WSDOT

U. S. Department of Transportation
Federal Highway Administration

April 2018

I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6)

Attachment E: Geology, Soils, and Groundwater Discipline Report

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SUMMARY

The Washington State Department of Transportation (WSDOT) is proposing to construct the I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6) (the Project) to improve traffic operations and safety on Interstate 405 (I-405) through Bellevue. This discipline report assesses the Project's operational and construction effects on geology, soils, and groundwater, as well as No Build conditions if the Project were not constructed.

What is our study approach?

This study consisted of the following tasks:

- Review the available information on project design.
- Evaluate soils and geologic and groundwater conditions.
- Identify and assess potential effects of the Project.
- Identify and assess ways to avoid or minimize effects.

We analyzed construction and long-term operation of both the Project and No Build conditions. We also reviewed relevant regulatory criteria and WSDOT design and construction standards to determine the existing site conditions within the project limits and assess the appropriate construction/design activities to minimize effects on the environment. Where appropriate, the study area also extended outside these limits to properly assess the relevant conditions.

What are the existing conditions in the study area?

The Project is located along the west-facing slopes of the topographic trough occupied by Lake Washington. The geology within the study area is heavily influenced by glacial scour and deposition such that the soils likely to be encountered during construction would be dense to very dense, with the depth to groundwater at 25 feet or below or in a dispersed or perched condition. The area is seismically active and potentially subjected to ground motions resulting from the Cascadia subduction event or rupture along the Seattle Fault. However, due to the dense nature of the soils and the lack of near surface groundwater, there is a moderate to low liquefaction potential in the study area. Prior work in the area has shown that there are no landslide hazard areas in the study area, but we anticipate surface erosion from construction disrupting the surface soils. This can be mitigated through existing best management practices (BMPs).

What would be the Project's effects?

Anticipated short-term effects would include increased erosion, construction-related vibration, and possible excavation of soft, wet soils. The described effects are common to highway construction, but can be an annoyance to anyone living in or near the study area.

What measures would WSDOT use to avoid or minimize effects?

WSDOT has well-established construction practices for avoiding or minimizing potential adverse on geology and soils. Appropriate construction plans and procedures would be incorporated into the Project specifications. These anticipated effects would be minimized through BMPs.

Would there be any unavoidable effects?

In general, with proper construction practices, the Project should cause no unavoidable effects related to geology, soils, and groundwater.

What would happen if the Project is not built?

No effects on geology, soils, or groundwater would occur under No Build conditions other than those associated with routine maintenance and local improvements to existing transportation facilities.

SECTION 1 INTRODUCTION

This discipline report was prepared in support of the *I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6)* (the Project) *Environmental Assessment* (EA) to evaluate environmental effects related to proposed improvements on Interstate 405 (I-405).

The Project is part of a comprehensive strategy identified in the 2002 *I-405 Corridor Program Final Environmental Impact Statement* and subsequent Federal Highway Administration (FHWA) *Record of Decision* to reduce traffic congestion and improve mobility along the state's second-busiest highway. The Project is needed because travelers on I-405 face one of the most congested routes in the state, particularly during peak travel times.

What are the primary features of the Project?

The Project would widen to accommodate an additional lane both northbound and southbound. The additional lane would be coupled with the existing northbound and southbound high-occupancy vehicle (HOV) lane to create a dual express toll lane (ETL). When combined with the existing dual ETL north of NE 6th Street the Project would result in a continuous ETL system from Interstate 90 (I-90) in Bellevue to Interstate 5 (I-5) in Lynnwood.

What is the purpose of this report?

This report describes the geologic, soil, and groundwater conditions in the study area, identifies and assesses potential effects of the Project on these conditions, and identifies measures to avoid or reduce effects resulting from the Project. Common to any large highway project, the geologic, soil, and groundwater conditions in the project limits and study area would have some environmental effects during construction and operations.

Why are geology, soils, and groundwater important elements to consider?

Geology, soils, and groundwater contribute to the ground conditions in the study area. Soils and geology relate to the physical material that makes up the ground, while groundwater refers to the subsurface water contained in the soil and bedrock. These conditions are a major factor in determining the type of foundations for structures, pavement sections, subsurface drainage requirements, allowable cut/fill slopes, and retaining wall requirements. These conditions also determine the risk of landslides, liquefaction, erosion, and other types of behavior that would affect the environment. Potential effects of the Project on groundwater quantity and quality also depend on these conditions.

SECTION 2 PROJECT DESCRIPTION

What improvements are proposed with the Project?

The Project would extend along I-405 approximately 2.7 miles from just north of the I-90 interchange (milepost [MP] 11.9) to north of the NE 6th Street interchange (MP 14.6). The Project proposes the following improvements by mile posts, as shown in Exhibit 2-1, sheets 1 and 2:

- **Northbound I-405, I-90 to NE 6th Street (MP 11.9 to 13.7) –** Develop approximately 1.6 miles of new lane in the northbound direction by widening or restriping I-405 from MP 11.9 to 13.5. In this same section of I-405, convert the existing HOV lane to an ETL. The new lane coupled with the existing HOV lane would create a dual ETL. Between MP 13.5 and 13.7, convert the existing HOV lane to an ETL. The ETL would connect to the existing ETLs from downtown Bellevue to Lynnwood. Westward expansion of I-405 is proposed south of SE 8th Street, and eastward expansion is proposed north of SE 8th Street.
- **Southbound I-405, I-90 to NE 6th Street (MP 11.9 to 13.7) –** From MP 11.9 to 12.5, reconfigure the existing outside HOV lane to the inner roadway and convert both of the existing HOV lanes to ETLs. From MP 12.5 to 13.5, develop a new lane by widening or restriping. This new lane coupled with the existing HOV lane would result in a dual ETL south of NE 4th Street. Between MP 13.5 and 13.7, convert the existing HOV lane to an ETL. The ETL would connect to the existing ETLs from downtown Bellevue to Lynnwood. Where new pavement is needed, eastward expansion is proposed.
- **I-405 Eastside Rail Corridor Overpass (MP 12.4) –** Build a new northbound I-405 bridge structure adjacent to the existing I-405 structure over the Eastside Rail Corridor Regional Trail. The new structure would carry the two ETLs and the general purpose (GP) lanes would remain on the existing structure.

- **Eastside Rail Corridor Regional Trail (MP 12.09 to 12.49) –** Construct a new bridge for nonmotorized travel over southbound I-405 near MP 12.15. Build a section of nonmotorized trail to connect with the Eastside Rail Corridor Regional Trail.
- **SE 8th Street Interchange (MP 12.78) –** Widen the northbound I-405 overpass over SE 8th Street.
- **Main Street Overpass (MP 13.31) –** Reconstruct the Main Street bridge (photo on right) over I-405.
- **Northbound I-405 to SR 520 Ramp (MP 14.6) –** Widen the existing northbound off-ramp to SR 520 from two lanes to three lanes for approximately 600 feet beginning where the NE 10th Street on-ramp merges onto the I-405 ramp.
- **Stormwater –** Build new flow control and runoff treatment facilities.
- **Other Improvements –** Provide pavement markings, drainage improvements, permanent signing, illumination, intelligent transportation systems, barriers, and tolling gantries.
- **Context Sensitive Solutions –** Incorporate Context Sensitive Solutions (CSS) to enhance mobility, safety, the natural and built environment, and aesthetics throughout the project corridor.
- **Property Acquisitions –** Acquire portions of five commercial and public properties to accommodate the Project.
- **Minimization Measures –** Implement avoidance and minimization measures or compensate for unavoidable effects on the environment, as described in Chapter 6, Measures to Avoid or Minimize Effects.

Existing Main Street Overpass

What are Context Sensitive Solutions?

The *Context Sensitive Solutions (CSS)* process is a model for transportation project development that has received much discussion and broad acceptance. Its essence is that a proposed transportation project must be planned not only for its physical aspects and road serving specific transportation objectives, but also for its effects on the aesthetic, social, economic, and natural environment, as well as the needs, constraints, and opportunities in a larger community setting.

Exhibit 2-1. Project Improvements, Sheet 1 of 2

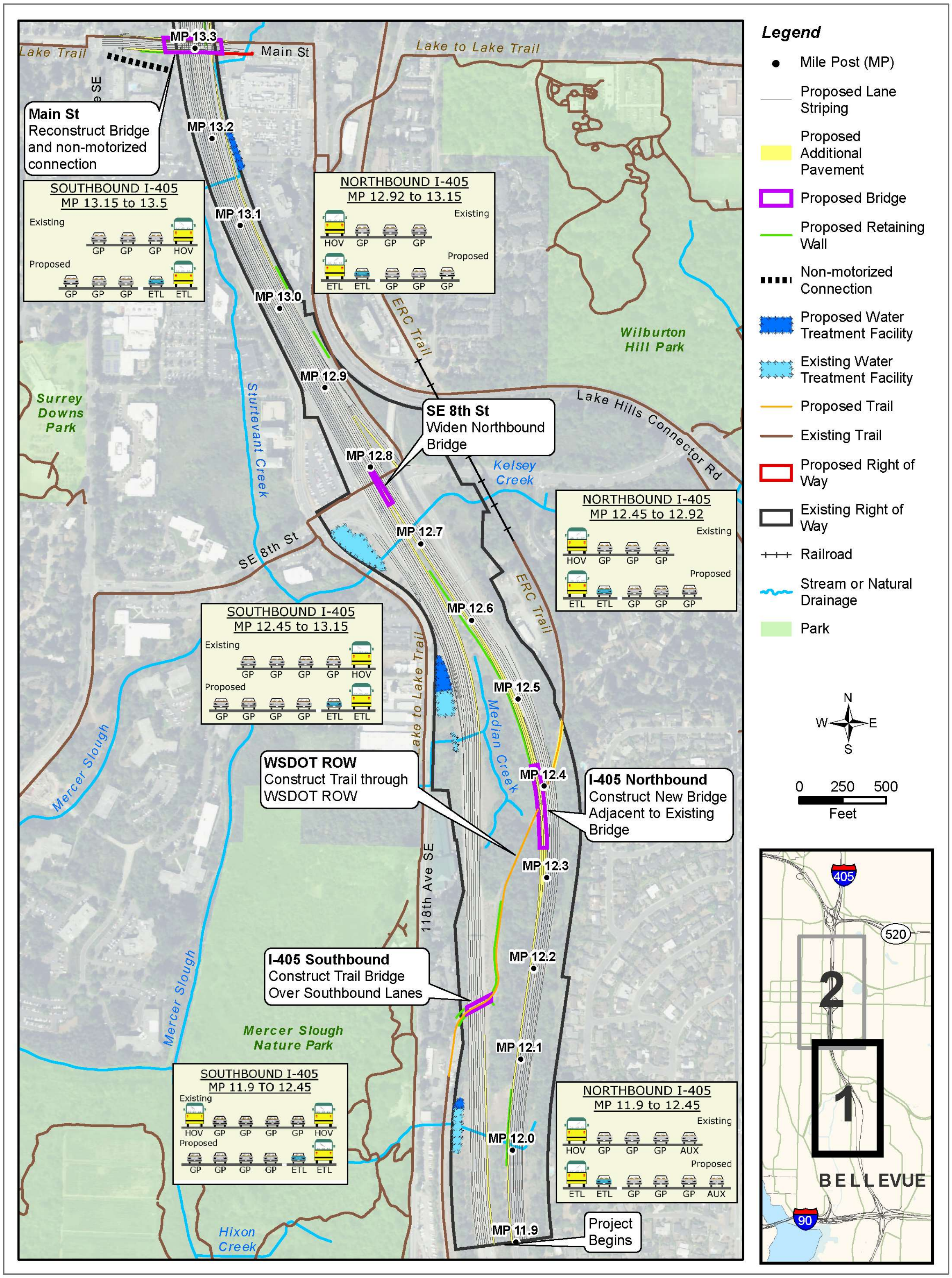
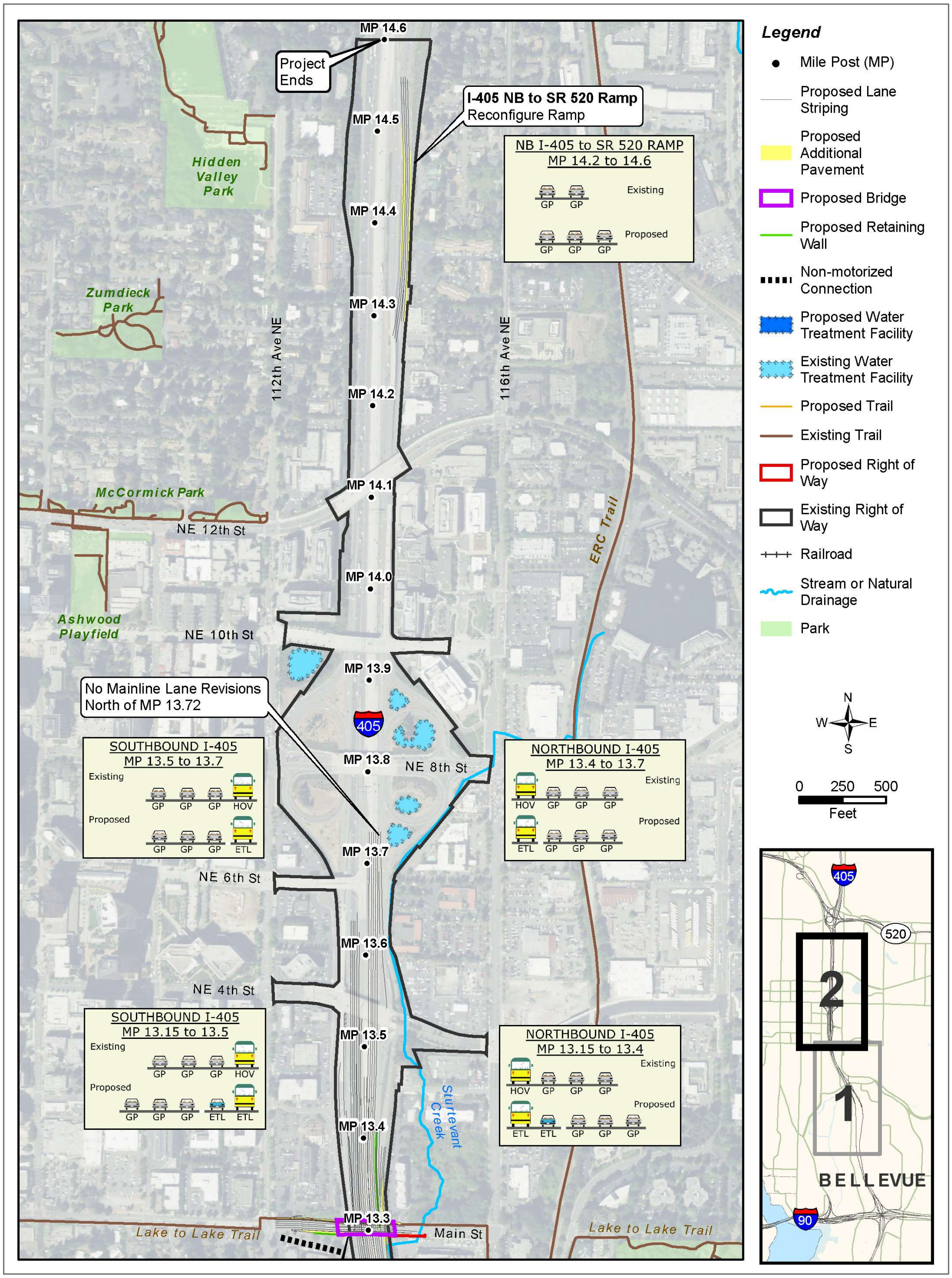


Exhibit 2-1. Project Improvements, Sheet 2 of 2



How would the express toll lanes work?

At this time, the Washington State Transportation Commission (WSTC) has not established operational hours, user exemptions, occupancy requirements, and operating parameters for ETLs proposed with the Project. WSTC would set operational requirements for the ETLs prior to opening day. For this analysis, we assumed the requirements for the current I-405, Bellevue to Lynnwood ETL system would be used for the Project. These assumptions, listed below, represent the most recent operating guidance from the WSTC for ETLs:

- **Limited Access –** The system would have designated entry and exit points, with a buffer between the ETLs and the GP lanes. These access points would vary in length, depending on the location.
- **Dynamic and Destination Pricing –** The I-405 ETL system would use both dynamic and destination pricing to determine a driver's toll at the time they enter the ETL. With *dynamic pricing*, toll rates vary based on congestion within the corridor to maintain performance. Electronic signs are used to communicate the current toll rate for drivers. Toll rates are updated every few minutes, but the driver's price is set when they enter the system. With *destination pricing*, the toll is based on the driver's destination. Toll signs show up to three toll rates for different toll zones, or destinations. Drivers pay the rate they see upon entering the ETLs to reach their destination, even if they see a different toll rate for their destination further down the road. When both pricing approaches are used together, it means the toll that drivers pay is based both on the congestion in the corridor and the distance they are traveling.
- **Operating Hours and *Good To Go!* Passes –** The ETL system is expected to operate from 5 a.m. to 7 p.m. on weekdays, with the system toll-free and open to all at other hours and on major holidays. Transit, HOVs, and motorcycles would need to have a *Good To Go!* pass to use the ETLs for free during operating hours. Eligible HOV users would be required to set the *Good To Go!* pass to the HOV mode to avoid charges. SOVs could

How does dynamic pricing work?

Electronic monitors along the roadway measure real-time information on speed, congestion, and number of vehicles in the ETLs. This information is used to determine whether tolls go up or down to optimize lane use.

As the ETLs become congested, toll rates increase, and as congestion decreases, toll rates decrease. The use of dynamic pricing allows the lanes to operate with high volumes, but avoid becoming congested.

When would tolls be charged to use the ETLs?

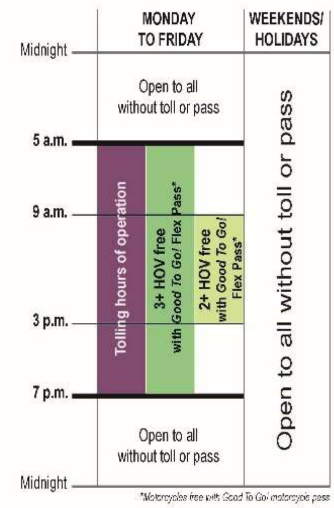
It is assumed the ETLs would operate from 5 a.m. to 7 p.m. on weekdays. At all other times and major holidays, the lanes would be free and open to all without a *Good To Go!* pass.

During operating hours:

- **SOVs** would pay a toll to use the lanes.
- **Transit, HOV 3+, and Motorcycles** would travel for free with a *Good To Go!* pass.
- **HOV 2+** would travel for free from 9 a.m. to 3 p.m. with a *Good To Go!* pass. From 5 a.m. to 9 a.m. and 3 p.m. to 7 p.m. HOV2+ would pay a toll to use the ETLs with or without a *Good To Go!* pass.
- **Large vehicles** over 10,000 pounds gross vehicle weight would not be able to use the ETLs at any time.

choose to pay a toll to use the ETLs during operating hours with or without a *Good To Go!* pass.

- **Occupancy Requirements –** During the peak periods (weekdays from 5 a.m. to 9 a.m. and 3 p.m. to 7 p.m.), transit vehicles and carpools with three or more persons (HOV 3+) would be able to use the lanes for free with a *Good To Go!* pass. From 9 a.m. to 3 p.m., the system would be open toll-free to those with two or more passengers with a *Good To Go!* pass. Motorcycles ride toll-free in the ETLs with a *Good To Go!* pass.



- **Vehicle Weight –** Vehicles over 10,000 pounds gross vehicle weight would be prohibited, which is consistent with HOV lane restrictions throughout Washington.
- **Electronic Tolling –** Payments would be made via electronic tolling with a *Good To Go!* pass. For drivers who choose not to use a *Good To Go!* Pass, WSDOT offers optional photo billing (pay by mail) for an extra fee.

How would tolling revenue be used?

Federal law and state law provide specific requirements on how toll revenues can be used. Federal law regarding the use of toll revenues is contained in 23 United States Code (USC) Section 129 (a)(3). This law states that all toll revenues received from operation of the toll facility are used for such things as debt service, a reasonable return on investment for any private financers of the Project, operations and maintenance costs, and payments associated with any public–private partnership agreements.

In addition to these federal requirements, the Revised Code of Washington (RCW) 47.56.820 requires that all revenue from an eligible toll facility must be used only to construct, improve, preserve, maintain, manage, or operate the eligible toll facility on or in which the revenue is collected. Similar to the federal law, expenditures of toll revenues must be approved by the Legislature and must be used only to cover operations and maintenance costs; to repay debt, interest and other financing costs; and to make improvements to the eligible toll facilities.

As required by state law, all toll revenue generated from the Project ETLs would be used to construct, improve, preserve, maintain, manage, or operate the I-405 corridor.

What is the Project construction schedule?

Construction of the Project is expected to last up to 5 years beginning in 2019 and ending in 2024.

SECTION 3 STUDY APPROACH

What is the study area and how was it determined?

The study area for geology, soils, and groundwater included the project limits, which extend approximately 2.7 miles from just north of the I-90 interchange just past NE 6th Street in Bellevue (i.e., from MP 11.9 to 14.6) and laterally to the area immediately adjacent to the roadway. Where appropriate, the study area also extended outside the project limits to assess the relevant conditions.

What policies or regulations are related to effects on geology, soils, and groundwater?

For this report, we reviewed the following WSDOT design standards:

- *WSDOT Standard Specifications for Road, Bridge and Municipal Construction* (2015)
- *WSDOT Geotechnical Design Manual* (2015)

How did we collect information for this report?

We obtained information for this report by reviewing the preliminary design plans for the Project, as well as relevant published geologic and groundwater information cited throughout this report.

How did we evaluate effects?

We evaluated effects by considering construction and long-term operation of both the Project and No Build conditions. In addition, we reviewed WSDOT design and construction standards to determine the existing site conditions and assess the appropriate construction/design activities to minimize effects on the environment.

SECTION 4 EXISTING CONDITIONS

What is the regional geology in the study area?

The Project is located along the west facing slopes of a glacially carved trough that is occupied by Lake Washington. Several glacial periods within the past 2 million years have dominated the recent geologic history of the Puget Sound Lowland region. The most recent glacial advance to affect the central Puget Sound Lowland was the Vashon stade of the Fraser glaciation, which occurred approximately 20,000 years to 12,000 years ago. This glacial advance is responsible for most of the present-day geologic and topographic conditions in the study area.

The Puget lobe of the Cordilleran ice sheet advanced southward from British Columbia and deposited a heterogeneous assemblage of proglacial lacustrine deposits, advance outwash, lodgement till, and recessional outwash on top of older pre-Vashon glacial and nonglacial deposits and Tertiary-age (between 66 million to 2.6 million years ago) bedrock. As the glacier retreated northward, it uncovered a sculpted landscape of elongated uplands and intervening troughs or valleys, such as the Lake Washington and Lake Sammamish troughs. Post-glacial deposition has included alluvium along modern drainages; modern lacustrine deposits, including local accumulations of organic silts and peat; and landslide deposits. The study area is located primarily within dense to very dense glacial deposits.

What is alluvium?

Alluvium is loose, unconsolidated soil or sediments that has been eroded, reshaped by water in some form, and redeposited in a non-marine setting.

What are lacustrine deposits?

Lacustrine deposits are sedimentary rock formations that formed in the bottom of ancient lakes.

What are the subsurface conditions and soil units in the study area?

Exhibit 4–1 illustrates the particular geologic units within and adjacent to the study area. The general characteristics of these units are described as follows:

- Alluvium (Qa) – Alluvium deposits encompass a wide range of compositions, from soft organic rich clayey silt to very stiff sandy silt to loose to dense sand and gravel.
- Pleistocene Continental Glacial Drift (Qgd) – This unit is glaciofluvial sediment deposited during the advance of the Vashon stade glacier and subsequently

overridden by the glacial ice. It typically consists of dense to very dense silty sand to sandy gravel and may be interbedded with laminated clayey silt and silt.

Given these soil conditions in the study area, we do not anticipate encountering soft ground that could present settlement or subgrade stability problems.

What are the groundwater conditions in the study area?

Groundwater conditions in the study area can have effects on structural stability, settlement, dewatering subdrainage requirements, and earthworks in general. Groundwater levels are anticipated to be approximately 25 feet below the ground surface at the southern project limit (e.g., MP 11.9) and increase in depth to the northern project limit (e.g., MP 14.6). As the groundwater increases in depth, discontinuous perched aquifers can be expected and are likely to exhibit seasonal fluctuations.

To comply with design standards for each type of project structure (e.g., bridge and retaining wall) WSDOT would perform site-specific explorations, which would determine groundwater elevation at each of the structure locations. Project designers would consider this information when determining how each individual element would perform during seismic events.

The tectonic and seismic conditions of the Puget Lowland region are strongly influenced by convergent plate interaction along the Cascadia subduction zone, between the Juan de Fuca oceanic plate to the west and the North American crustal plate to the east (Hyndman et al. 2003; Stanley et al. 1999; Weaver and Shedlock 1996; Rogers et al. 1991; McCrumb et al. 1989). The Juan de Fuca plate is converging to the northeast with the North American plate. Consequently, the Juan de Fuca plate is being subducted under the North American plate along the Cascadia subduction zone (Rogers et al. 1991).

Exhibit 4-1. Geologic Units, Sheet 1 of 2

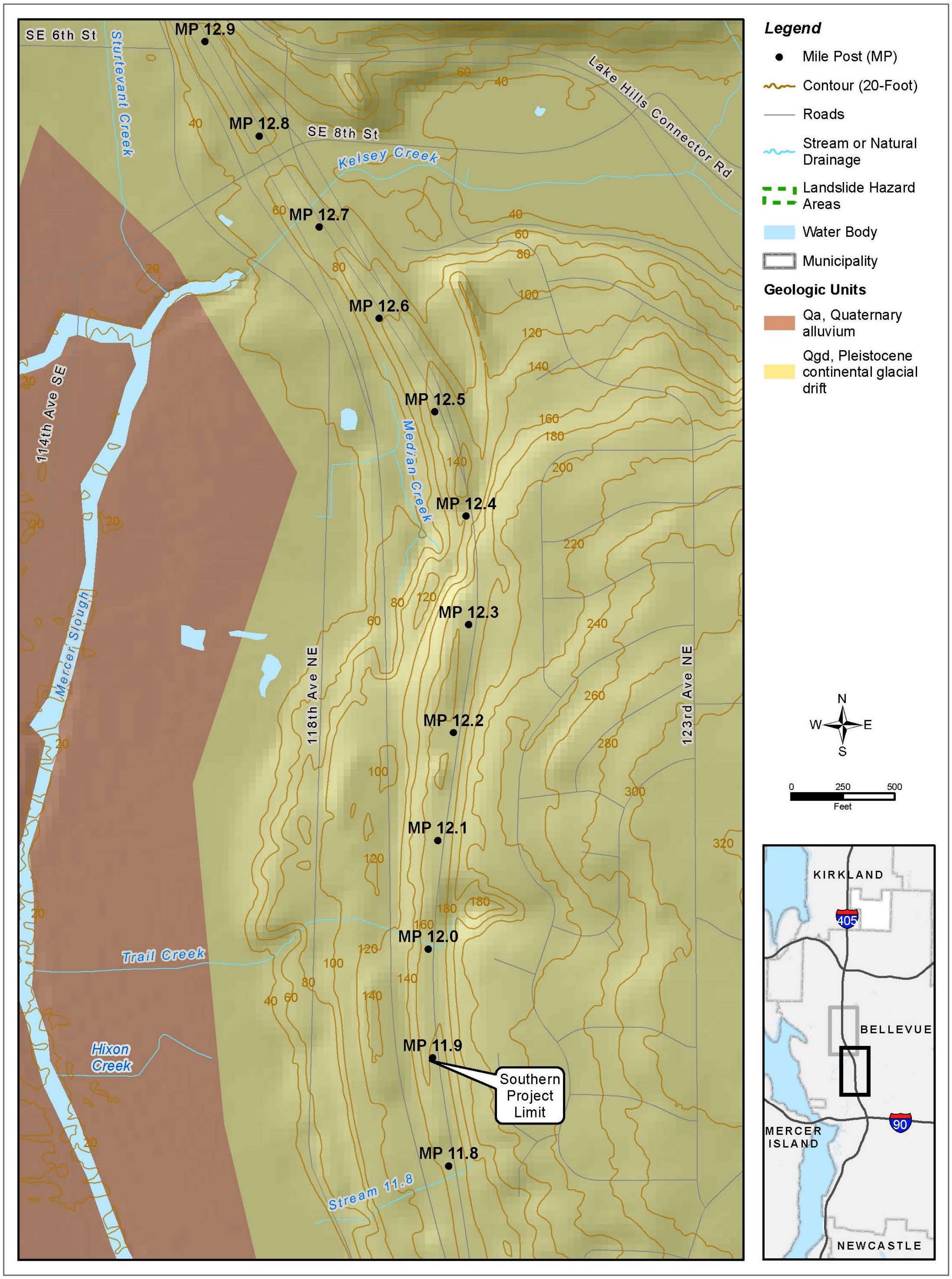
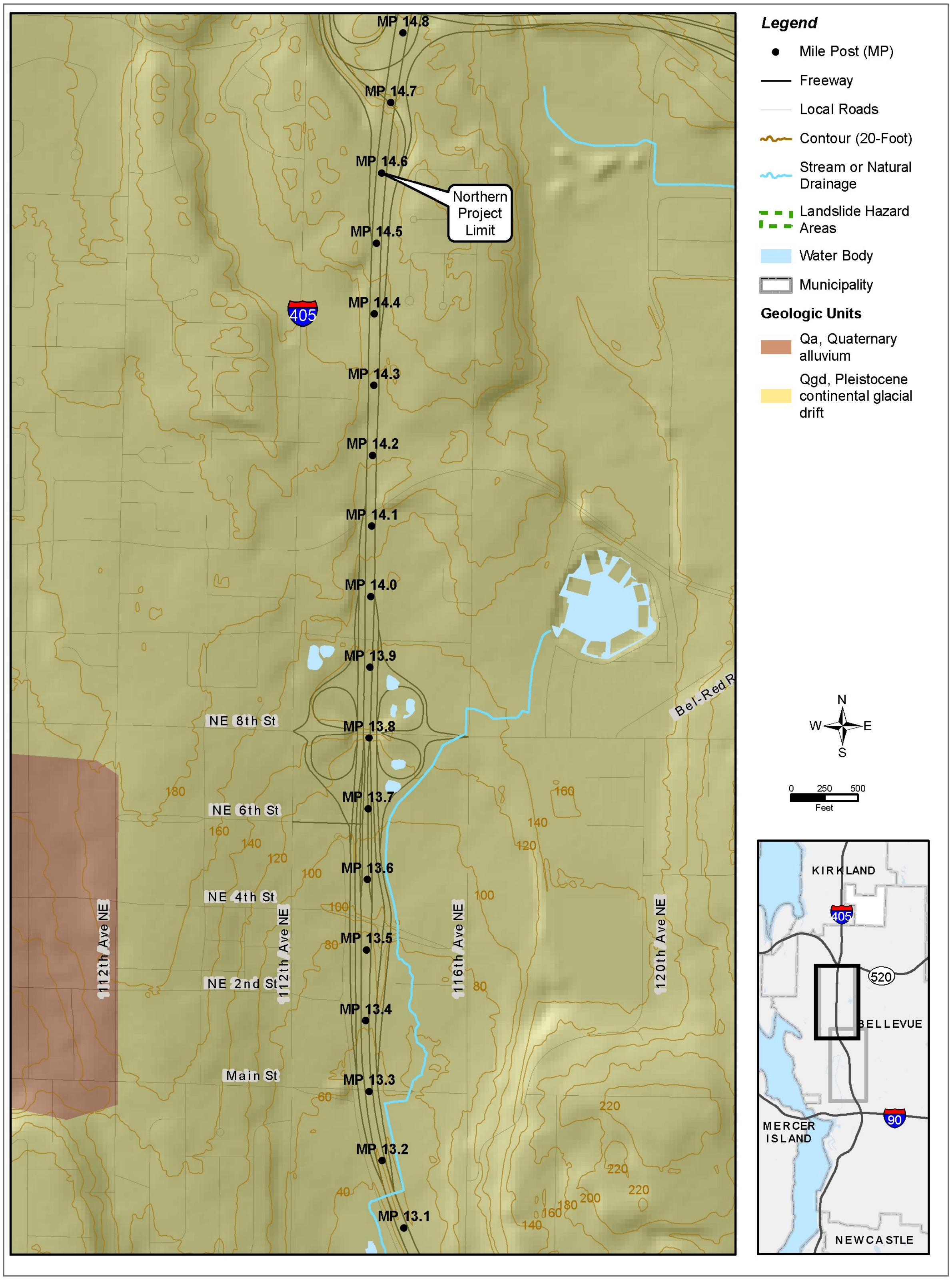


Exhibit 4-1. Geologic Units, Sheet 2 of 2



The Seattle Fault zone is the closest active crustal fault to the study area. The Seattle Fault zone is a broad 2.5 to 4 miles wide, multitrace, east-west-striking reverse-slip fault zone that extends more than 43 miles across central Puget Sound (Calvert et al. 2003; Nelson et al. 2003; Ten Brink et al. 2002; Johnson et al. 1999). Along the I-405 corridor, the southernmost mapped trace of the Seattle Fault zone crosses the corridor north of Exit 7 (NE 44th interchange), and the northernmost trace crosses the corridor near I-90 (Karlin et al. 2004; Blakely et al. 2002; Shannon and Wilson 2001; CH2M Hill 2001). Exhibit 4-2 shows the inferred location of the Seattle Fault zone.

The American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge specifications would govern the seismic design criteria for the Project. These specifications are based on a hazard level of 5 percent probability of exceedances in 50 years and an approximately 1,000-year return.

Liquefaction can ensue during a seismic event and may occur in areas of loose saturated soils. Exhibit 4-3 identifies the liquefaction potential in the study area. With the anticipated groundwater levels and ground conditions described previously, liquefaction potential in the study area ranges from moderate to very low. Based on the site-specific explorations, we would conduct a liquefaction susceptibility analysis and develop and implement hazard mitigation measures in accordance with WSDOT design guidance.

Exhibit 4-2. Seattle Fault Zone

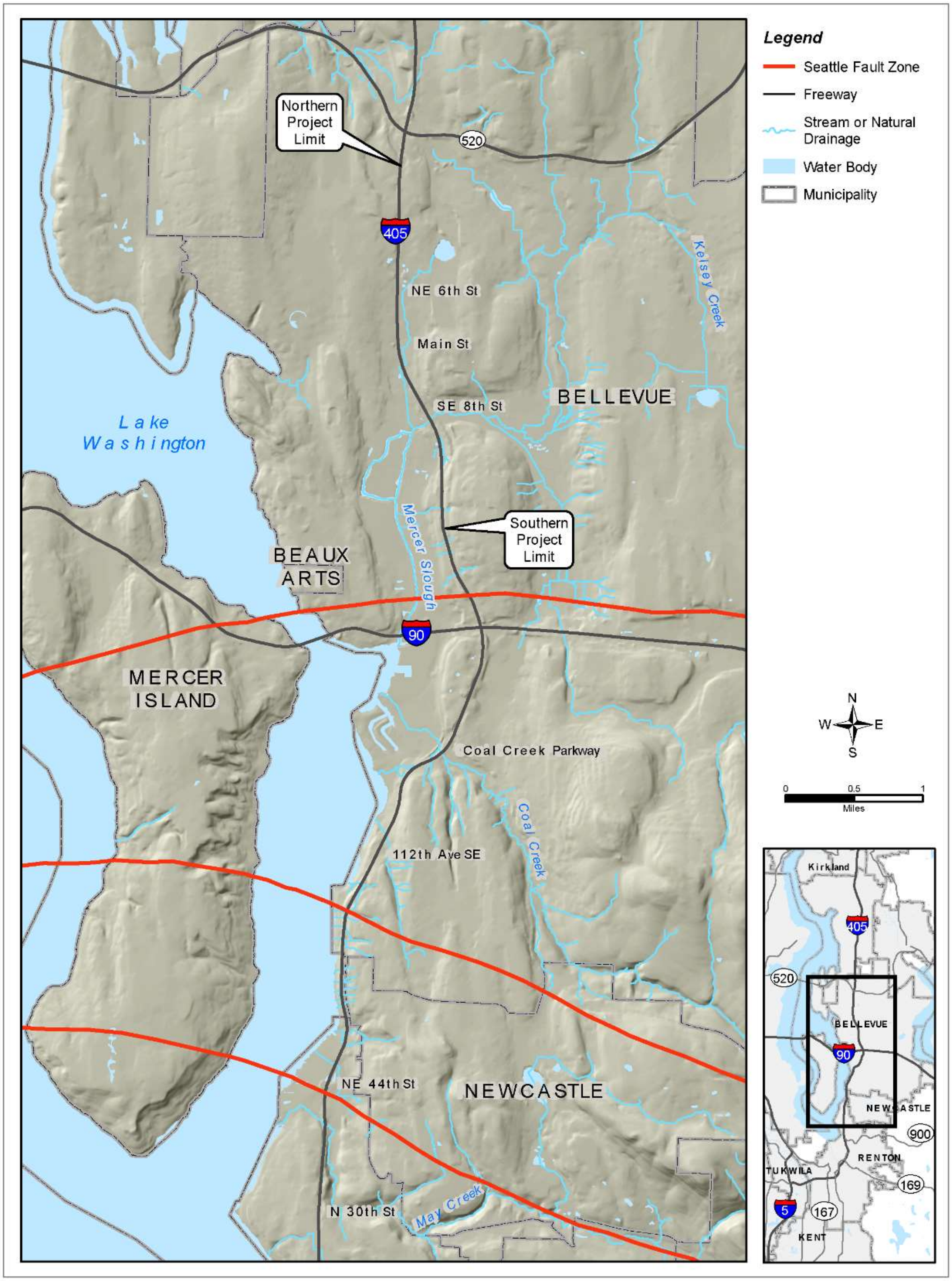
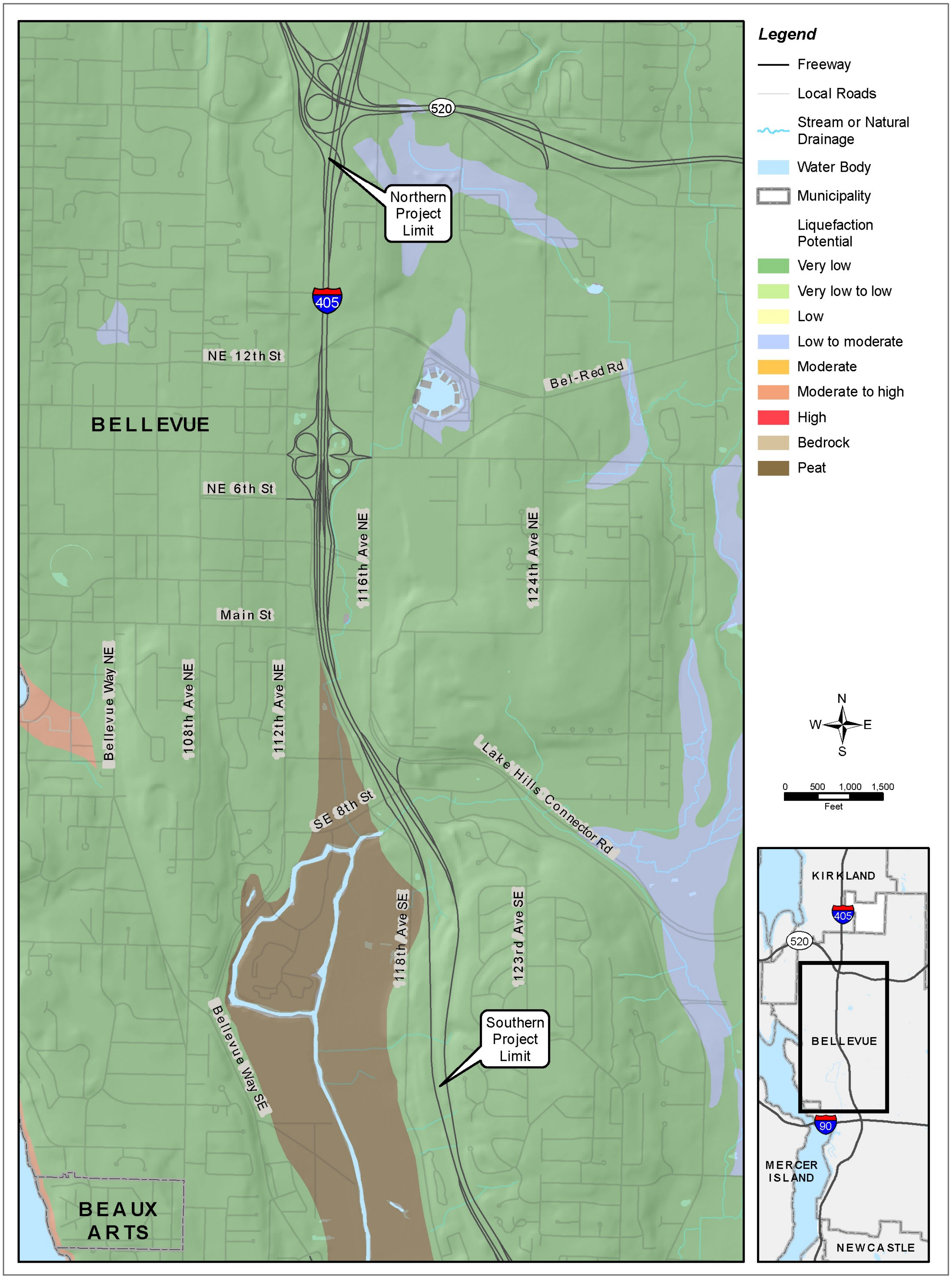


Exhibit 4-3. Liquefaction Potential



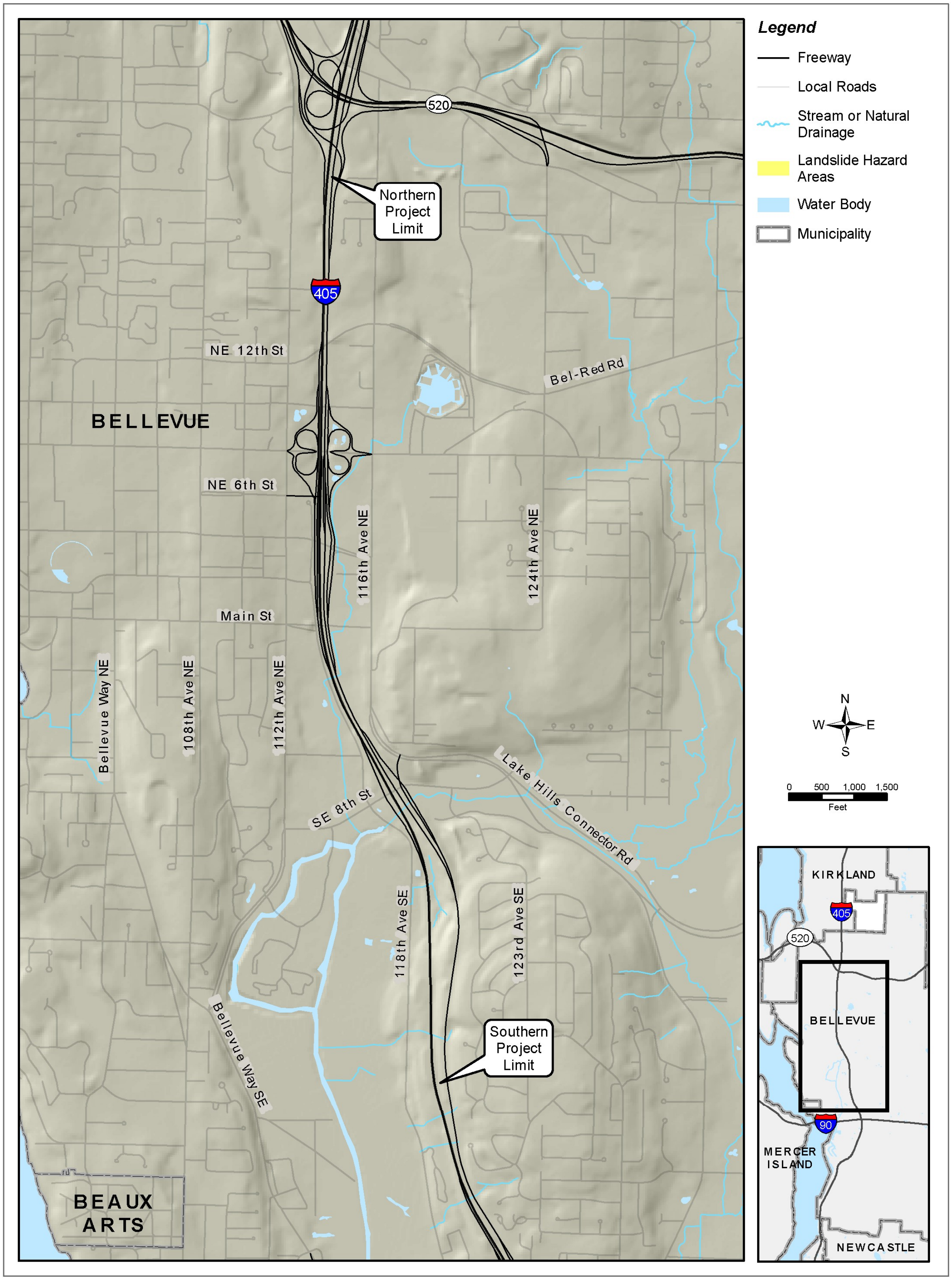
What are the landslide conditions in the study area?

Exhibit 4-4 identifies the landslide hazards in the study area. Landslide hazard areas are defined by King County as areas with a combination of slopes steeper than 15 percent; impermeable soils, such as silt and clay frequently interbedded with granular soils such as sand and gravel, and springs or groundwater seepage. Also included in the landslide hazard classification are areas that have shown movement during the Holocene era (the last 10,000 years) or that are underlain by mass wastage debris from the Holocene, or areas potentially unstable as a result of rapid incision, streambank erosion, or undercutting by wave action. We do not anticipate encountering any landslide hazard areas in the study area.

What is the erosion potential in the study area?

Most of the soils in and adjacent to the study area have been extensively modified by earlier construction activities. These soils may be disturbed again during construction activities, such as clearing brush and setting up work sites, and as such, the erosion potential could increase during project construction. In addition, runoff from the construction area may increase the rate of surface erosion that could damage slopes and result in silt laden runoff, which could degrade water quality.

Exhibit 4-4. Landslide Hazard Areas



SECTION 5 PROJECT EFFECTS

How would the Project affect geology, soils, and groundwater?

WSDOT has well-established design and construction practices for managing the types of soil, geologic, and groundwater conditions anticipated in the study area. The project team would complete an in-depth geotechnical site investigation (i.e., the combined efforts of WSDOT and the Design-Builder) to identify the subsurface conditions in adequate detail for final design and construction. With implementation of normal WSDOT practices and activities to avoid effects on the environment, there would be minimal adverse effects associated with geology, soils, and groundwater from the Project.

Highway design and construction through the type of soil and geologic conditions anticipated in the study area have been established based on extensive experience in completing similar projects in the study area. WSDOT is aware of the issues and would avoid or minimize potential effects through proper design, construction, and operation procedures.

What would be the Project effects during construction?

Erosion

Implementation of a temporary erosion and sedimentation control (TESC) plan would substantially reduce the volume of erosion and the potential for discharge of silt-laden runoff to nearby bodies of water. A TESC plan is typically oriented to a specific major storm event, such as the 2-year, 24-hour, or the 10-year, 24-hour storm event. A larger storm event could cause some silt to escape and be transported outside of the study area, thus, temporarily affecting nearby bodies of water. We expect these effects to be minor and of short duration.

Stormwater generated during construction is commonly turbid, with suspended solids in the runoff from disturbed and exposed soil surfaces. Stormwater containing elevated levels of turbidity and suspended solids generally do not affect groundwater quality because surface soils in which the stormwater must infiltrate to reach the aquifer usually filters and adequately removes turbidity.

Earthworks

Common to most large highway projects, project construction would involve substantial earthwork, including major cuts and fills. There would be areas where the excavated soils are unsuitable for reuse as fill, particularly during wet weather. We anticipate that both off-site disposal of unsuitable soils and importing of fill would be required in the study area. This would result in truck traffic and associated effects, including traffic operation, noise, dust, mud, and damage to roadways. General on-site earthwork activities would result in noise, vibration, and other relatively minor and short-term effects related to heavy construction equipment. Dry weather construction could result in dust and air quality problems.

What would be the Project effects during operation?

Seismicity

The Seattle Fault is close to the study area. Should a rupture along the fault occur during the life of the Project, it could cause substantial damage to the roadway, utilities, and structures. The most recent large earthquake in the Seattle Fault zone was approximately 1,100 years ago. Five more major earthquakes are thought to have occurred in the Seattle Fault zone in the previous 12,000 years. Due to the long recurrence interval between major earthquakes and current WSDOT practices, the Project would not be designed to accommodate potential fault rupture because of the cost and difficulty in designing structures to avoid faults and the difficulty in locating active traces of the Seattle Fault Zone.

What would be the indirect effects of the Project on geology, soils, and groundwater?

We do not anticipate there would be indirect effects on geology, soils, or groundwater associated with the Project.

What is No Build?

No Build consists only of routine maintenance projects occurring in the study area. These projects are assumed to occur regardless of the outcome of this analysis. Therefore, these maintenance projects are referred to collectively as No Build.

What would be the No Build effects during construction and operation?

Construction and operations effects under No Build would include short-term minor construction and maintenance necessary for continued operation of the existing transportation facilities and minor arterial improvements. If necessary, their effects would be the subject of separate and independent project-specific environmental analyses, documentation, and review. There would be no construction- or operations-related effects under No Build conditions.

Were potential cumulative effects for geology, soils, and groundwater considered?

WSDOT's evaluation of cumulative effects is presented in the *I-405, Downtown Bellevue Vicinity Express Toll Lanes Project (MP 11.9 to 14.6) Environmental Assessment*.

SECTION 6 MEASURES TO AVOID OR MINIMIZE EFFECTS

What measures will WSDOT take to mitigate geology, soils, and groundwater effects during project construction?

WSDOT has well-established practices for managing construction issues associated with the types of geologic, soil, and groundwater conditions anticipated in the study area. Listed below are the measures that WSDOT will implement during construction of the Project to avoid or reduce such potential effects.

Seismicity

WSDOT will design project elements to the AASHTO design standards and implement design methods that will make project elements stable and limit susceptibility to collapse under an unlikely larger event.

Liquefaction Prone Areas

Liquefaction potential in the study area is assessed as low. WSDOT will identify areas where liquefaction-prone soils may be located. For structures underlain by liquefaction-prone soils, WSDOT will evaluate the potential effects on the structure from liquefaction. If liquefaction risks are determined unacceptable, then WSDOT will use appropriate measures to reduce long-term liquefaction and lateral spreading risks. Such measures might include soil densification such as stone columns, vibratory compaction, compaction grouting, and dynamic compaction.

Soft Ground Areas

Soft-ground areas are not likely to be encountered in the study area. WSDOT will take appropriate measures to assess and reduce potential settlement problems associated with existing utilities or structures in areas underlain by soft, compressible soil. If deemed necessary, structures could be underpinned and utilities relocated or made more flexible. In cases where settlement exceeds WSDOT tolerance and the settlement is allowed, any repairs as needed will be made after the settlement is complete. Where soft-ground areas are identified, WSDOT will conduct preconstruction surveys and monitor construction settlements.

WSDOT will assess the potential for settlement for structures and embankments underlain by soft, compressible soil. If the potential settlement is unacceptable, WSDOT will design the structures and embankments to accommodate or avoid the settlement, such as deep foundations for structures or surcharge fills for embankments.

WSDOT will develop the means and methods to avoid or minimize settlement resulting from construction vibration in areas underlain by soft or loose soils.

Slope Stability and Landslide Areas

WSDOT will develop appropriate construction procedures to maintain or enhance slope stability in areas underlain by landslides or with landslide-prone geology. The design through these areas will include suitable wall types, such as soldier piles with tiebacks, possibly supplemented with enhanced drainage, such as improved surface drainage or horizontal drains. This analysis has not identified any landslide hazard areas in the study area.

WSDOT will drain suspected or observed seepage to reduce the risk of landslide and surface sloughing by using gravel drainage blankets, French drains, horizontal drains, placement of a surface rock facing, or other methods.

Dewatering

WSDOT will use properly designed, installed, and operated dewatering systems because dewatering for utility trenches can induce ground settlement in areas of soft compressible soils. This might include sheet pile cut-off shoring, recharge wells, a settlement and groundwater level monitoring system, and other procedures. Complete elimination of settlement in proximity to excavations can be difficult, particularly if loose granular soils are densified by installing sheet piles.

WSDOT will control dewatering discharge to avoid adverse effects. If dewatering occurs in contaminated ground, discharge into storm drains or adjacent surface drainages could affect water quality. This condition is normally mitigated by disposing the discharge in a sanitary sewer or performing on-site treatment.

Erosion

WSDOT will prepare and implement a TESC plan to minimize erosion and protect water quality.

WSDOT will take additional action to minimize erosion, maintain water quality, and achieve the intended environmental performance, should any BMP or other operation not function as intended.

Earthworks

WSDOT will control dust by using a water truck or other dust-control measures (see the Air Quality Discipline Report). WSDOT will also control soil tracked onto nearby surface streets from truck tires. WSDOT will place and maintain stockpiles properly to avoid erosion or slope stability problems. Proper traffic control and construction-management procedures will be implemented to reduce truck-related construction effects. Erosion control of stockpiles will be included in the TESC plan.

Groundwater Quantity

WSDOT will avoid drawdown of nearby wells during construction. These effects can be avoided by using recharge wells and/or cut-off walls, if necessary. WSDOT will implement good construction management, safety precautions, and safety enforcements to avoid construction-related traffic accidents, which could damage and disrupt these wells.

WSDOT will locate areas where permanent drainage will be required by site conditions for cut slopes. If local private groundwater users or downgradient wetlands and spring water rights holders could become affected by drawdown of the groundwater table from these drain systems, these effects will be avoided on a site-specific basis by designing the permanent drainage system to recharge or replenish the downgradient water table.

What measures will WSDOT take to mitigate geology, soils, and groundwater effects from project operation?

WSDOT has well-established design, operational, and maintenance practices for managing long-term operation issues associated with the types of geologic, soil, and groundwater conditions anticipated in the study area. This section describes the measures that WSDOT will implement during project operation to avoid potential effects.

Seismicity

WSDOT has procedures in place to inspect critical highway elements following a major seismic event. These procedures will be implemented for the Project as necessary.

Soft Ground

WSDOT will conduct long-term monitoring of embankments or walls constructed on soft ground to ensure that they do not experience unacceptable settlement.

Slope Stability and Landslides

WSDOT will conduct long-term maintenance of surface and subsurface drainage in areas of landslide risk. If installed, horizontal drains will be periodically inspected and maintained because these types of drains tend to clog over time. If identified as a need during the design geotechnical investigation, long-term monitoring of slopes and walls may be appropriate in selected areas.

SECTION 7 UNAVOIDABLE EFFECTS

Would the Project have any effects that could not be avoided?

With proper construction practices, there should be no unavoidable effects related to geology, soils, and groundwater other than those common to any large highway project. These normal unavoidable effects related to earthwork, wall, and foundation installation include construction noise, erosion, vibration, construction traffic, and dust. Implementing BMPs can minimize but not completely eliminate these effects.

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APPENDIX A ACRONYMS AND ABBREVIATIONS

Term	Meaning
AASHTO	American Association of State Highway and Transportation Officials
BMPs	best management practices
CSS	Context Sensitive Solutions
EA	Environmental Assessment
ETL	express toll lane
FHWA	Federal Highway Administration
GP	general purpose
HOV	high-occupancy vehicle
I-405	Interstate 405
I-5	Interstate 5
I-90	Interstate 90
LRFD	Load and Resistance Factor Design
MP	milepost
Qa	Alluvium
Qgd	Pleistocene Continental Glacial Drift
RCW	Revised Code of Washington
TESC	temporary erosion and sedimentation control
USC	United States Code
WSDOT	Washington State Department of Transportation
WSTC	Washington State Transportation Commission

APPENDIX B GLOSSARY

Term	Meaning
Advance and recessional outwash	Sand and gravel deposited by an active glacier as it advances or retreats.
Alluvium	Alluvium is loose, unconsolidated soil or sediments that has been eroded, reshaped by water in some form, and redeposited in a non-marine setting.
Express toll lane	A limited-access freeway lane that is actively managed through a variable toll system to regulate its use and thereby maintain express travel speeds and reliability. Toll prices rise or fall in real time as the lane approaches capacity or becomes less used. This ensures that traffic in the express toll lane remains flowing at express travel speeds of 45 to 60 miles per hour. Transit and carpools do not pay a toll.
Glacial scour	Concentrated erosive action
Glaciofluvial	Deposits derived from stream flows from a glacier
Lacustrine deposits	Lacustrine deposits are sedimentary rock formations that formed in the bottom of ancient lakes.
Liquefaction	Phenomenon whereby a saturated soil loses its strength or stiffness
Lodgement till	A till characterized by particles oriented parallel to the movement of glacial ice.