installed in the Levee to address remaining dissolved phase groundwater impacts by enhanced biodegradation. This system includes vertical wells to inject the air and associated piping and blowers. This system is considered a contingency, since the preferred remedy includes excavation of soil above 3,400 mg/kg NWTPH-Dx to 135 feet inland from the river into the NW Developed Zone, and calculations (Appendix S) indicate that groundwater will meet cleanup levels at the levee.

Excavated soil and sediment will be transported off-site to a licensed commercial landfill for disposal or reuse as daily cover. The existing subsurface barrier wall will either be preserved or it will be replaced; this will be determined during the remedial design.

Work performed at this Zone will have to satisfy substantive and procedural requirements of Section 404 of the Clean Water Act due to the presence of wetlands and navigable water, and Section 7 of the Endangered Species Act due to the presence of bull trout and salmon. For example, this will require work to be performed in the summer months during a "fish window," which is typically July 1 to August 31. Habitat enhancement and mitigation will also be performed to maintain or improve riparian habitat; this will likely include a new design for the Levee and the use of native plantings on the reconstructed levee. King County has expressed an interest in being actively involved in the new design and in opportunities to enhance the existing habitat at the base of the levee. Work within this Zone that could impact threatened or endangered species in the river will be scheduled to occur during a single "fish window."

Institutional controls will be required in this Zone to prevent exposure to soil, sediment and groundwater until monitoring confirms that the zone meets cleanup levels.

10.2.2 Former Maloney Creek Channel Aquatic Resource Zone

The Former Maloney Creek Channel Aquatic Resource Zone includes the ditch and wetland areas located north of the Old Cascade Highway and associated storm water that drains through the former Maloney Creek channel. This Zone also includes contaminated sediment on the south side of the Old Cascade Highway, west of the culvert at Fifth Street. This Zone may be occasionally recharged by contaminated groundwater from the railyard during high water events. Coho salmon, a threatened species, have reportedly been observed in this drainage and the zone has several acres of wetlands. Cleanup in this zone will be closely coordinated with cleanup in the South Developed Zone and southern edge of the Railyard Zone, which are immediately south and north, respectively, of the Former Maloney Creek Channel Aquatic Resource Zone.

The objectives of cleanup in the former Maloney Creek channel are to prevent contaminated groundwater from discharging to surface water while preserving existing habitat. BNSF's preferred alternative minimizes the need to physically remove contaminated sediments and disrupt the existing wetland habitat by focusing on restoration of the groundwater that recharges the zone rather than excavating all the contamination (and the existing habitat) and then attempting to reconstruct the wetlands.

The following remediation levels have been developed for the Former Maloney Creek Channel Aquatic Resource Zone:

- Groundwater contaminated with petroleum will achieve 208 µg/L total EPH/VPH and NWTPH-Dx to protect surface water and sediment

- Soil contaminated with free product will be removed to protect groundwater

- Soil contaminated with petroleum will be removed within the upper 2 feet to protect people from direct contact with soil

- Additional soil contaminated with petroleum will be removed within the upper 1 foot to protect terrestrial ecological species from direct contact with soil.

The preferred alternative for this zone also includes hydrogeologic assessment of the area to refine our understanding of groundwater flow from the Railyard Zone and the extent to which it discharges to the former Maloney Creek channel. If groundwater flows south from the railyard, then the groundwater cleanup in the Railyard Zone will also cleanup groundwater in the Former Maloney Creek Channel Aquatic Resource Zone.

BNSF's preferred remedy for this Zone includes:

- Assessing groundwater, surface water and sediment quality in the vicinity of the wetland and the former Maloney Creek to refine our understanding of conditions beneath the former Creek channel and the former Creek channel's hydrologic connection to the surrounding area.

- Excavating soil or sediment hot spots within or adjacent to the wetland to remove free product and the most heavily-impacted soil in order to protect surface water quality. The locations that are currently candidates for excavation are near sample location 2A-B-8 and along the former creek channel that existed during railyard fueling operations; additional locations may be identified during the final assessment.

- Monitoring groundwater quality to determine whether excavation is protecting surface water, and implementing enhanced bioremediation of groundwater as a contingent remedy if, and as, needed.

- Placing a physical barrier at the west end of the culvert at 5th Street to temporarily prevent salmon from entering the former Creek Channel and redirecting them to suitable habitat in Maloney Creek.

The final assessment of groundwater, surface water and sediment quality will require a year to collect data and prepare a report. Hot spot removal can be performed during a single summer construction season. Excavated soil and sediment will be transported off-site to a licensed commercial landfill for disposal or reuse as daily cover. Monitoring will occur until a decision can be made regarding the need for enhanced bioremediation of groundwater. The current estimate for monitoring in this area following excavation is one to three years.

Institutional controls will be required to prevent direct contact exposure to soil and groundwater.

10.2.3 Northeast Developed Zone

The NE Developed Zone includes residences, commercial buildings, streets, and public institutions such as Town Hall. The NE Developed Zone is affected by petroleum in groundwater and in soil where groundwater is first encountered (known as the "smear" zone). The petroleum in the NE Developed Zone contains a higher proportion of diesel fuel and is less viscous, more soluble, and more biodegradable than the petroleum present in the NW Developed Zone or the South Developed Zone. As a result, dissolved petroleum in groundwater in the NE Developed Zone is less closely associated with free product than other cleanup zones.

The cleanup level for groundwater in the NE Developed Zone (208 µg/L total EPH/VPH and NWTPH-Dx) will protect sediment and surface water where groundwater discharges to the river. In addition, the following remediation levels have been developed for this zone:

- Groundwater contaminated with petroleum will be treated to 477 µg/L total EPH/VPH to protect groundwater as a potential drinking water source.

- Soil containing free product will be excavated to help ensure the effectiveness of enhanced bioremediation as a groundwater and soil treatment technology. The free product at MW-21 appears to be more viscous than diesel and is likely heavier-end oil associated with a former oil column.

- Soil contaminated with petroleum above 2,900 mg/kg total EPH/VPH beneath buildings will trigger soil vapor, indoor air or ambient air quality monitoring. Where soil vapors consistently exceed applicable MTCA or other health-based criteria adjacent to structures, then contingency measures can be implemented to assess and mitigate the accumulation of vapors in buildings.

Ultimately, all of the groundwater and soil will be treated to cleanup levels within this zone and institutional controls could then be removed.

BNSF's preferred remedy for this Zone includes:

- Excavating free product from under Railroad Avenue just north of the railyard (near MW-21) to a depth of about 15 to 16 feet below grade. This excavation is not anticipated to impact any structures.

- Enhancing biological treatment of soil and groundwater in the Railroad Avenue area to achieve direct contact soil cleanup levels, the groundwater remediation level protective of human health (477 µg/L total EPH/VPH) within the residential area, and groundwater cleanup levels protective of sediment prior to discharge to the river (208 µg/L NWTPH-Dx)

Following excavation, and pending biological treatment of soil and groundwater at depth, human health and the environment will be protected from direct contact with soil by about 8 feet of clean soil that already overlies the NE Developed Zone, from ingestion of groundwater by the availability of public water supply, and from contact with soil and groundwater at depth by institutional controls that provide a safe mechanism for managing contaminated soil and groundwater that may be removed during routine excavation activities in the zone.

The excavation work in the NE Developed Zone can be completed within one construction season. This work is not anticipated to impact any structures; however, utilities such as telephone and power may be temporarily impacted and a bypass road will be necessary to maintain access to the area east of the excavation. Excavated soil will be transported off-site to a licensed commercial landfill for disposal or reuse as daily cover. The enhanced biological treatment system within the zone will operate until soil and groundwater meet cleanup levels and remediation levels (approximately 5 to 10 years following excavation).

Institutional controls will be required to prevent exposure to soil and groundwater until monitoring confirms the zone meets cleanup levels.

10.2.4 South Developed Zone

The South Developed Zone includes two residences and involves petroleum composed of primarily of bunker C. The petroleum affects surface soil, smear zone soil and groundwater in a limited area. Free product present in MW-39 is more viscous than free product noted elsewhere on the site and appears to be coincident with the original channel of Maloney Creek. Cleanup of this zone will be closely coordinated with cleanup of the adjacent Former Maloney Creek Channel Zone.

Soils contaminated with petroleum will be excavated to the remediation level (3,400 mg/kg NWTPH-Dx) in this zone due to its relatively small size, limited number of obstructions, and proximity to the wetland. Excavated soil will be transported off-site to a licensed commercial landfill for disposal or reuse as daily cover. This work can be completed within one construction season. Groundwater monitoring will continue for a period of 1 to 3 years to ensure that groundwater cleanup levels (208 µg/L total EPH/VPH) have been achieved to protect surface water and to protect groundwater as a potential future drinking water source. After the cleanup is complete and compliance monitoring is initiated, an empirical demonstration will show that soil excavation to a 3,400 mg/kg remediation level also results in groundwater meeting groundwater cleanup levels.

Long-term institutional controls will be required for soils with TPH concentrations between the site-specific cleanup level (less than 22 mg/kg total TPH/VPH and NWTPH-Dx)) and the remediation level (3,400 mg/kg NWTPH-Dx). Short-term institutional controls (less than 5 years) will be required to prevent exposure to groundwater until monitoring confirms the Zone meets cleanup levels.

10.2.5 Railyard Zone

Most of the Railyard Zone has historically been used for industrial purposes and will continue as an industrial facility for the foreseeable future. It includes BNSF property with surface soil contaminated with metals and petroleum, and subsurface soil contaminated with petroleum. This Zone also includes portions of two properties immediately south of BNSF's property: surface soil is contaminated with metals on one of these properties (next to the library) and surface and subsurface soil is contaminated with petroleum on the second property. The Railyard Zone has an active main line with two sidings and two other active sidings south of the main line area. Both passenger and cargo trains use the main line and sidings; approximately one train per hour passes the site. Underground utilities, such as fiber optics, electrical, and signal lines, are present within the Railyard Zone. Any crossing of the rail lines for remediation system utilities and piping will require horizontal boring or jacking and boring.

The following remediation levels have been developed for this Zone:

- Free product will be recovered using trenches at BNSF's northern property boundary. The containment and removal of free product should ensure that groundwater discharging to the river will satisfy the cleanup level of 208 µg/L total EPH/VPH and NWTPH-Dx.

- Soil contaminated with metals will be excavated within the upper 2 feet to protect people from direct contact with soil and to prevent people from breathing contaminated dust from the railyard.

The preferred alternative for this Zone includes:

- Excavating the upper 2 feet of soil impacted with metals and TPH. PCBs have on occasion been detected in this same area and will also be removed. Clean fill will be placed over the excavated area.

- Installing product recovery trenches along Railroad Avenue, between the main rail lines and Railroad Avenue. The trenches will prevent further migration of free product north of the railyard and facilitate product recovery.

Each phase of this work (excavation, installing recovery trenches) will require one construction season. More detailed information on phasing of the cleanup in discussed later in this section. Excavated soil will be transported off-site to a licensed commercial landfill for disposal or reuse as daily cover.

Long-term institutional controls will be required on BNSF's property to prevent exposure to soil and groundwater. Short-term institutional controls will be required on the three properties adjacent to the railyard until cleanup levels are achieved in soil and groundwater.

10.2.6 Northwest Developed Zone

The NW Developed Zone has multiple residences, commercial buildings, streets, and public institutions such as the school and community center. The zone is primarily affected by petroleum contaminants in the smear zone soil and groundwater, and the petroleum consists primarily of bunker C. This is the largest and most developed zone at the site and it presents several unique challenges. For example, the zone includes several historic structures that are important to the community, such as Maloney's General Store (now the Stove Shop), the Skykomish Hotel and the School. This zone also has a very shallow smear zone in some areas (approximately 2 feet below the surface). Finally, the zone is immediately upgradient of the Levee Aquatic Resource Zone such that cleanup in the NW Developed Zone will directly affect the scope, timing and nature of cleanup in the Levee Zone.

Free product is present in this zone between the Railyard Zone and the Levee Aquatic Resource Zone. The petroleum appears to originate in the vicinity of a former oil sump that was used to transfer bunker C from railcars to the aboveground 100,000 gallon oil storage tank on a 30-foot steel tower. This interpretation is based on free product thickness measurements, the location of oil seeps to the river, soil and groundwater data, known or suspected petroleum sources, lithologic controls and historic documents.

Interim actions have been performed in the NW Developed Zone that included:

1) Installing free product recovery wells along levee in 1996

2) Constructing a subsurface, free product barrier wall along the levee in 2001

3) Installing new recovery wells and upgrading existing wells in 2002.

The following remediation levels have been developed for the NW Developed Zone:

- Excavation is proposed to a remediation level of 3,400 mg/kg NWTPH-Dx for the area within 135 feet of the river. As discussed in Appendix S, this distance will ensure that groundwater discharging to the river satisfies the cleanup level.

- Free product will be contained and removed by a combination of excavation and recovery trenches. Excavation will occur as noted above and recovery trenches are proposed to remove free product from the area between the Railyard Zone and the excavated area.

- Soil contaminated with metals in the school yard, 4 residential yards, and at the Post Office within the upper 2 feet will be removed to protect people from direct contact with soil. Clean fill will be placed in the excavated areas.

- Soil contaminated with petroleum above 2,900 mg/kg total EPH/VPH beneath buildings will trigger vapor quality monitoring. Where soil vapors consistently exceed MTCA or other health-based criteria adjacent to structures, then contingency measures can be implemented to assess and mitigate the accumulation of vapors in buildings.

BNSF's preferred remedy for this Zone includes:

- Excavating the upper 2 feet of soil impacted by metals in private residential yards and on the school yard

- Excavating to a soil remediation level of 3,400 mg/kg NWTPH-Dx from within 135 feet of the river to a depth of 12 to 20 feet below grade.

- Installing four recovery trenches upgradient of the excavation area to minimize impacts to the commercial district and installing a recovery trench on the upgradient side of the excavation area.

- Replacing the Town's water supply lines in this Zone during excavation work to ensure over the long-term that groundwater does not enter the water supply.

The remedy is intended to avoid the temporary relocation or demolition of historic structures. Relocation and excavation beneath a few residences along West River Road is included to ensure that free product will not migrate toward the levee following levee cleanup and restoration. Excavation may also occur across 5th Avenue just south of the bridge such that this access point to the town will be impacted for part of one summer; due to the limited size of this excavation, additional investigation and information in the Final EIS will help Ecology and BNSF make the appropriate decision regarding this excavation, in consultation with the Town. Innovative approaches have been investigated to address free product remaining under structures in the commercial district of the zone. These approaches have showed some promise but they are highly innovative, not well tested and verified for viscous LNAPL, and expensive. BNSF intends to perform a review of viscous LNAPL removal technologies during successive 5-year reviews of the cleanup action in this Zone to investigate whether any new technology is developed that is effective and implementable. Construction activities associated with relocating these buildings and excavating free product is outside the commercial district to minimize impacts to the community.

Excavation can be completed in one or two construction seasons, including the temporary relocation of three to four homes. Excavated soil will be transported off-site to a licensed commercial landfill for disposal or reuse as daily cover. Recovery trenches can be completed in one construction season. Work will be phased and scheduled to minimize inconvenience to the Town, residents, businesses and the school.

Institutional controls will be required for an extended period of time until soil and groundwater achieve cleanup standards.

10.3 Project Schedule and Phasing

A preliminary schedule and phasing is presented below. Remedial actions will start at the levee to eliminate impacts to the river as quickly as possible. The ability to perform this work is contingent on finalizing the Cleanup Action Plan and receiving permits and approvals from federal agencies to perform work in the river and the wetland. The preliminary proposed schedule and phasing is provided below.

10.3.1 Remedial Design

Remedial Design	
Spring-Summer 2005	Remedial Design Investigations Start
Winter 2005/2006	Former Maloney Creek channel Assessment
Cleanup Actions	
Summer 2006	Excavate impacted sediment and soil in the Levee Zone Excavate shallow soil impacts in the NW Developed Zone and the Railyard
Summer 2007	Excavate in the NW Developed Zone to 135 feet from the river Excavate Free Product in the NE Developed Zone
Summer 2008	Install product recovery trenches along Railyard and in the NW Developed Zone Install enhanced biological treatment system in the NE Developed Zone
Summer 2009	Excavate the South Zone and the former Maloney Creek channel

10.4 Regulatory Evaluation of Alternative

The new preferred alternative (Figure 10-1) has been designed to satisfy both the MTCA "threshold" requirements and "other" MTCA requirements (WAC 173-340-360(2) and (3)). The threshold requirements state that the overall cleanup action must provide the following:

- Protection of human health and the environment
- Compliance with cleanup standards
- Compliance with applicable state and federal laws
- Provision for compliance monitoring

MTCA also defines other requirements that the cleanup action must satisfy. These are:

- Use of permanent solutions to the maximum extent practicable
- Provision for a reasonable restoration time frame
- Consideration of public concerns raised during the public comment period.

MTCA further identifies specific criteria that apply when certain types of cleanup actions are considered, such as restoration of groundwater, institutional controls, remediation levels, and cleanups in residential areas. This section describes how the new preferred alternative meets these criteria within the framework set forth in MTCA.

10.4.1 Threshold Requirements

All cleanup actions shall fulfill the "threshold requirements" as specified in WAC 173-340-360(2)(a). This section describes how the preferred remedy meets these threshold requirements.

10.4.1.1 Protect Human Health and the Environment

Cleanup levels that protect human health and the environment are provided in Section 5. A cleanup action that achieves cleanup levels at the point of compliance within a reasonable period of time is deemed to protect human health and the environment. Protection can be achieved by excavating all contaminated soil and sediments and attaining cleanup levels throughout the site, as described in alternative STD, or by removing free product and highly contaminated soils and then containing residual contamination in soil and groundwater and using institutional controls to minimize long-term exposure. The use of containment and institutional controls is acceptable under MTCA (WAC 173-340-360(2)(e)) as long as the overall cleanup action meets threshold and other requirements and the cleanup action does not "rely primarily on institutional controls." The new preferred alternative protects human health and the environment by achieving cleanup levels at the point of compliance within a reasonable period of time.

Human Health

Section 5 demonstrates there are potential long-term risks to human health under the following conditions:

- Direct contact with soil containing concentrations of TPH (based on the sum of EPH/VPH data) greater than 2,130 mg/kg in the vadose zone and 2,765 mg/kg in the smear zone, arsenic above 20 mg/kg, and lead above 250 mg/kg. These numeric criteria are based on conservative exposure assumptions (i.e., a child ingesting 200 grams of soil per day for 6 years).

- The ingestion of groundwater or surface water containing greater than 477 µg/L TPH (based on the sum of EPH/VPH).

- Direct contact with oil seeps in the river during low water.

The preferred alternative includes the excavation and capping of all surface metals in soil in both the NW Developed and Railyard Zones. All other soil impacts are not present in surface soil and, therefore, require some form of excavation before there is human exposure. These intermittent exposures can be controlled with a high degree of certainty using institutional controls to limit direct contact exposures to subsurface soil and groundwater and ensure that contaminated soil and groundwater are safely managed during excavation projects. Railyard workers regularly receive training regarding operational procedures that limit potential exposures and maintain institutional controls.

The preferred alternative includes the removal of free product and soil above 3,400 mg/kg NWTPH-Dx from the NW Developed Zone that is within 135 feet of the river, including the area of town where the vadose zone is thin and utilities may be located within impacted areas. This provides a more permanent means of protecting residents and utility or construction workers from being accidentally exposed to soil that presents a risk while working in yards or public rights-of-way, and a more permanent means of protecting the river. An additional layer of permanence and protectiveness will be achieved by excavating and replacing the town water line in the NW Developed Zone and placing it in a clean soil corridor.

The community currently has a public drinking water supply that is not at risk of contamination from the site. State and local institutional controls prohibit installation of wells within contaminated areas. These include the King County Board of Public Health, Public Water System Rules and Regulations (Title 12) and the Declaration of Covenant for Individual Water Supply, both managed by the Department of Health and Department of Ecology Minimum Standards for Construction and Maintenance of Wells, WAC 173-160. Even though human health risk related to groundwater is already controlled by the existing water supply system and institutional controls, MTCA generally requires that groundwater be cleaned-up to drinking water standards and that contaminated groundwater that may discharge to the river be controlled.

Human health cleanup levels for groundwater and surface water are based on restoring the water for use as drinking water. Off-railyard exceedances of the 477 µg/L groundwater level protective of human health are concurrent with free product (see Figure 3-11). The preferred alternative aggressively addresses free product in off-railyard areas to achieve the groundwater cleanup level in off-railyard areas in a relatively short timeframe, except for free product in the commercial district of the NW Developed Zone.

The Ecology-derived soil screening level for potential impacts to air quality is 2,900 mg/kg total EPH/VPH based on the 4-phase model. Previous air quality monitoring at the site demonstrated that there was no risk to human receptors in indoor and outdoor air. The preferred remedy includes additional air quality testing to verify that air quality levels are protective of human health.

Environment

Section 5 demonstrates that risks to the environment under existing conditions at the site are the following:

- Sediment in the Skykomish River that failed bioassay tests due to the presence of product seeps.

- Groundwater discharging to the Skykomish River that may cause sediment to accumulate contaminants to levels that would present a risk to aquatic receptors. A groundwater TPH cleanup level of 208 μg/L total EPH/VPH and NWTPH-Dx was developed using conservative assumptions related to groundwater-sediment interaction.

- Groundwater discharging to the surface water of the Skykomish River and the former Maloney Creek channel that would present a risk to aquatic receptors. A groundwater TPH cleanup level of 700 μg/L (NWTPH-Dx) was developed based on WET testing bioassays on water column organisms.

The preferred alternative includes excavating free product and impacted soil at the levee to eliminate free product seeps to the river and providing contingent groundwater treatment if necessary to ensure that groundwater is clean before it discharges to the Skykomish River. With respect to the former Maloney Creek channel, it is not clear that groundwater above cleanup levels is discharging into the channel, although it may be inferred from the data. The preferred remedy includes excavating hot spot smear zone soil from the Railyard side of the wetland to protect surface water and shallow sediment removal to protect terrestrial and human receptors. Aggressive cleanup is proposed for the South Developed Zone, which is immediately upgradient of the former Maloney Creek channel and would be a source of groundwater that may discharge to the channel during certain times of the year. Active groundwater treatment within the former Maloney Creek channel is retained as a contingent remedy.

Based on bioassays, some sediment in the Skykomish River has been identified for cleanup. In addition, a correlation of the bioassay results with TPH concentrations produces a numeric cleanup level of 40.9 mg/kg NWTPH-Dx (diesel + motor oil).

Environmental health will also be protected by minimizing disruption to the wetland. This is accomplished by focusing cleanup efforts on hot spots. It is well documented, and Ecology concurs, that it is more difficult to reestablish habitat than to retain existing habitat.

10.4.1.2 Comply With Cleanup Standards

Cleanup standards consist of both a cleanup level and a point of compliance where the cleanup level must be met (WAC 173-340-700). Per the regulation, "a cleanup level is the concentration of a hazardous substance in soil, water, air, or sediment that is determined to be protective of human health and the environment under specified exposure conditions." For the preferred alternative, the standard points of compliance apply to soil and sediment. The cleanup standard applicable to groundwater in the preferred alternative is that groundwater must achieve a cleanup level of 208 μg/L total EPH/VPH and NWTPH-Dx prior to discharging to the Skykomish River (i.e., surface water conditional point of compliance).

Only remedial alternative STD can achieve groundwater cleanup levels at the standard point of compliance (i.e., throughout the site, including the railyard and off-railyard properties). STD is considered a permanent groundwater cleanup action. Per WAC 173-340-360(2)(c)(ii), less permanent groundwater cleanup actions shall include "removal [of] free product consisting of petroleum and other light nonaqueous phase liquid (LNAPL) from the groundwater using normally accepted engineering practices" and "[g]round water containment…to the maximum extent practicable to avoid lateral and vertical expansion of the ground water volume affected by the hazardous substance." The preferred alternative addresses these requirements through free product removal using excavation, barrier walls, and recovery trenches in off-railyard areas and barrier walls and recovery trenches on the railyard. Excavation, barrier walls, and recovery trenches are normal engineering practice for removing heavy, viscous free product.

Institutional controls are required to ensure compliance with cleanup standards and must be implemented in accordance with WAC 173-340-440. For the preferred alternative, long-term (10+ years) institutional controls are required to comply with cleanup standards. Institutional controls include restrictive covenants on individual properties and legal or administrative mechanisms. Restrictive covenants require the consent of the property owner of the property with contamination above cleanup levels to which the restrictive covenant is applied. Legal or administrative mechanisms include "zoning overlays, placing notices in local building department records or state lands records, public notices and education mailings." State and local institutional controls already in place prohibit installation of wells within contaminated areas. Additional institutional controls (local ordinances and landowner agreements) can further limit exposure and provide a mechanism for BNSF (or the Town with technical and financial assistance from BNSF) to safely manage contaminated soil and water encountered during construction activities on private and public properties. Any of these institutional controls could be removed or modified once the cleanup is completed.

10.4.1.3 Comply With Applicable Local, State and Federal Laws

Several applicable local, state and federal laws have been incorporated into the cleanup level development process. These include the Sediment Management Standards (WAC 173-204). The State Environmental Policy Act (WAC 197-11-400) was also considered in developing the preferred alternative with alternatives, adverse impacts and mitigation measures disclosed and discussed in the Draft FS/EIS and subsequent environmental documents. Additional laws may apply to implementation of the cleanup action. An example is Section 404 of the Clean Water Act that will require permitting and mitigation associated with cleanup actions that impact the South Fork Skykomish River or the wetland at the former Maloney Creek channel, and Section 7 of the Endangered Species Act requires consultation with federal resource agencies. The preferred alternative has been devised and will be designed to comply with applicable local, state and federal laws.

10.4.1.4 Provide for Compliance Monitoring

Compliance monitoring is not a cleanup element that is described in detail during the FS process. These provisions are better developed in the Cleanup Action Plan and detailed Compliance Monitoring Plans are developed during engineering design of the cleanup action. Compliance Monitoring Plans will provide for a monitoring program that ensures that cleanup levels are obtained and will include provisions for contingent remedies should any part of the new preferred alternative fail to meet cleanup standards. A brief description of the compliance monitoring program is discussed in Section 10.5.

10.4.2 Use Permanent Solutions to the Maximum Extent Practicable

The first of three "other requirements" for selection of cleanup actions under MTCA is the use of permanent solutions to the maximum extent practicable. The procedure for determining whether a cleanup action uses permanent solutions to the maximum extant practicable is provided in WAC 173-340-360(3). This section presents a "disproportionate cost analysis" to compare the relative costs and benefits of a permanent alternative with the other alternatives being considered. Costs are disproportional to benefits if the incremental cost of the permanent alternative exceeds the incremental benefit achieved by that permanent alternative with the additional cost. The analysis may be quantitative or qualitative. The analysis begins by ranking alternatives from the most permanent to the least permanent. Once alternatives are ranked from the most permanent to the least permanent, they are evaluated based on seven criteria in WAC 173-340-360(f).

A "permanent cleanup action" achieves cleanup standards without further action at the site, such as long-term monitoring, maintenance or institutional controls (WAC 173-340-200). In the draft Final FS and in this document, the measure used to quantify permanence is termed "equivalent soil volume" but it is a relative measure of petroleum mass removed in each alternative rather than volume. An alternative that treats or removes a greater equivalent soil volume (or mass of petroleum) than other alternatives may be considered more permanent because it represents a larger reduction in the volume of hazardous substances at the site and a reduced need for long-term monitoring, maintenance or institutional controls. The remedial alternatives are ranked in Figure 10-2 from the most permanent (STD) to the least permanent (No

Action). The new preferred alternative is ranked seventh in level of permanence.

10.4.2.1 Protectiveness

Protectiveness of human health and the environment includes the degree to which existing risks are reduced, time required to reduce risk at the site and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.

The discussion regarding protection of human health and the environment in Section 10.1.1 demonstrates of how the preferred remedy protects human health and the environment. The preferred remedy was designed to aggressively address possible human health risk associated with exposure to impacted surface soil. The preferred alternative also includes replacement of the water service line in the NW Developed Zone to ensure that the water supply system is not impacted. While human health risk associated with consumption of groundwater is already controlled through institutional controls, the preferred alternative aggressively addresses free product in the developed zones to achieve the groundwater concentration protective of human health (477 µg/L total EPH/VPH) in most off-railyard areas.

The preferred alternative provides the greatest level of environmental protectiveness by addressing soil and sediment in the former Maloney Creek channel and by addressing soil, sediment, and free product at the Levee. The preferred remedy also minimizes impacts to the wetland while addressing risk issues, thereby contributing to overall environmental quality.

The preferred remedy places a priority on addressing the most significant risks in the shortest period of time. Specifically, the preferred remedy includes addressing the most significant environmental impact by proposing to excavate the levee and the surface metals impacts.

The preferred remedy addresses implementation risks by minimizing the amount of excavation within portions of the town. This occurs through the use of recovery trenches in the commercial portion of town. The excavation of free product and impacted soil closer to the river provides more certainty that exposure risks are controlled in areas closest to the sensitive receptors associated with the river.

Based on the description of protectiveness, all of the alternatives were ranked using a scoring system. The scoring system is intended to take into account all of the criteria associated with protectiveness listed in MTCA, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, risks resulting from implementing the alternative and improvement of the overall environmental quality. The results are summarized in Table 10-1. The results illustrate that for protectiveness, the preferred alternative receives a ranking of 9.25, slightly below the 10 ranking for alternatives PB4, PB5, and STD.

10.4.2.2 Permanence

Permanence was discussed earlier and the relative permanence of the remedial alternatives was illustrated in Figure 10-2. The preferred remedy is the seventh most permanent remedy considered for the site. The permanence associated with the preferred remedy is focused more on the Aquatic Resource Zones than the Developed Zones and the Railyard.

10.4.2.3 Cost

Figure 10-3 indicates the cost for each alternative with the alternatives ranked by level of permanence. Detailed cost estimates are provided in Appendix N. The largest cost elements are associated with cleanup of the NW Developed Zone, Levee Aquatic Resource Zone, and the Railyard Zone. Cleanup of the other three zones combined contribute on the order of 15 percent or less of total costs. The total project costs range from less than $10 million to almost $80 million.

Figure 10-4 illustrates the cost to achieve the increasing levels of permanence. Lower unit costs (total cost divided by total equivalent soil volume) indicate increased cost-effectiveness of the remedial alternative with respect to equivalent soil volume removal or treatment where equivalent soil removal volumes are used as a surrogate for contaminant mass removal and permanence.

10.4.2.4 Effectiveness Over the Long-Term

Long-term effectiveness includes "the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations above cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes."

MTCA suggests the use of the following hierarchy of cleanup action components in descending order of long-term effectiveness:

1) Reuse or recycling
2) Destruction or detoxification
3) Immobilization or solidification
4) On- or off-site disposal
5) On-site isolation or containment
6) Institutional controls.

The remedial technologies in the proposed remedial alternatives fit this hierarchy as follows:

1) Reuse or recycling (free product skimming or trenches with free product recovery and recycling)

2) Destruction or detoxification (natural attenuation and enhanced bioremediation)

3) Immobilization or solidification (none)

4) Excavation (requires off-site disposal)

5) Containment (soil and groundwater managed in place)

6) Institutional controls (soil and groundwater managed if and when excavated for other projects).

Equivalent soil volumes were calculated for each cleanup action component for each alternative (see Appendix N). The volumes were then divided by the hierarchy number and summed for each alternative to derive a normalized equivalent soil volume. The higher normalized equivalent soil volume suggests a higher level of long-term effectiveness. This approach was used to score the alternatives from 0 to 5 points. The other 5 points were scored based on site remediation activities that were most likely to contribute to the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time that hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The resulting scores for long-term effectiveness are provided in Table 10-1. The preferred alternative ranks sixth, behind SW4, PB3, STD, PB5, and PB4.

10.4.2.5 Management of Short-Term Risks

Impacts from remedial action implementation include vehicle traffic, temporary relocation of residences/structures, odor, open excavations, and noise, dust and safety concerns associated with extensive heavy equipment activity. The greatest short-term risk to human health is related to safety and general construction activity. As a result, the short-term risks to human health would be greatest for the more permanent alternatives. In all cases, similar measures would be taken to manage risk such as fencing, signage, dust controls, and traffic control.

With respect to short-term risks to the environment, more aggressive remedies in the Aquatic Resource Zones present a greater short-term risk to the environment. So, similar to human health risks, the short-term risks to the environment would be greatest for the more permanent alternatives. In all cases, similar measures would be taken to manage risk such as temporary dams to prevent surface water discharges, angle boring to minimize drilling in sensitive areas, and scheduling work to avoid sensitive species during critical stages.

Based on the description of short-term risk, all of the alternatives were ranked using a scoring system. The results are summarized in Table 10-1. The preferred alternative received a moderate score, similar to the other more aggressive remedies. Overall the preferred alternative was ranked sixth.

10.4.2.6 Technical and Administrative Implementability

Three major administrative concerns with the remedial alternatives are institutional controls, permitting, and relocating residents, businesses, transportation facilities and public facilities such as the school. The preferred alternative requires long-term institutional controls on off-railyard properties where soil and/or groundwater will remain above cleanup levels for extended periods of time. The preferred alternative is rather aggressive in that excavation beneath properties abutting the river (requiring movement of several homes and buildings) is included, although the extent of excavation is limited to minimize disruption to the community. The use of institutional controls diminishes the administrative implementability, generally in proportion to the number of properties requiring some from of institutional control and the length of time these controls must be enforced.

The second administrative implementability issue relates to permitting and mitigating adverse impacts from cleanup actions at the Levee and the former Maloney Creek channel. Permits are required from the US Army Corps of Engineers under Section 404 of the Clean Water Act, and the Endangered Species Act requires the Corps to consult with NOAA-Fisheries and the U.S. Fish and Wildlife Service. Permitting of environmental cleanup activities under this process is expected to take one to two years. The preferred remedy would likely require this permit. In addition, invasive work on or in the Levee requires coordination with King County to ensure the structural integrity of the Levee is not compromised.

Finally, the more aggressive remedies necessarily involve administrative and technical challenges associated with work around and under buildings and facilities such as the school, the community center, residences, businesses, the main rail line, streets and utilities. The use of excavation has been minimized in the preferred alternative to reduce these technical and administrative challenges. Temporary dwellings will be required for only a small number of residents due to excavation. Businesses should not be disturbed, although the community center may have to close for one summer.

The preferred alternative ranks seventh for technical and administrative implementability, due to the triggering of in-water work permit requirements, and the remaining need for institutional controls.

10.4.2.7 Consideration of Public Concerns

The preferred alternative incorporates concerns raised during the public comment process for the Draft FS/Draft EIS as well as concerns that have been raised during technical workshops sponsored by BNSF over the past 2 years. These concerns have been incorporated into development of the preferred remedial alternative to the extent possible while still providing a remedy that satisfies the MTCA threshold requirements. Additional public comment and community involvement will occur during remedial design and when determining how to phase the cleanup activities within each cleanup zone.

10.4.2.8 Permanence to the Maximum Extent Summary

As noted at the beginning of this section, the analysis of whether an alternative is permanent to the maximum extent practicable involves the comparison of the alternatives based on the seven evaluation criteria as described above. The goal is to determine whether the incremental cost of an alternative is disproportionate to the incremental benefit relative to the lower cost alternative (WAC 173-340-360(e)(i). A systematic approach was developed to quantify the relative benefit of the alternatives. The total benefit of each alternative was calculated as the sum of ratings for five of the evaluation criteria:

1) Protectiveness
2) Permanence
3) Effectiveness over the long-term
4) Management of short-term risks
5) Technical and administrative feasibility.

Public concerns were based on the public comment received on the Draft FS/Draft EIS and these were incorporated in the development of the preferred remedy. Cost is part of the analysis to determine if the incremental cost of an alternative is disproportionate to the incremental benefit relative to the lower cost alternative. The benefit ratings are provided in Table 10-1 and Figure 10-5 illustrates these benefit ratings and alternative costs.

To further evaluate the ratings, benefit was plotted versus cost in Figure 10-6. Where a line between two alternatives is steeper (closer to vertical), there is greater incremental benefit per incremental dollar expended. This figure indicates that SW3, PB2, and the preferred alternative are alternatives where the cost of proceeding to the next more costly alternative outweighs the benefits. SW3 was not selected as BNSF's preferred alternative since it does not aggressively address impacts in the Aquatic Resources Zones or the NE

Developed Zone. The preferred alternative provides greater benefit than PB2 for a similar cost, indicating that the cost is disproportionate to benefit for PB2. In addition, PB2 includes complete removal of free product in the NW Developed Zone, which was deemed not likely to be acceptable to the community.

MTCA also states that the most practicable permanent alternative shall be the "baseline cleanup action" against which other alternatives are compared (WAC 173-340-360(e)(ii)(B)). To evaluate the alternatives using this criterion, the data was further evaluated. STD was considered the most practicable permanent alternative since it had the highest benefit rating. Figure 10-7 illustrates the percentage incremental benefit and percentage decrease in cost of each alternative versus STD. This analysis indicates that the preferred alternative is permanent to the maximum extent practicable, followed by PB4, PB2, SW4, and PB3.

10.4.3 Provide for a Reasonable Restoration Timeframe

The second of three "other requirements" for selection of cleanup actions under MTCA is a reasonable restoration timeframe. Restoration timeframe is the time it takes to meet cleanup standards (i.e., to meet all cleanup levels in all media at all points of compliance). A cleanup action can meet cleanup standards through the use of treatment, removal or containment, or some combination of these three approaches. Each alternative relies on removal of free product and restoring groundwater before it discharges to surface water. The PB alternatives rely on containment and institutional controls for soil in off-railyard areas while the SW alternatives rely on containment and institutional controls for both soil and groundwater in off-railyard areas.

Estimates of time to remove free product and to restore groundwater and cleanup soil were generated for each zone and remedial alternative. Since detailed phasing was not considered for each alternative and restoration timeframes are provided separately for each cleanup zone, the restoration timeframes provided in this section do not account for the additional time required to phase cleanup in the different zones. These estimates assume that containment and institutional controls can be established for off-railyard areas for soil and groundwater. Figures 10-8 through 10-10 illustrate the estimated restoration timeframes. These charts present the mid-point from estimated ranges, as follows:

- "4 years" represents a 3 to 5 year range
- "8 years" represents a 5 to 10 year range
- "15 years" represents a 10 to 20 year range
- "25 years" represents a 20 to 30 year range
- "40 years" represents greater than 30 years.

The procedure for determining whether a cleanup action provides for a reasonable restoration timeframe is provided in WAC 173-340-360(4). The nine factors used to determine whether a cleanup action provides for a reasonable restoration timeframe are provided in the rule and include:

1) Potential risks posed by the site to human health and the environment

2) Practicability of achieving a shorter restoration timeframe

3) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site

4) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site

5) Availability of alternative water supplies

6) Likely effectiveness and reliability of institutional controls

7) Ability to control and monitor migration of substances from the site

8) Toxicity of hazardous substances at the site

9) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

The rule (WAC 173-340-360(4)(c)) also states that: "a longer period of time may be used for the restoration timeframe for a site to achieve cleanup levels at the point of compliance if the cleanup action selected has a greater degree of long-term effectiveness than on-site or off-site disposal, isolation, or containment options."

Figure 10-8 indicates that free product will be removed from all off-railyard areas within two years for the preferred alternative, except for the NW Developed Zone. Free product will have been excavated from the area of the NW Developed Zone closest to the river where it poses a risk to river sediment. The remaining free product will be contained and removed using trenches in the commercial and historic district. Free product will also remain on the railyard for an extended period of time because the free product on the railyard does not pose a significant risk to human health or the environment.

Figures 10-9 and 10-10 indicate that the preferred alternative achieves cleanup standards for soil and groundwater within two years in the Levee, Former

Maloney Creek Channel, and South Zones. The Aquatic Resource Zones are the drivers of the groundwater cleanup levels that will be achieved by the preferred remedy. The soil and groundwater restoration timeframes for the NE Developed Zone are 5 to 10 years where soil and groundwater impacts are present beneath 8 feet of clean soil and where enhanced biodegradation is expected to be effective. Free product will have been excavated from the area of the NW Developed Zone closest to the river where it poses a risk to river sediment and the remaining soil and groundwater impacts will be effectively contained. Residual impacts on the Railyard will not pose a risk to human health and the environment. The use of the preferred alterative rather than more aggressive remedies avoids significant disruption to the community. Residual impacts in the NE Developed Zone, the NW Developed Zone, and the Railyard Zone do not pose a significant risk to human health and the environment, water is provided by the town, and institutional controls are likely to be effective and reliable.

10.4.4 Consider Public Concerns

The third of the three "Other Requirements" in MTCA is to consider public concerns. The public comment process included review of the Draft FS/Draft EIS. These public comments were used in the development of the preferred remedy.

10.4.5 MTCA Site-Specific Requirements

Site-specific requirements for MTCA cleanup actions were listed at the beginning of this Section. The means by which the preferred remedy satisfies these requirements is presented below.

10.4.5.1 Requirements for Groundwater cleanup actions (WAC 173-340-360 (2)(c))

The groundwater cleanup action included in the preferred remedy is a nonpermanent cleanup action. When a nonpermanent cleanup action is used, MTCA requires treatment or removal of the source and the use of groundwater containment. The preferred remedy satisfies these requirements by removing free product from most off-railyard areas in a short timeframe, and by containing and collecting free product remaining in the NW Developed Zone and on the railyard. Removal of free product achieves human health criteria in groundwater, and enhanced bioremediation will be used as a contingent remedy at the Levee and/or the Former Maloney Creek Zone, if monitoring shows that it is necessary to treat groundwater before it discharges to surface water.

10.4.5.2 Requirements for Soil Cleanup Actions for Residential Areas, Schools and Child Care Centers (WAC 173-340-360(2)(d))

MTCA requires that soils with hazardous substance concentrations that exceed cleanup levels be treated, removed, or contained. The preferred remedy includes aggressive removal of free product and shallow soil impacts from all residential areas and the school in Skykomish. All soil impacts will be removed from the South Developed Zone. All soil impacts will be addressed by enhanced bioremediation in the NE Developed Zone and in the interim an 8-foot clean soil cap is present. In the NW Developed Zone, a 2-foot clean soil cap will be used to contain soil impacts.

10.4.5.3 Requirements for Cleanup Actions that use Institutional Controls (WAC 173-340-360(2)(e) and 173-340-440)

Cleanup actions that use institutional controls shall satisfy the threshold and other requirements, shall use institutional controls to demonstrably reduce risk, and shall not rely primarily on institutional controls where it is technically possible to implement a more permanent cleanup action.

The preferred alternative satisfies the threshold and other criteria defined in MTCA, as discussed earlier in this section. Institutional controls are used primarily on the railyard where they are more effective and reliable at reducing risk but they will also reduce risk in both the NE and NW Developed Zone by preventing direct contact with soil and ingestion of groundwater. The preferred remedy is an aggressive remedy that includes substantial removal and treatment of soil and groundwater. Institutional controls are only used where they are effective and reliable or where the disruption associated with a more permanent cleanup would not substantially reduce risk to human health and the environment.

10.4.5.4 Requirement to prevent or minimize present or future releases and migration of hazardous substances (WAC 173-340-360(2)(f))

Cleanup actions shall prevent or minimize present and future releases and migration of hazardous substances in the environment.

The preferred remedy includes aggressive cleanup actions in off-railyard areas. The remedy also includes the physical containment of free product on the railyard and enhanced bioremediation of groundwater as a contingency, if monitoring shows that it is necessary to achieve groundwater cleanup levels before groundwater discharges to surface water.

10.4.5.5 Requirements for Cleanup Actions that use Dilution and Dispersion (WAC 173-340-360(2)(g))

Cleanup actions shall not rely primarily on dilution and dispersion unless the incremental costs outweigh the incremental benefits of active remedial measures.

The preferred remedy does not rely on dilution or dispersion for any cleanup zone on the site. In off-railyard areas, sources of petroleum, such as free product, are aggressively addressed and ongoing treatment of residual impacts is addressed using enhanced bioremediation, as necessary.

10.4.5.6 Requirements for Cleanup Actions that Use Remediation Levels (WAC 173-340-360(2)(h))

Cleanup actions that use remediation levels require a determination that a more permanent cleanup action is not practicable based on a disproportionate costs analysis and the selected alternative must meet the threshold and other requirements specified in MTCA.

The disproportionate cost analysis for the preferred remedy was presented in Section 10.1.2. The analysis demonstrated that the preferred alternative is permanent to the maximum extent practicable. In addition, Sections 10.1.1 and 10.1.3 through 10.1.5 demonstrate that the preferred alternative satisfies the threshold and other criteria.

10.4.5.7 Types, Levels, and Amounts of Hazardous Substances Remaining On Site (WAC 173-340-380(1)(ix))

A Cleanup Action Plan must include a description of the types, levels, and amounts of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances. Ecology requested that the types, levels, and amounts information be included in the FS. Figure 10-11 presents this information for the preferred alternative. The figure includes a map of remaining contamination after active remediation where active remediation includes excavation and enhanced bioremediation when used for treatment rather than containment. A graph is also provided to show what percentage of remaining impacts will be recovered or degraded over time. The preferred alternative data may be compared with similar data provided for the other alternatives in Figures 8-1 to 8-10. It should be noted that the graphs were based on gross assumptions that allow for comparison between alternatives but are not intended to indicate actual degradation rates or timeframes.

10.4.6 SEPA

The Draft FS and Draft EIS were integrated into a single document that described alternatives, significant adverse environmental impacts and reasonable mitigation measures consistent with SEPA (WAC 197-11-400), as well as MTCA The adverse impacts described in an EIS include short- and long-term impacts, direct and indirect impacts and cumulative impacts.

The information in the Draft EIS and the public and agency comments received in response to the Draft EIS were used by BNSF in developing the preferred remedy presented in this Draft FS. For example, specific mitigation measures include standard construction BMPs for the protection of soil and water, air quality, fish and wildlife, vegetation, aesthetic and historical resources, human health and public property, including construction timing restrictions, implemented under all alternatives. In addition, replacement of excavated soil with comparable material mitigates for soil impacts in the developed areas and the aquatic resource zones. Replacement of septic systems can mitigate the impact to the leach fields. Due to Department of Health requirements, leach field replacement may have to occur using a centralized system placed in native soil. Mitigation measures focusing on appropriate timing of work in the riverfront area mitigates against risk of flooding and hydrologic impacts. Compensatory wetland mitigation would be detailed in a Wetland Mitigation Plan to off-set impacts to the former Maloney Creek channel wetlands consistent with the requirements of the Skykomish Critical Areas Ordinance and the U.S. Army Corps of Engineers regulations. Impacts on land use from contaminated soil and groundwater can be mitigated by maintaining a clean soil cover at the surface, continuing to make public water available, and implementing institutional controls which will limit exposure and provide a mechanism for BNSF (or the Town with technical and financial assistance from BNSF) to safely manage contaminated soil and water encountered during construction activities on private and public properties.

Unavoidable significant impacts associated with the preferred alternative include:

- Relatively high noise levels in town during working hours
- Increased truck traffic in the town of Skykomish
- Increased truck traffic on U.S. Highway 2
- Road closures
- Effects to public services, housing, historic structures, and aesthetics
- Temporary loss of salmonid habitat.

Before Ecology makes a final decision on a cleanup plan, a Final EIS will be issued.

10.4.7 Preferred Alternative Selection

Ecology will choose the cleanup action based on an analysis similar to that presented earlier in Section 10. The selected cleanup alternative must:

- Satisfy MTCA threshold requirements
- Be permanent to the maximum extent practicable
- Provide for a reasonable restoration timeframe
- Consider public concerns
- Minimize environmental impacts through alternative selection and mitigation.

The selected cleanup alternative may or may not be one of the remedial alternatives presented in this Draft FS, including the preferred alternative. It may combine cleanup actions by zone in a manner that better satisfies MTCA requirements or it may use technologies that were retained (Appendix M of the Draft FS) but not included in any of the remedial alternatives. The selected cleanup alternative will be presented by Ecology in the Cleanup Action Plan.

Section 10.4 demonstrates that the preferred remedy proposed herein satisfies the MTCA criteria listed above and also considers the environmental impacts that will be addressed in the EIS.

10.5 Compliance Monitoring Plan

The preferred remedial alternative includes all phases of compliance monitoring, including protection, performance and confirmational monitoring. Compliance monitoring requirements are provided in WAC 173-340-410. This section provides an overview of the compliance monitoring concepts that will be applied to the preferred remedy. A compliance monitoring plan will be prepared as part of the remedial design process.

Protection monitoring ensures that human health and the environment are protected during implementation of the cleanup alternative. Examples of protection monitoring include: 1) monitoring air quality for dust during excavation and hauling activities; and 2) monitoring surface water quality downstream of sediment removal activities to ensure that turbidity is not affecting water quality.

Performance monitoring is used to determine if a cleanup action has achieved performance standards. The primary performance standards are cleanup levels and remediation levels, although they can also include construction quality control monitoring or monitoring for compliance with permit conditions.

Confirmational monitoring is used to determine the long-term effectiveness of the remedy once performance monitoring has determined that performance standards have been achieved. Through the remainder of this section performance and confirmational monitoring approaches will be discussed assuming similar approaches.

10.5.1 Compliance with Cleanup Standards

The cleanup standards used in developing the preferred alternative were:

- **Soil – 22** mg/kg total EPH/VPH and NWTPH-Dx throughout the site based on the protection of sediment from dissolved groundwater from leaching from soil

- **Groundwater –** 208 µg/L total EPH/VPH and NWTPH-Dx at the point of groundwater discharge to surface water to protect sediment in the South Fork Skykomish River from recontamination due to groundwater

- **Sediment –** cleanup will occur for the area defined based on bioassay failures.

BNSF proposes to use an empirical demonstration in accordance with WAC 173-340-747(9) to demonstrate compliance with the soil cleanup level. The empirical demonstration will be performed at wells within the levee and at the downgradient extent of the dissolved plume in the NE Developed Zone. Remediation levels have been incorporated into the preferred remedy to ensure that the remedy is protective of human health and the environmental through all pathways.

Compliance with the groundwater cleanup level will be determined at the same locations as proposed for the empirical demonstration of compliance with the soil cleanup level.

The area for removal of sediment has been pre-defined based on bioassay testing. Following removal and backfill of these sediments, groundwater compliance monitoring, discussed above, will be used to verify long-term compliance with cleanup levels.

10.5.2 Compliance with Remediation Levels

The preferred remedy incorporates several remediation levels, as follows:

- Groundwater will be treated to achieve the 477 µg/L total EPH/VPH to protect groundwater to human health standards in the NE Developed Zone.

- Free product will be removed by excavation. Excavation is proposed for NE, NW and South Developed Zones and the former Maloney Creek channel.

- Soil exceeding levels protective of direct contact and empirically protective of leaching to groundwater (3,400 mg/kg NWTPH-Dx) in the smear zone will be excavated at the Levee, within 135 feet of the River in the NW Developed Zone, and in the South Developed Zone.

- Soil exceeding levels protective of direct contact will be achieved within the upper 2 feet of soil in residential yards in the NW Developed Zone and in the former Maloney Creek channel.

- Soil exceeding levels protective of terrestrial ecological receptors will be achieved within the upper 1 foot of soil in residential yards in the NW Developed Zone and in the former Maloney Creek channel.

- Soil exceeding levels protective of air (vapor) quality for human health will be achieved in the upper 15 feet in the NE and NW Developed Zones.

These remediation levels are grouped below to simplify the discussion of compliance monitoring.

10.5.2.1 Soil Protective of Direct Contact

Compliance with remediation levels based on direct contact will be evaluated during performance monitoring. Remediation levels that are included in this category are:

- Soil exceeding levels protective of direct contact in the smear zone

- Soil exceeding levels protective of direct contact will be achieved within the upper 2 feet of soil.

- Soil exceeding levels protective of terrestrial ecological receptors will be achieved within the upper 1 foot of soil.

Compliance with these remediation levels will be achieved using excavation. Performance monitoring of an excavation typically includes sampling of excavation sidewalls and bottom at an appropriate frequency to confirm that the remediation level has been achieved. Excavation in the NW Developed Zone will occur for metals and petroleum impacts. Excavation in the former Maloney Creek channel and the South Developed Zone would occur due to the presence of petroleum.

10.5.2.2 Soil Protective of Leaching to Groundwater

Compliance with remediation levels based on leaching to groundwater will be evaluated during both performance and conformational monitoring. The remediation level included in this category is:

- Soil empirically protective of leaching to groundwater (3,400 mg/kg NWTPH-Dx) in the smear zone will be excavated.

Compliance with this remediation level will be achieved using excavation. Performance monitoring of an excavation typically includes sampling of excavation sidewalls and bottom at an appropriate frequency to confirm that the remediation level has been achieved. Excavation will occur at the Levee, within 135 feet of the River in the NW Developed Zone, and in the South Developed Zone.

For confirmational monitoring when soil is excavated to this remediation level, the compliance monitoring will include sampling wells and analyzing for NWTPH-Dx. This sampling will be used to determine if excavation to the remediation level achieves the groundwater cleanup level.

10.5.2.3 Soil Protective of Air Quality

Compliance with remediation levels based on protecting air quality will be evaluated during performance monitoring. The remediation level that is included in this category is:

- Soil exceeding levels protective of air quality for human health will be achieved between the bottom of the smear zone and ground surface.

Ecology developed a soil screening level of 2,900 mg/kg total EPH/VPH based on the 4-phase model.

Performance monitoring is proposed to demonstrate that existing and post-cleanup soil quality is protective of human health, consistent with WAC 173-340-745(5)(c)(iv)(B)(II). This monitoring will be used to demonstrate that air concentrations do not exceed levels that will be established consistent with WAC 173-340-750. Air quality concentrations above protective levels will trigger contingent actions.

10.5.2.4 Free Product Removal

Compliance with remediation levels for excavating free product will be evaluated during performance monitoring and confirmational monitoring. The remediation level that is included in this category is:

- Free product will be removed by excavation and recovery trenches. Excavation is proposed for NE and NW Developed Zones and the former Maloney Creek channel. Recovery trenches are proposed for the NW Developed Zone and between the NE Developed Zone and upgradient impacts in the Railyard Zone.

When free product is removed by excavation during low water conditions, the primary focus will be removing the heavily impacted soil associated with the free product area. Free product will be removed from groundwater at the base of the excavation and a soil concentration level will be used to guide the extent of excavation. A preliminary evaluation of NW Developed Zone soil concentrations indicative of free product indicates that a concentration of about 10,000 to 15,000 mg/kg NWTPH-Dx (diesel plus motor oil) in the smear zone above the water table elevation or a concentration of greater than 20,000 mg/kg NWTPH-Dx (diesel plus motor oil) at or below the water table indicates the presence of free product. A separate analysis will be needed to develop the appropriate concentrations in the NE Developed Zone.

For confirmational monitoring when free product is excavated or recovered in trenches, the compliance monitoring will include gauging of wells for the presence of free product. This gauging will be used to determine if there is a separate, distinct layer indicative of free product and it will also be used to demonstrate compliance with the nonaqueous phase liquid limitation (WAC 173-340-720(7)(d)).

10.5.2.5 Groundwater Protective of Human Health

Compliance with remediation levels based on protecting human health will be evaluated during performance monitoring. The remediation level that is included in this category is:

- Groundwater will be treated to achieve the 477 µg/L total EPH/VPH level to protect groundwater to human health standards in the NE Developed Zone.

Compliance with this remediation level will be determined by direct monitoring of groundwater quality in monitoring wells. Due to the expense of EPH/VPH analysis, a correlation may be derived between NWTPH-Dx and EPH/VPH to allow groundwater compliance monitoring to use NWTPH-Dx.

10.5.3 Contingent Actions

Contingent actions are triggered when performance or confirmational monitoring indicates that a remedial alternative has failed to achieve performance standards, generally remediation or cleanup levels. The compliance monitoring plan will document procedures for determining when a contingent action is triggered and will specify the contingent action to be used to the extent possible. Some examples of possible contingent actions are provided below:

- **Levee –** The installation and operation of an enhanced bioremediation air sparging system should the groundwater cleanup level not be achieved due to excavation alone.

- **Former Maloney Creek Channel –** The implementation of an enhanced bioremediation system should hot spot removal not achieve the groundwater cleanup level and should the hydrogeologic assessment indicate potential discharges to the channel.

- **NE Developed Zone –** Enhancement of the bioremediation system using surfactants to make the petroleum compounds more biologically available should the cleanup level or the remediation level not be achieved.

- **NW Developed Zone –** The implementation of additional free product excavation activities should performance of confirmational monitoring demonstrate the presence of free product in a well.

- **NW Developed Zone –** The installation of vapor barriers or ventilation systems beneath building if air quality monitoring indicates that air quality exceeds human health criteria.

These concepts will be developed further and included in a compliance monitoring plan as part of the remedial design process.

10.6 Financial Assurance

BNSF’s revised preferred alternative includes short-term capital and long-term cost operation, monitoring and maintenance requirements of various remedial systems. BNSF is confident that it has the financial resources needed to implement the revised preferred alternative. Ecology may choose to include specific “financial assurance” requirements in a consent decree with BNSF to implement a final remedy. The purpose of financial assurance is to ensure that sufficient financial resources are available to implement the final remedy. Following is the financial assurance required by MTCA:

> WAC 173-340-440(11) Financial Assurances. The department shall, as appropriate, require financial assurance mechanisms at sites where the cleanup action selected includes engineered and/or institutional controls. It is presumed that financial assurance mechanisms will be required unless the PLP can demonstrate that sufficient financial resources are available and in place to provide for the long-term effectiveness of engineered and institutional controls adopted. Financial assurances shall be of sufficient amount to cover all costs associated with the operation and maintenance of the cleanup action, including institutional controls, compliance monitoring, and corrective measures.
>
> (a) Mechanisms. Financial assurance mechanisms may include one or more of the following: A trust fund, a surety bond, a letter of credit, financial test, guarantee, standby trust fund, government bond rating test, government financial test, government guarantee, government fund, or financial assurance mechanisms required under another law (for example, requirements for solid waste landfills or treatment, storage, and disposal facilities) that meets the requirements of this section.
>
> (b) Exemption from requirement. The department shall not require financial assurances if persons conducting the cleanup can demonstrate that requiring financial assurances will result in the PLPs for the site having insufficient funds to conduct the cleanup or being forced into bankruptcy or similar financial hardship.

BNSF currently provides financial assurances at various sites in Washington and other states. BNSF utilizes a “financial test” to provide financial assurance for cleanup costs at these sites. The annual test performed by BNSF takes into account all such liabilities consistent with EPA regulations in 40 CFR Part 264, Subpart H. The financial test requires BNSF to show on an annual basis three things: 1) Total Net Worth (TNW) is greater than seven times the cleanup costs for all sites where financial assurance is required; 2) TNW is greater than $10 million; and 3) 90 percent of BNSF’s assets are located in the U.S. BNSF has consistently met all of these criteria for many years and adding the revised preferred alternative to the annual financial test will not cause BNSF to fail the test. A copy of BNSF’s 2004 financial assurance documentation for a site in Washington is attached as Appendix R as an example. Five Year Reviews for New Technology Developments

Under BNSF’s preferred alternative, TPH contamination will remain in soil and groundwater as non-recoverable NAPL. Excavation has been determined to be the most effective and practicable remedial technology for addressing the TPH impacts associated with the Site. Less intrusive *in situ* technologies would be preferable to excavation with respect to having significantly less disruption to the Town. However, such technologies have not been found to be practicable at Skykomish at their current state of development and understanding. As a result, BNSF's preferred alternative includes areas of the Town and railyard that will be excavated, and others that will not be disrupted by excavation, but will contain these contaminants for a long-term future (likely to approach 100 years). Existing and/or new technologies may be further developed over this timeframe and could be effectively and practicably implemented in the future.

Five-year reviews of the project will be required as long as residual contamination remains above cleanup levels to ensure that the cleanup action continues to protect human health and the environment. In addition to reviewing successful implementation and progress of the selected remedial alternative in accordance with the Cleanup Action Plan/Design, these reviews will provide an opportunity to evaluate cleanup technology developments on an on-going basis. The five-year reviews will include an evaluation of technology developments that could be applicable to residual contamination at Skykomish. This evaluation will include an update on technologies that have been previously thought applicable to this site but not implementable due to their early stage of development. The evaluation will also include consideration of new technologies thought to have promise for use at Skykomish. These technology evaluations will be focused on contaminants that remain at the site – primarily non-recoverable NAPL, residual TPH in soil, and/or TPH dissolved in groundwater.

A technology would be considered for implementation if it met the following criteria:

- Significantly reduces restoration time frame – generally to less than five years, when there are otherwise anticipated to be several decades remaining without additional technology implementation.

- The technology will achieve a final cleanup level that allows for cessation of a current remedial technology (such as NAPL recovery trench operation) and/or removal of an institutional control (groundwater or soil use could become unrestricted).

- Sufficient data exists from other site applications to provide a high degree of confidence that the technology will be successful and to allow for substantial design of the technology implementation. Pilot testing may be part of the technology implementation – but this would be for site-specific design purposes and not technology development.

- Meets criteria of MTCA feasibility analysis including the substantial and disproportionate cost analysis.

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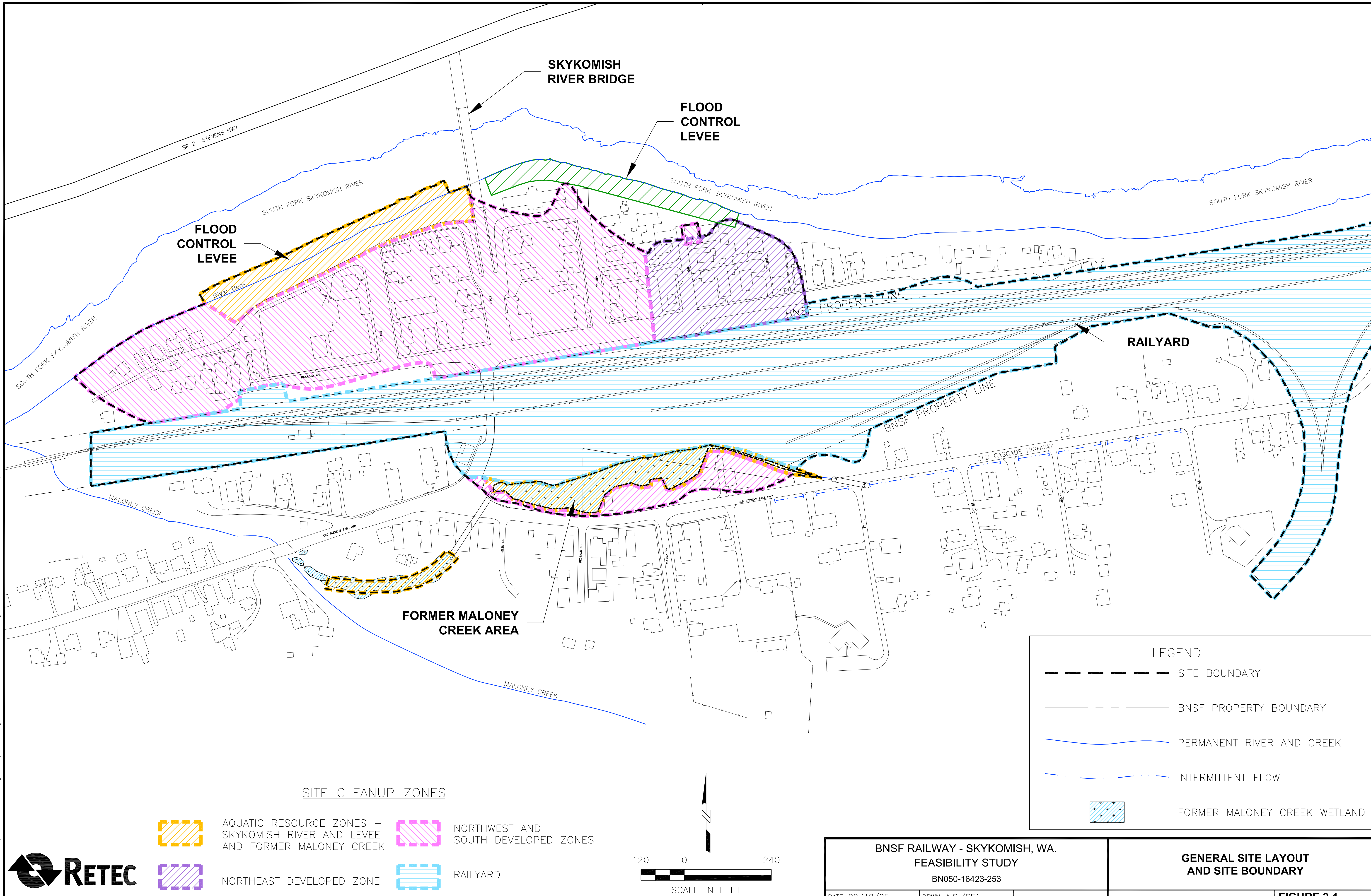

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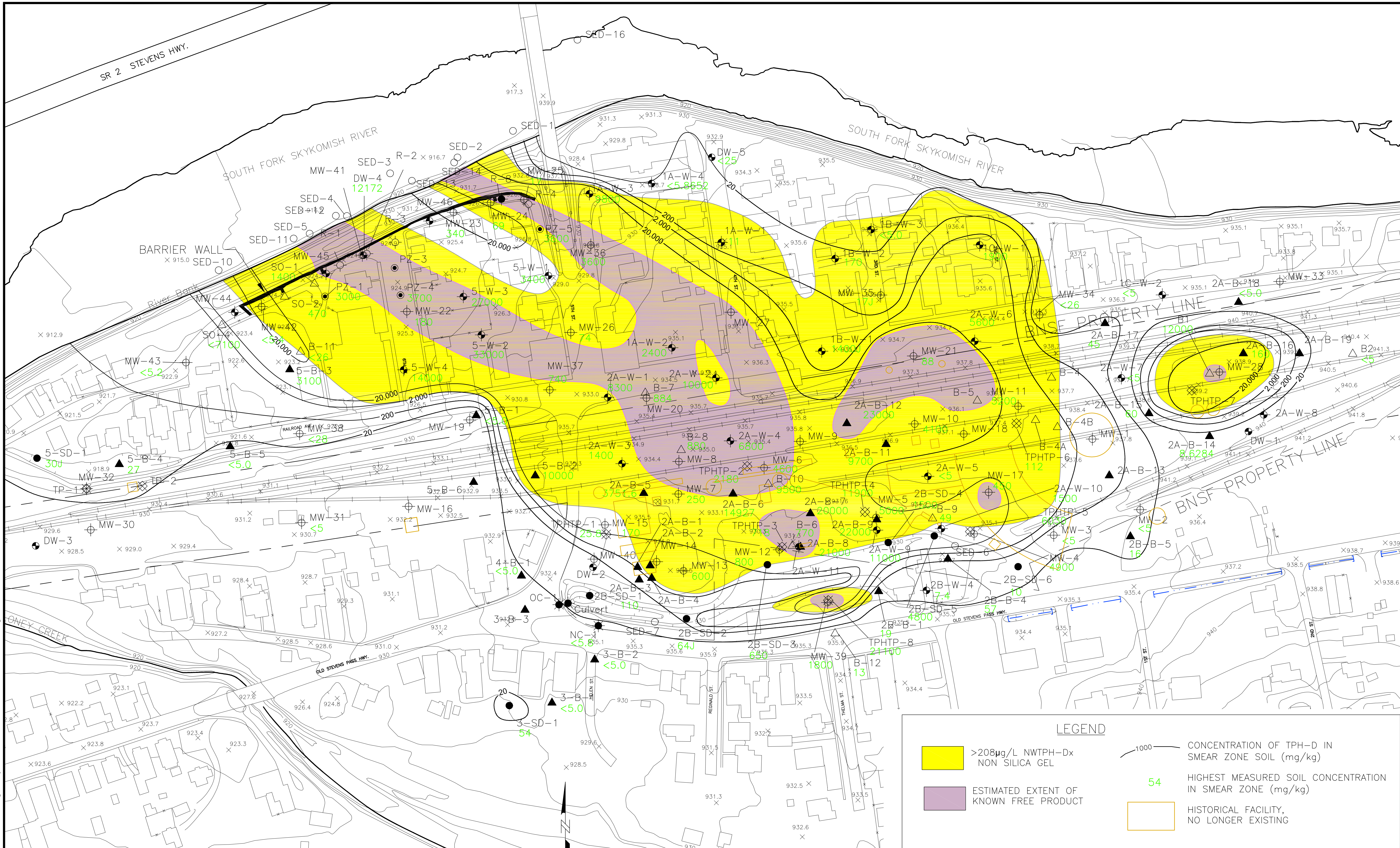

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RETEC

BNSF RAILWAY - SKYKOMISH, WA.
FEASIBILITY STUDY
BN050-16423-253

DATE: 02/18/05 DRWN: A.S./SEA

EXTENT OF TPH THROUGHOUT SITE

FIGURE 3-13