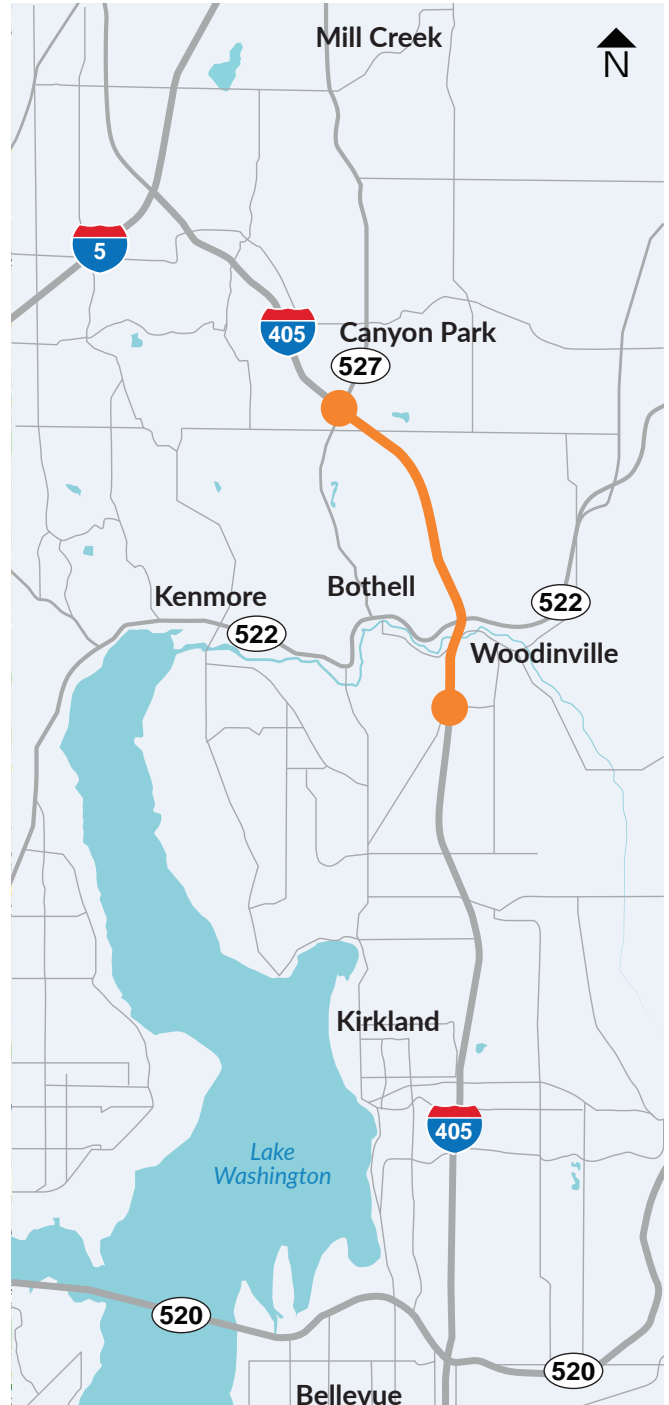


ENVIRONMENTAL ASSESSMENT

Appendix K: Geology, Soils, and Groundwater Technical Memorandum I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project (MP 21.79 to 27.06)



Title VI Notice to Public

It is the Washington State Department of Transportation's (WSDOT) policy to assure that no person shall, on the grounds of race, color, national origin or sex, as provided by Title VI of the Civil Rights Act of 1964, be excluded from participation in, be denied the benefits of, or be otherwise discriminated against under any of its federally funded programs and activities. Any person who believes his/her Title VI protection has been violated, may file a complaint with WSDOT's Office of Equal Opportunity (OEO). For additional information regarding Title VI complaint procedures and/or information regarding our non-discrimination obligations, please contact OEO's Title VI Coordinator at (360) 705-7090.

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This material can be made available in an alternate format by emailing the Office of Equal Opportunity at wsdotada@wsdot.wa.gov or by calling toll free, 855-362-4ADA (4232). Persons who are deaf or hard of hearing may make a request by calling the Washington State Relay at 711.

Notificación de Título VI al Público

Es la política del Departamento de Transporte del Estado de Washington el asegurarse que ninguna persona, por razones de raza, color, nación de origen o sexo, como es provisto en el Título VI del Acto de Derechos Civiles de 1964, ser excluido de la participación en, ser negado los beneficios de, o ser discriminado de otra manera bajo cualquiera de sus programas y actividades financiado con fondos federales. Cualquier persona quien crea que su protección bajo el Título VI ha sido violada, puede presentar una queja con la Comisión Estadounidense Igualdad de Oportunidades en el Empleo. Para obtener información adicional sobre los procedimientos de queja bajo el Título VI y/o información sobre nuestras obligaciones antidiscriminatorias, pueden contactar al coordinador del Título VI en la Comisión Estadounidense de Igualdad de Oportunidades en el Empleo 360-705-7090.

Información del Acta Americans with Disabilities Act (ADA)

Este material es disponible en un formato alternativo enviando un email/correo electrónico a la Comisión Estadounidense de Igualdad de Oportunidades en el Empleo wsdotada@wsdot.wa.gov o llamando gratis al 855-362-4ADA (4232). Personas sordas o con discapacidad auditiva pueden solicitar llamando Washington State Relay al 711.

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SECTION 1 SUMMARY

The *Geology, Soils, and Groundwater Technical Memorandum* was prepared in support of the I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project (Project) Environmental Assessment (EA). This report evaluates the environmental effects of proposed improvements on Interstate 405 (I-405) from milepost (MP) 21.79 to MP 27.06 in support of the EA.

1.1 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.

1.2 Study Approach

To evaluate the Project's effects on geology, soils, and groundwater during construction and operation, this study consisted of the following main tasks:

- Reviewing the available information on Project design.
- Evaluating soils and geologic conditions.
- Identifying and assessing potential effects of the Project.
- Identifying and assessing ways to avoid or minimize effects.

The Washington State Department of Transportation (WSDOT) reviewed relevant regulatory criteria and WSDOT design and construction standards to determine the existing conditions in the study area and assess the appropriate design and construction activities to minimize effects on the environment. The study area for the geology, soils, and groundwater analysis includes the Project limits and laterally to the area immediately adjacent to the roadway. Where appropriate, the study area also extended outside these limits to properly assess the relevant conditions.

1.3 Existing Conditions Overview

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. The soils that would be encountered during construction are anticipated to vary from very soft to dense and very dense. Groundwater levels are variable, ranging from at or near the surface to depths of 75 feet or below the ground surface. Perched groundwater conditions can also be expected in the study area.

The study area is seismically active and potentially subjected to ground motions resulting from the Cascadia subduction event or rupture along the Seattle and Whidbey Island faults. There is a low to moderately high potential for liquefaction in the study area. Prior work in the area has shown that there are several landslide hazard areas within the study area. Surface erosion resulting from surface soil disruption by construction activities should be anticipated. These risks can be mitigated through existing best management practices.

1.4 *Project Effects Overview*

1.4.1 No Build Alternative

If the Project is not built, no effects on geology, soils, or groundwater in the study area would occur other than those associated with routine maintenance and local improvements to existing transportation facilities.

1.4.2 Build Alternative

With proper construction practices, there would be minimal effects related to geology, soils, and groundwater with the Build Alternative. Anticipated short-term effects of the Project would include increased erosion, construction-related vibration, slope instability, and possible excavation of soft, wet soils.

SECTION 2 PROJECT DESCRIPTION

2.1 Proposed Project Elements

The Project begins on I-405 south of the I-405/SR 522 interchange at milepost (MP) 21.79 and continues to just north of the I-405/SR 527 interchange to MP 27.06. Exhibit 2-1 lists improvements proposed with the Project. Exhibit 2-2, Sheets 1 through 5, show the locations of the proposed improvements.

Exhibit 2-1. Improvements Proposed with the I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project

Project Element	I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project
I-405 lanes and shoulders from SR 522 to SR 527	<ul style="list-style-type: none"> – Create a dual ETL system from MP 21.79 (south of the I-405/SR 522 interchange) to MP 27.06 (just north of the I-405/SR 527 interchange). <ul style="list-style-type: none"> • From MP 21.79 to MP 22.30: Restripe existing lanes to create a dual ETL system. • From MP 22.30 to MP 26.30: Resurface and widen I-405 to add one ETL in each direction. • From MP 26.30 to MP 27.06: Widen I-405 to construct direct access ramps and connect to the existing single ETL starting near MP 26.30.
I-405 tolling from SR 522 to SR 527	<ul style="list-style-type: none"> – Construct new tolling gantries to collect tolls for the ETLs and direct access ramps.
I-405/SR 522 interchange area	<ul style="list-style-type: none"> – Construct new direct access ramps and two inline transit stations in the I-405 median (one in each direction). Transit stations would include station platforms, signage, artwork, lighting, fare machines, and site furnishing such as shelters, lean rails, benches, bollards, bicycle parking, and trash receptacles. – Construct a bus station and turnaround loop, pick-up and drop-off facilities, and new nonmotorized connection to the North Creek Trail near the SR 522 interchange. Funding and construction timeline to be coordinated with local transit agencies. – Construct new northbound bridge through the SR 522 interchange. <ul style="list-style-type: none"> • Reconfigure the northbound I-405 to eastbound SR 522 ramp from one lane to two lanes. – Reconfigure I-405 on- and off-ramps. <ul style="list-style-type: none"> • Realign the southbound I-405 to westbound SR 522 ramp. • Realign the eastbound and westbound SR 522 ramps to northbound I-405.
SR 522 roadway	<ul style="list-style-type: none"> – Add three signalized intersections, which would change where the freeway portion of SR 522 begins and ends. Signals would be added at the following locations: <ul style="list-style-type: none"> • The northbound I-405 to westbound SR 522 off-ramp and the eastbound SR 522 to northbound I-405 on-ramp. • The southbound I-405 to eastbound SR 522 ramp. • Between the above two locations where the new I-405 ETL direct access ramps connect with SR 522.
228th Street SE	<ul style="list-style-type: none"> – Widen the northbound I-405 bridge over 228th Street SE.

I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

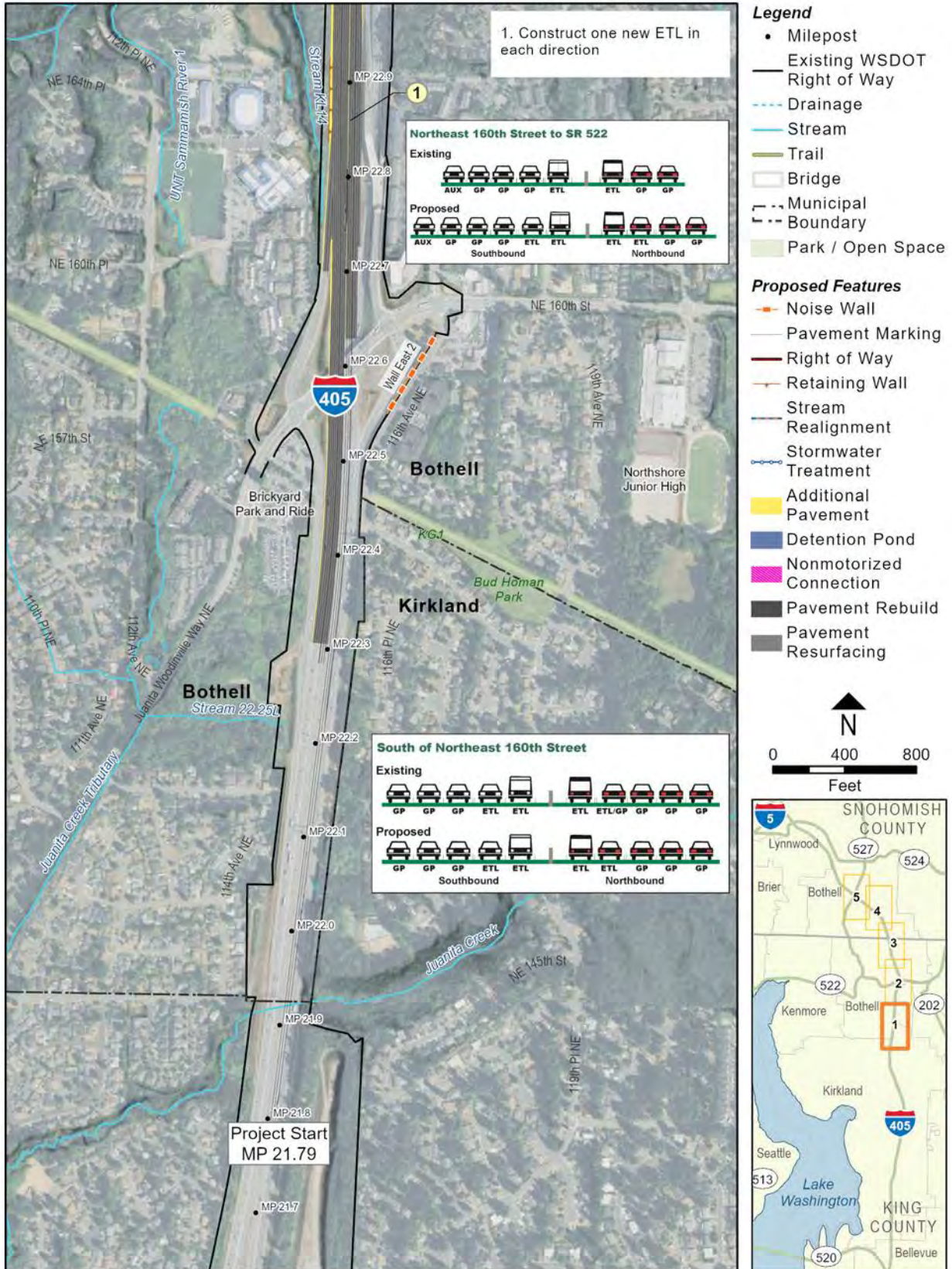
Exhibit 2-1. Improvements Proposed with the I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project

Project Element	I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project
SR 527 interchange area	<ul style="list-style-type: none"> – Construct new direct access ramps to the north, south and east just south of SR 527 at 17th Avenue SE. – Construct two inline transit stations (one in each direction) in the I-405 median. Transit stations would include station platforms, signage, artwork, lighting, fare machines, and site furnishing such as shelters, lean rails, benches, bollards, bicycle parking, and trash receptacles. – Reconstruct the pedestrian bridge over I-405.
17th Avenue SE, 220th Street SE, SR 527	<ul style="list-style-type: none"> – Reconfigure 17th Avenue SE and portions of 220th Street SE and SR 527 to include a roundabout at the Canyon Park Park and Ride, bicycle and pedestrian improvements, and improvements at the SR 527 and 17th Avenue SE intersections with 220th Street SE.
Fish barrier corrections	<ul style="list-style-type: none"> – Replace five fish barriers with restored stream connections at the following streams: <ul style="list-style-type: none"> • Par Creek (WDFWID 993083) • Stream 25.0L (WDFWID 993104) • North Fork of Perry Creek (WDFW ID 08.0070 A0.25) • Two fish barriers at Queensborough Creek (WDFWID 993084 and 993109)
Sammamish River bridges	<ul style="list-style-type: none"> – Remove the existing northbound I-405 to eastbound SR 522 bridge over the Sammamish River, including two bridge piers within the OHWM. – Remove the existing northbound I-405 to westbound SR 522 bridge over the Sammamish River, including two bridge piers within the OHWM. – Build a new bridge for northbound I-405 traffic over the Sammamish River. – Build a new bridge over the Sammamish River for the new direct access ramp at SR 522. – Build a new bridge over the Sammamish River for the northbound I-405 to SR 522 ramp.
Noise and retaining walls	<ul style="list-style-type: none"> – Construct 3 new noise walls near NE 160th Street and SR 527. See Exhibit 2-2, Sheets 1, 4 and 5. – Construct several new retaining walls. See Exhibit 2-2, Sheets 1 through 5.
Stormwater management	<ul style="list-style-type: none"> – Provide enhanced treatment for 100 percent of new PGIS (approximately 24 acres). – Retrofit about 23 acres of existing untreated PGIS and continue to treat stormwater from the approximately 44 acres of PGIS that currently receives treatment. – Construct three new stormwater outfalls, one on the Sammamish River and two on the North Fork of Perry Creek.
Construction duration	<ul style="list-style-type: none"> – Construction is expected to last three to four years, beginning in 2021.

ETL = express toll lane; ID = identification number; MP = milepost; OHWM = ordinary high water mark; PGIS = pollution-generating impervious surfaces; WDFW = Washington Department of Fish and Wildlife

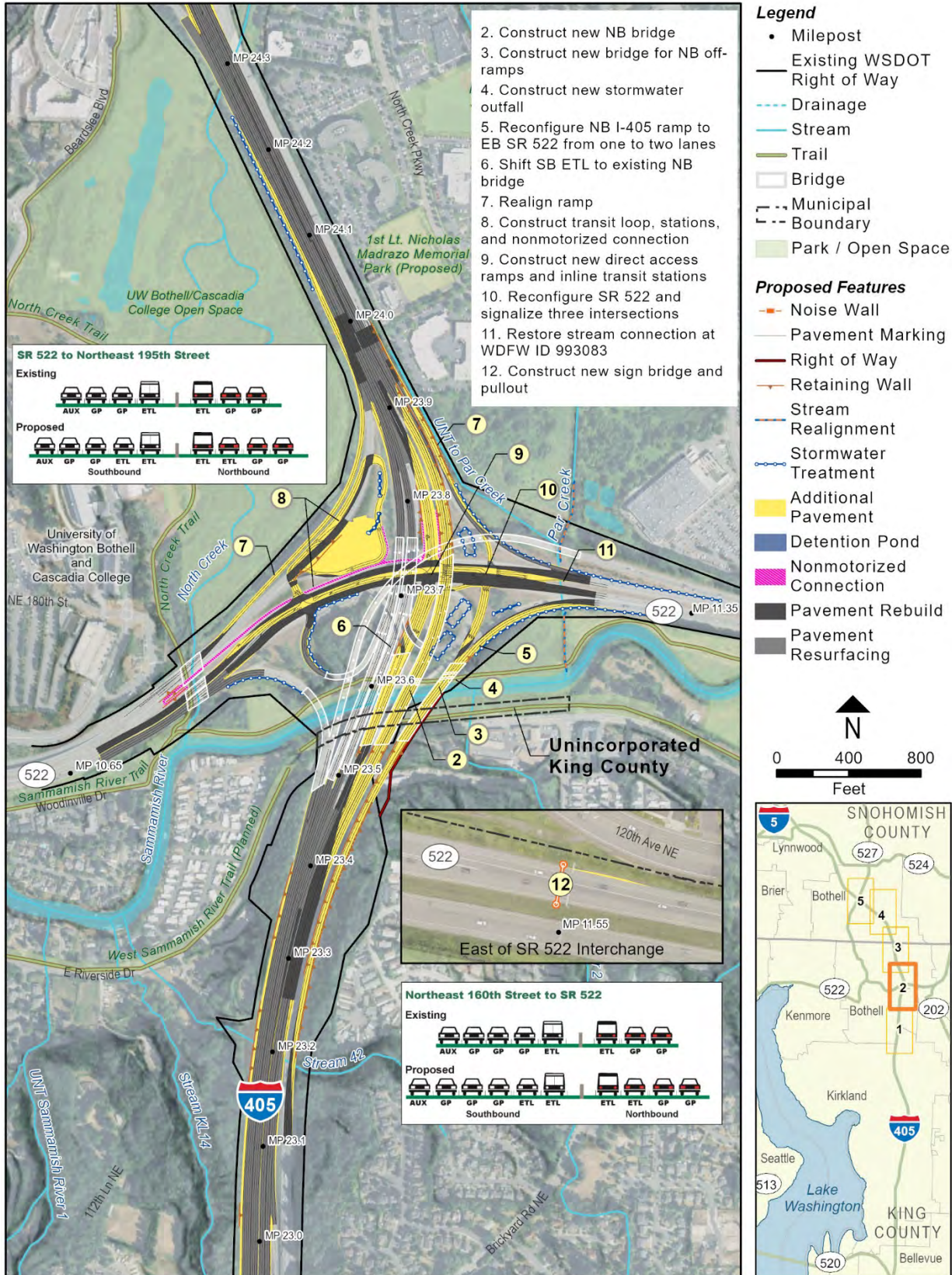
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
 GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 2-2. I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project, Sheet 1 of 5



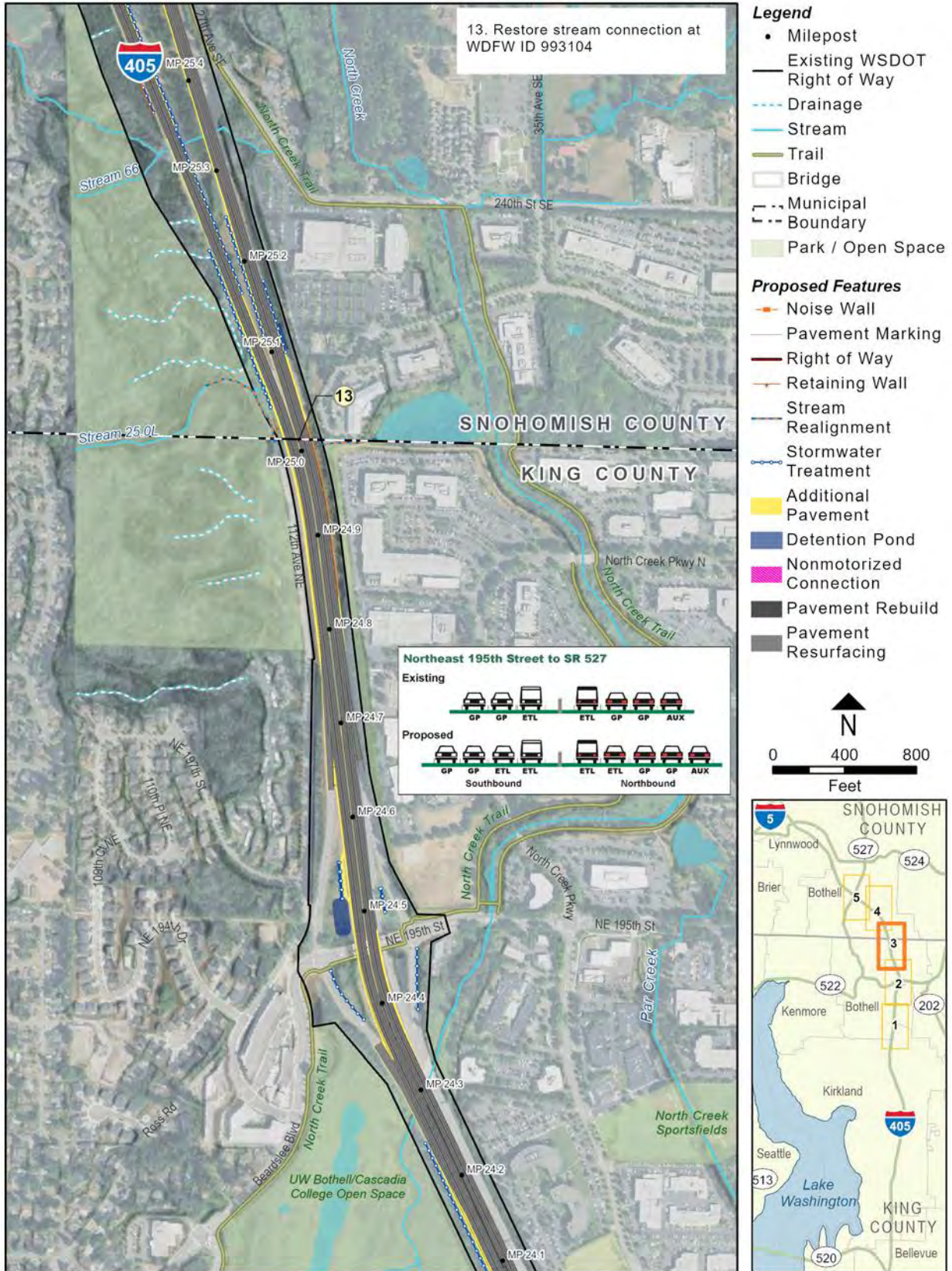
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 2-2. I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project, Sheet 2 of 5



I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
 GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 2-2. I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project, Sheet 3 of 5



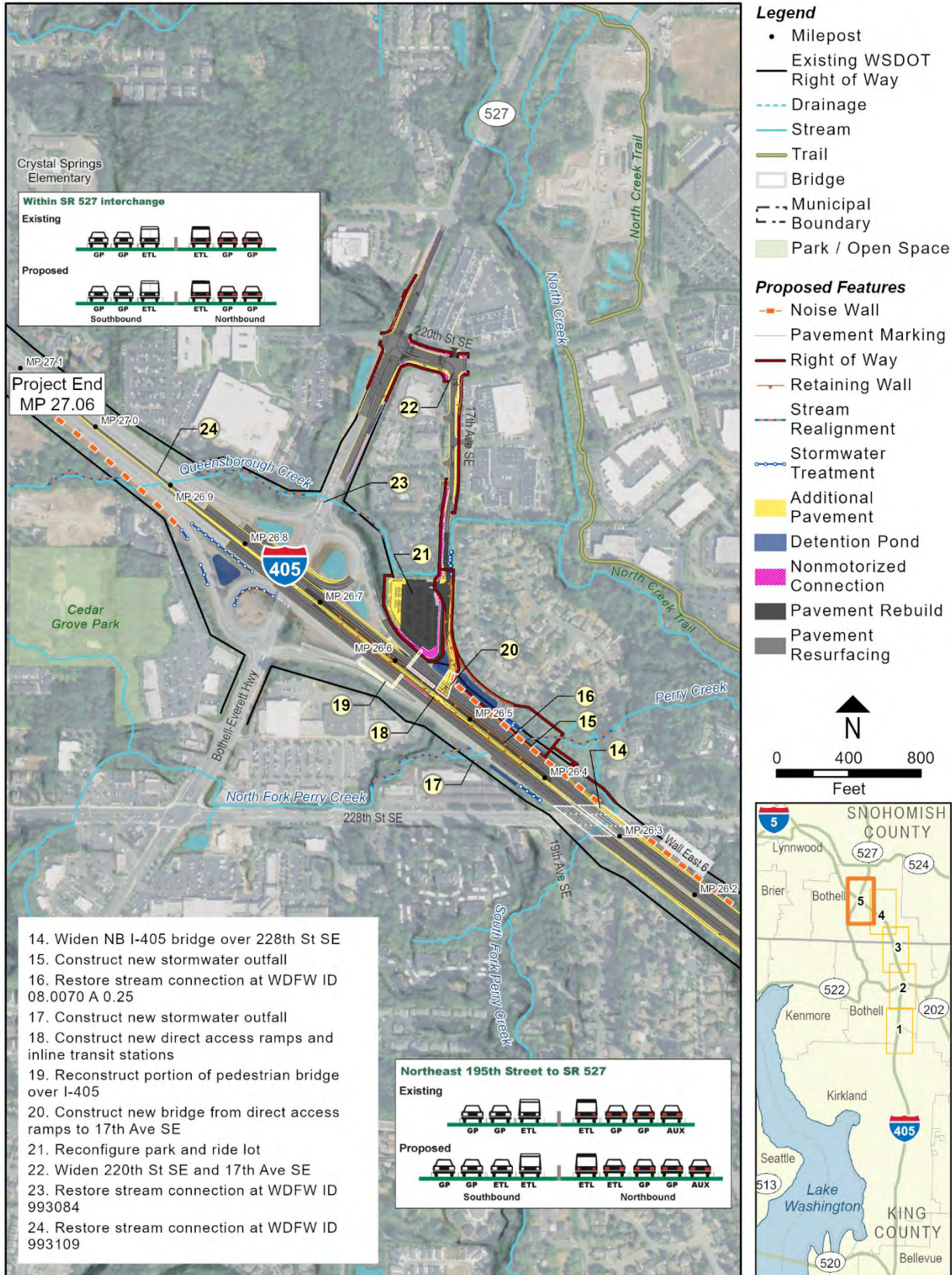
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 2-2. I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project, Sheet 4 of 5



I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
 GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 2-2. I-405, SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project, Sheet 5 of 5



2.2 Express Toll Lanes Overview

Currently, there is one ETL in each direction of I 405 between SR 522 and SR 527. WSDOT expects that the new ETL in this section would operate in the same way as the existing ETL, from 5 a.m. to 7 p.m. on weekdays. At all other times and on major holidays, the ETLs would be free and open to all without a *Good To Go!* pass. During operating hours:

How do I get more information about ETLs on I-405?

<https://wsdot.wa.gov/Tolling/405/>

- **Single-occupancy vehicles** would pay a toll to use the ETLs with or without a *Good To Go!* pass.
- **Transit, High-Occupancy Vehicles (HOV) 3+, and motorcycles** would travel for free with a *Good To Go!* flex or motorcycle pass.
- **HOV 2+** would travel for free from 9 a.m. to 3 p.m. with a *Good To Go!* flex pass. From 5 a.m. to 9 a.m. and 3 p.m. to 7 p.m. HOV 2+ would pay a toll to use the ETLs with or without a *Good To Go!* flex pass.
- **Large vehicles** over 10,000 pounds gross vehicle weight would not be able to use the ETLs at any time.

2.3 Project Construction Overview

WSDOT expects to construct the Project using a design-build delivery method, in which WSDOT executes a single contract with one entity for design and construction services. With design-build projects, contractors have the flexibility to offer innovative and cost-effective alternatives to deliver the project, improve project performance, and reduce project effects. If the contractor proposes design modifications not covered by this Environmental Assessment, additional environmental review would be conducted as needed.

Construction would generally occur between 2021 and 2025, but construction activities in some areas would be complete prior to 2025. Once a contractor is selected for the Project, they could use multiple work crews in multiple locations to reduce the overall construction period. Work would include removing existing asphalt and concrete surfaces, clearing and grading adjacent areas, laying the aggregate roadway foundation, placing new asphalt and concrete surfaces, replacing culverts, and building and demolishing bridges. Removing bridge piers from the Sammamish River could require the construction of temporary work bridges and would require in-water work, which may include temporary use of cofferdams and a work barge, depending on the contractors' chosen means and methods. Realigning the I-405 mainline would require approximately 170,000 cubic yards of excavation and 166,000 cubic yards of fill.

Construction equipment would include backhoes, excavators, front-end loaders, pavement grinders, jack hammers, trucks, vector trucks, cranes, drilling rigs and augers, concrete pumping equipment, and slurry processing equipment. Specific haul routes and the number of construction vehicles would not be known until a construction contract is signed. When possible, the work sites would be accessed from I-405 and SR 522. Construction staging areas for employee parking, large equipment storage, and material stockpiles would be located within WSDOT and Bothell right of way to the extent possible. The contractor may also find other locations for construction staging.

SECTION 3 STUDY APPROACH

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.

Geology and soils 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 major factors in determining the type of foundations for structures, pavement sections, subsurface drainage requirements, allowable cut or 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.

3.1 Study Area

The study area for this analysis includes the Project limits between milepost (MP) 21.79 and MP 27.06 and laterally to the area immediately adjacent to the roadway. Where appropriate, the study area also extends outside the Project limits to assess the relevant conditions.

3.2 Policies and Regulations

For this report, WSDOT reviewed the following design standards:

- *American Association of State Highway and Transportation Officials Load and Resistance Factor Bridge Design Specifications* (AASHTO 2017)
- *WSDOT Geotechnical Design Manual* (WSDOT 2015)
- *WSDOT Standard Specifications for Road, Bridge and Municipal Construction* (WSDOT 2018)
- *WSDOT Bridge Design Manual* (WSDOT 2019a)
- *WSDOT Environmental Manual* (WSDOT 2019b)

3.3 Data Sources and Information Collected

WSDOT reviewed the preliminary design plans for the Project and relevant published geologic and groundwater information in preparation of this report. Section 7, References, provides a full list of sources.

3.4 Methods Used to Evaluate Effects

To evaluate the Project's effects on geology, soils, and groundwater during construction and operation, this study consisted of the following main tasks:

- Reviewing available information on Project design.
- Evaluating soils and geologic conditions.
- Identifying and assessing potential effects of the Project.

- Identifying and assessing ways to avoid or minimize effects.

To evaluate effects, WSDOT considered the construction and long-term operation of both the No Build Alternative and Build Alternative (with the Project). WSDOT reviewed agency design and construction standards and conducted a visual examination of available hazard maps to evaluate the existing site conditions and assess the appropriate design and construction activities to minimize effects to the environment.

SECTION 4 EXISTING CONDITIONS

4.1 Regional Geologic Conditions

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 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 non-glacial deposits and Tertiary age (between 66 million and 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 geologic and soil conditions in the study area range from soft soil to dense and very dense glacial deposits.

4.2 Subsurface Conditions and Soil Units

Exhibit 4-1 illustrates the geologic conditions in and adjacent to the study area (WDNR 2019). The geologic characteristics can be described as highly variable. The majority of the project alignment is underlain by glacial till and drift deposits that can be dense to very dense. Just south of SR 522, the Project passes through alluvium, which encompass a wide range of deposits from soft organic rich clayey silt, to very stiff sandy silt, to loose to dense sand and gravel.

4.3 Erosion Hazards

Exhibit 4-2 identifies the areas of anticipated erosion hazards within the study area (King County 2019a; Bothell 2019). Within these areas, the soils in and adjacent to the study area have been modified by earlier construction activities.

4.4 Landslide Hazards

Landslide and slope stability hazard areas within the study area have been identified south of the I-405/SR 522 interchange. 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, as shown in Exhibit 4-3 (King County 2019b). 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

that are potentially unstable as a result of rapid incision, streambank erosion, or undercutting by wave action.

4.5 Seismic Hazards

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 (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).

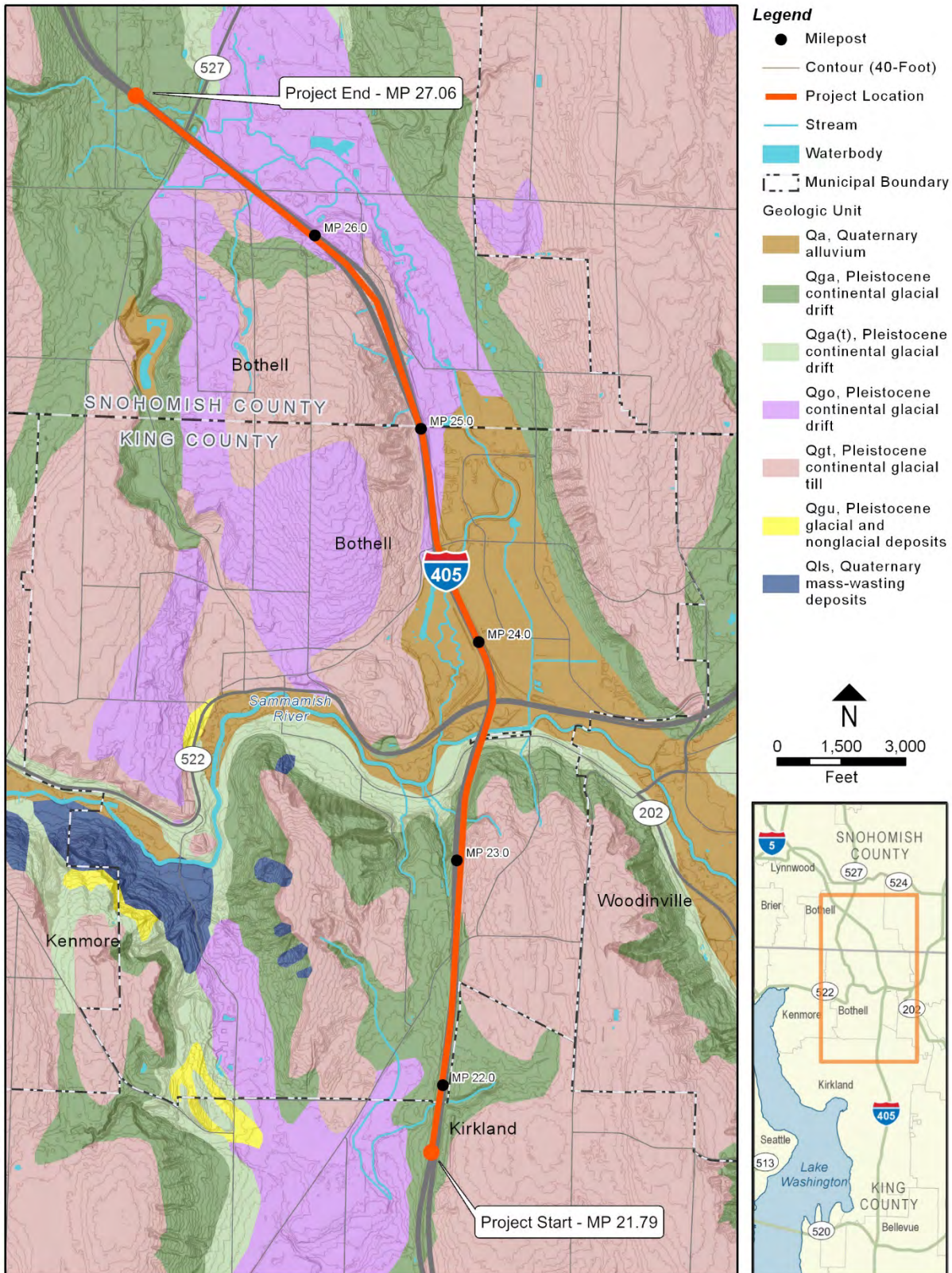
The Seattle Fault zone is located approximately 10 miles south of the study area. The Seattle Fault zone is a broad 2.5- to 4-mile-wide, multitrace, east-west striking reverse slip fault zone that extends more than 43 miles across central Puget Sound (Calvert et al. 2003; Nelson et al. 2003; Ten Brink et al. 2002; Johnson et al. 1999). The southern Whidbey Island fault is located within the study area. The most recent movement along this fault occurred approximately 3,000 years ago (Kelsey et al. 2003). Several inferred faults are also identified within the study area and are highlighted in Exhibit 4-4 (WDNR 2019).

The American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge design specifications, as modified by the WSDOT Bridge Design Manual, would govern the seismic design criteria for the Project (AASHTO 2017; WSDOT 2019a). These specifications are based on a hazard level of 5 percent probability of exceedances in 50 years and an approximate 1,000-year return.

Liquefaction and subsequent settlement and lateral spreading can occur during a seismic event in areas of loose saturated soils. The majority of the study area's susceptibility to this seismic hazard is low to very low. The area between just south of SR 522 and approximately 4,000 feet to the north is susceptible to a higher risk of liquefaction. Exhibit 4-5 identifies the level of liquefaction susceptibility within the study area (WDNR 2019).

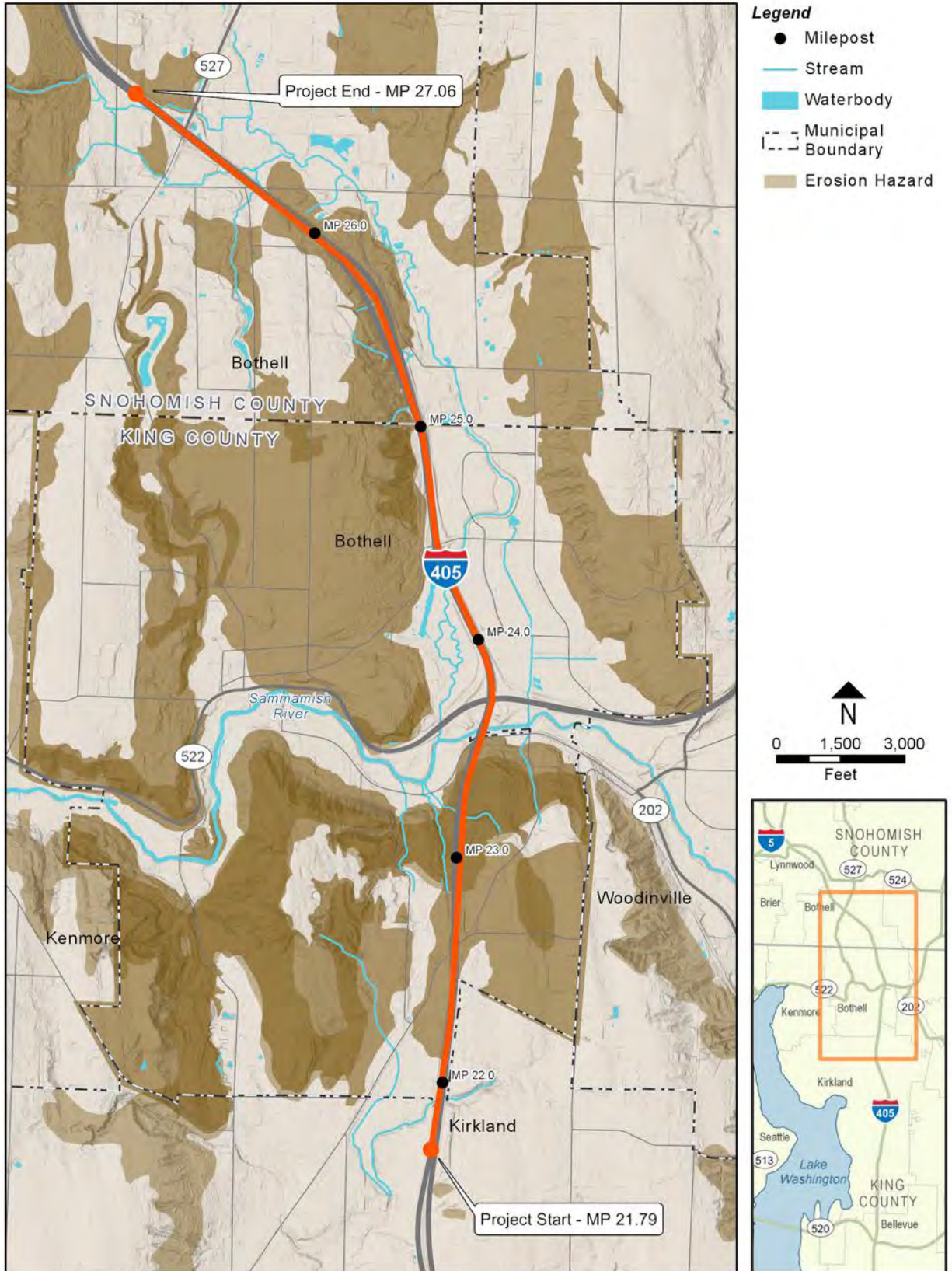
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
 GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 4-1. Geologic Conditions in and Adjacent to the Study Area



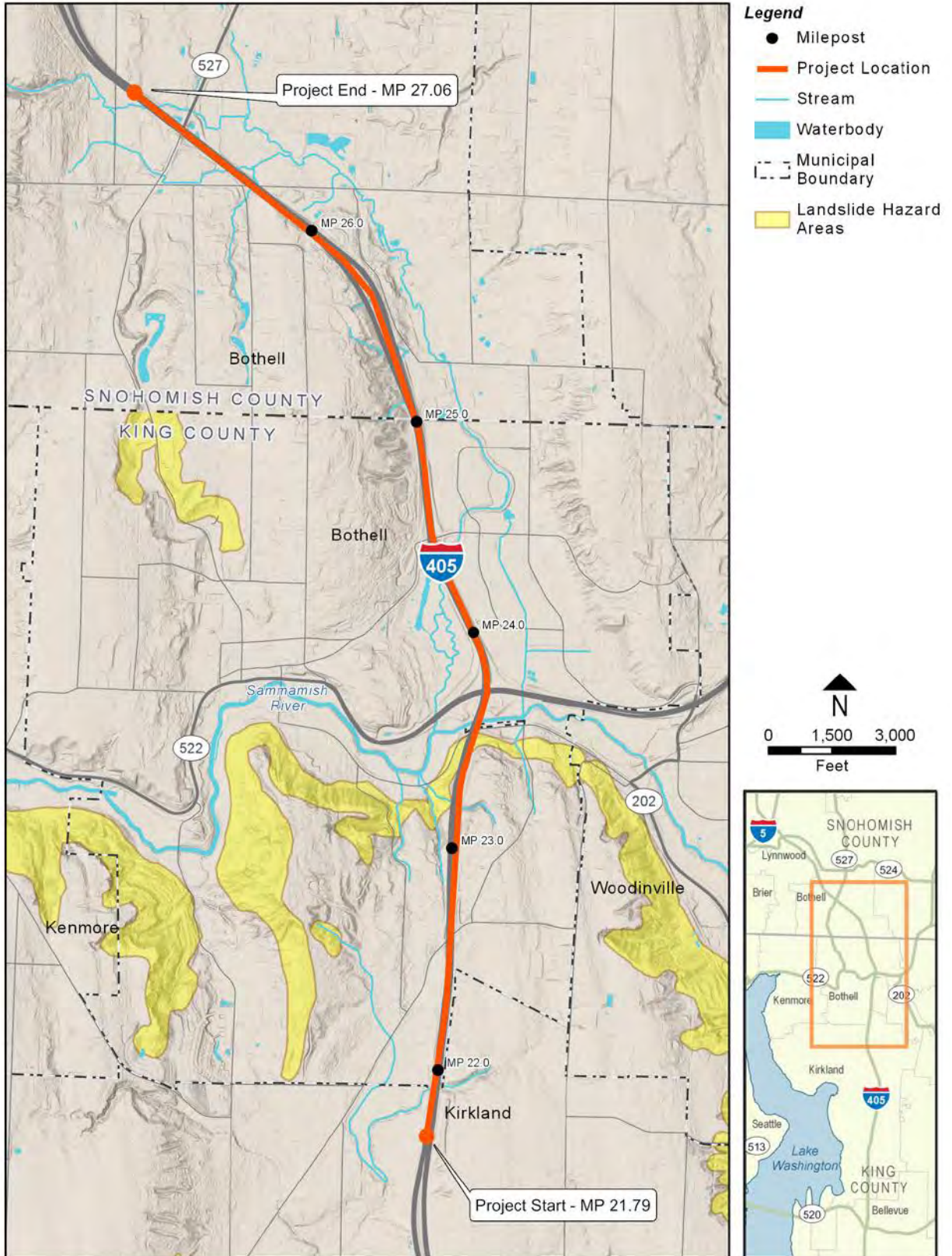
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 4-2. Erosion Hazards near the Study Area



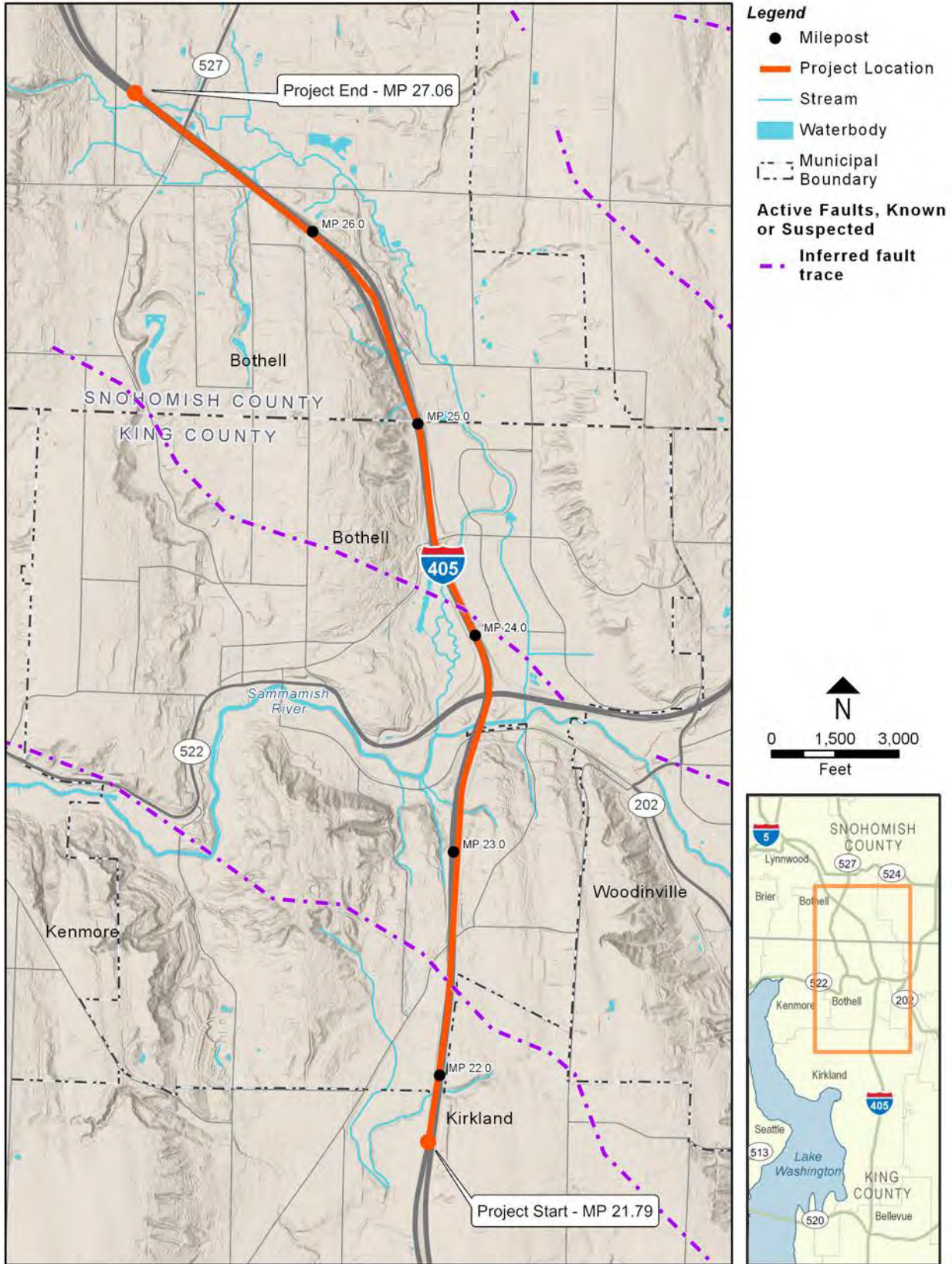
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 4-3. Landslide Hazards in and Adjacent to the Study Area



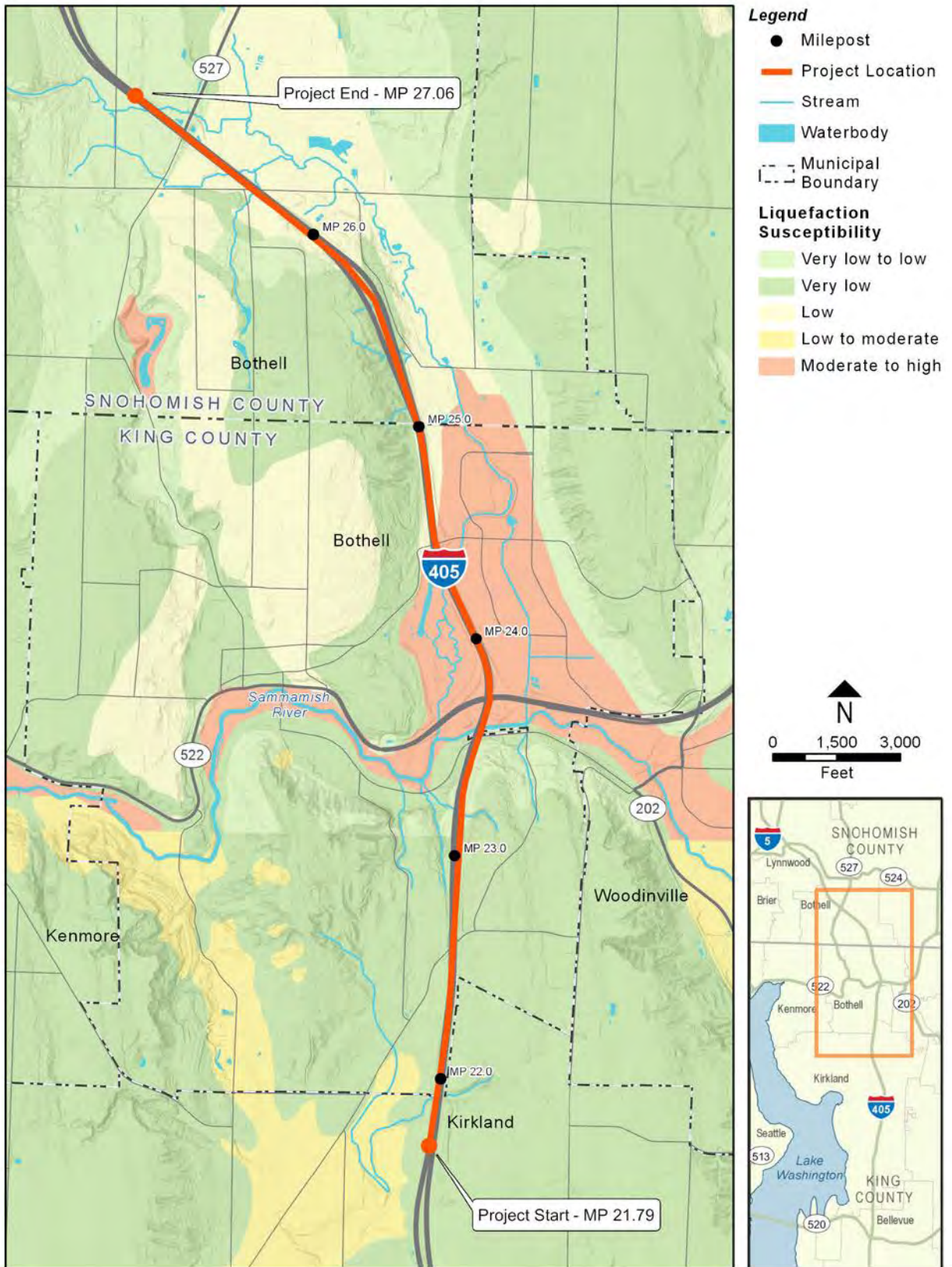
I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
 GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 4-4. Seismic Hazards Areas



I-405, SR 522 VICINITY TO SR 527 EXPRESS TOLL LANES IMPROVEMENT PROJECT
 GEOLOGY, SOILS, AND GROUNDWATER TECHNICAL MEMORANDUM

Exhibit 4-5. Liquefaction Hazards in and Adjacent to the Study Area



SECTION 5 PROJECT EFFECTS

This section compares the Project effects using the approach described in Section 3, Study Approach, for the No Build Alternative and Build Alternative (with the Project).

5.1 *No Build Alternative*

With the No Build Alternative, only routine activities such as road maintenance, repair, and safety performance improvements would take place over the next 20 years. Conditions would not change from the status quo. There would be no construction- or operations-related effects on geology, soils, or groundwater.

5.2 *Build Alternative*

5.2.1 *Operational Effects*

Seismic Hazards

The southeast segment of the southern Whidbey Island fault is within the area of the Project. If a rupture along the fault occurs during the life of the Project, it could cause substantial damage to the roadway, utilities, and structures. The most recent event along this feature was approximately 3,000 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 of designing structures to avoid faults and the difficulty in locating active traces. An exception would be if a surface rupture due to faulting from an active fault has been identified within 1 mile of the bridge site.

5.2.2 *Construction Effects*

WSDOT has well-established design and construction practices for managing the types of geologic, soil, and groundwater conditions anticipated in the study area. An in-depth geotechnical site investigation (i.e., the combined efforts of WSDOT and the design-builder) would be performed to identify the subsurface conditions for final design and construction. With the implementation of normal WSDOT practices and activities to avoid effects on the environment, there would be minimal effects on 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 same location. WSDOT is aware of the issues and would avoid or minimize potential effects through proper design, construction, and operational procedures.

Erosion

Erosion potential may increase during Project construction, as soils may be disturbed during brush clearing, setup of work sites, and other construction activities. 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.

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 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. It is expected that these effects (if they occur) would 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.

Earthwork

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. It is anticipated that both off-site disposal of unsuitable soils and importing of fills would be required in the study area. This could result in truck traffic and associated effects, including traffic operations, noise, dust, mud, slope instability, 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 issues.

5.3 *Indirect Effects*

Construction of the Project likely would not result in indirect effects on geology, soils, or groundwater.

SECTION 6 MEASURES TO AVOID OR MINIMIZE EFFECTS

The Project will mitigate for effects during and after construction using the strategies described in this section.

6.1 Operational Mitigation

No operational mitigation is proposed for the Project.

6.2 Construction Mitigation

WSDOT has well-established practices for managing design and 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 effects.

6.2.1 Seismicity

- Design Project elements to the American Association of State Highway and Transportation Officials (AASHTO) design standards and implement design methods that meet AASHTO's design event and limit susceptibility to collapse under an unlikely larger event.

6.2.2 Liquefaction-Prone Areas

- Identify Project areas where liquefaction-prone soils may be located.
- Evaluate the potential effects on Project structures from liquefaction, if structures underlain by liquefaction-prone soils are identified.
- Use appropriate measures to reduce long-term liquefaction and lateral spreading risks to Project elements if it is determined that liquefaction risks are unacceptable. Such mitigation might include soil densification such as stone columns, vibratory compaction, compaction grouting, and dynamic compaction. Liquefaction potential along the Project alignment is assessed as low and moderate to high.

6.2.3 Soft Ground Areas

- Take appropriate measures to assess and reduce potential settlement problems associated with existing utilities or structures in Project areas underlain by soft, compressible soil. If deemed necessary, structures could be underpinned and utilities could be relocated or made more flexible. In cases where settlement exceeds WSDOT-allowable tolerances 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.
- Assess the potential for settlement for structures and embankments underlain by soft, compressible soil. If the potential for 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.

- Develop the means and methods to avoid or minimize settlement resulting from construction vibrations in areas underlain by soft or loose soils.

6.2.4 Slope Stability and Landslide Areas

- 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.
- Drain suspected or observed seepage in Project areas to reduce the risk of landslide and surface sloughing through the use of gravel drainage blankets, French drains, horizontal drains, placement of a surface rock facing, or other methods.

6.2.5 Dewatering

- Use properly designed, installed, and operated dewatering systems as dewatering for utility trenches can induce ground settlement in areas of soft compressible soils. These activities may include sheet-pile cut-off shoring, recharge wells, a settlement and groundwater level monitoring system, and other procedures. WSDOT understands that complete elimination of settlement in proximity to excavations can be difficult, particularly if loose granular soils are densified by installing sheet piles.
- 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 will be mitigated by disposing the discharge in a sanitary sewer or performing on-site treatment.

6.2.6 Erosion

- Prepare and implement a temporary erosion and sedimentation control (TESC) plan to minimize erosion and protect water quality.
- Take additional action to minimize erosion, maintain water quality, and achieve the intended environmental performance, should any best management practice or other operation not function as intended.

6.2.7 Earthwork

- Control dust through the use of a water truck or other dust control measures.
- Control soil tracked onto nearby surface streets from truck tires.
- Place and maintain stockpiles properly to avoid erosion or slope stability problems. Erosion control of stockpiles will be included in the TESC plan.

6.2.8 Permanent Drainage Systems for Cut Slopes

- Locate areas where permanent drainage will be required by site conditions for cut slopes. At one location, installation of a drainage system adjacent to a new retaining wall

has the potential to impact additional wetland areas by drawdown of the groundwater table. If these additional impacts are identified during construction, they would be mitigated in accordance with federal, state, and local regulations.

SECTION 7 REFERENCES

- AASHTO (American Association of State Highway and Transportation Officials). 2017. *Load and Resistance Factor Design Bridge Design Specifications*.
- Bothell, City of. 2019. GIS data. Retrieved in June 2019 at <http://www.bothellwa.gov/238/GIS-Data>.
- Calvert, A.J., Fisher, M.A., Johnson, S.Y., and SHIPS Working Group. 2003. *Along-strike Variations in the Shallow Seismic Velocity Structure of the Seattle Fault Zone: Evidence for Fault Segmentation Beneath Puget Sound*: *Journal of Geophysical Research*, v. 108, n. B1, 2005.
- Johnson, S.Y., Dadisman, S.V., Childs, J.R., and Stanley, W.D. 1999. *Active Tectonics of the Seattle Fault and Central Puget Sound, Washington: Implications for Earthquake Hazards*: *Geological Society of America Bulletin*, v. 111, n. 7, p. 1042–1053.
- Kelsey, H.M., Sherrod, B.L., and Johnson, S.Y. 2003. *A Late Holocene Earthquake on Central Whidbey Island: Surface Folding Above a Blind Fault*. *Geological Society of America Abstracts with Programs*, Vol. 35, No. 6.
- King County. 2019a. Open GIS data – erosion hazards. Retrieved in June 2019 at <https://gis-kingcounty.opendata.arcgis.com/datasets/erosion-hazards-erode-area>.
- King County. 2019b. Open GIS data – landslide hazard areas. Retrieved in June 2019 at <https://gis-kingcounty.opendata.arcgis.com/datasets/landslide-hazards-incorporated-kc-1990-annexed-landslide-sao1990-area>.
- McCumb, D.R., Galster, R.W., West, D.O., Crosson, R.S., Ludwin, R.S., Hancock, W.E., and Mann, L.V. 1989. *Tectonics, Seismicity, and Engineering Seismology in Washington*: *Washington Division of Geology and Earth Resources Bulletin 78*, v. I, p. 97–120.
- Nelson, A.R., Johnson, S.Y., Kelsey, H.M., Sherrod, B.L., Wells, R.E., Bradley, L-A, Okumura, K., and Bogar, R. 2003. *Late Holocene Earthquakes on the Waterman Point Reverse Fault, Another ALSM-Discovered Fault Scarp in the Seattle Fault Zone, Puget Lowland, Washington*: *Geological Society of America Annual Meeting, Seattle, Washington*. November 2–5, 2003, Paper No. 35-12.
- Rogers, A.M., Walsh, T.J., Kockelman, W.J., and Priest, G.R. 1991. *Earthquake Hazards in the Pacific Northwest: An Overview*: U.S. Geological Survey Open-File Report 91-441-O.
- Stanley, D., Villasenor, A., and Benz, H. 1999. *Subduction Zone and Crustal Dynamics of Western Washington: A Tectonic Model for Earthquake Hazards Evaluation*: U.S. Geological Survey Open-File Report 99-311, Online Edition.
- Ten Brink, U.S., Molzer, P.C., Fisher, M.A., Blakely, R.J., Bucknam, R.C., Parsons, T., Crosson, R.S., and Creager, K.C. 2002. *Subsurface Geometry and Evolution of the Seattle Fault Zone and the Seattle Basin, Washington*: *Bulletin of the Seismological Society of America*, v. 92, n. 5, p. 1737–1753.

- Weaver, C.S. and Shedlock, K.M. 1996. *Estimates of Seismic Source Regions from the Earthquake Distribution and Regional Tectonics in the Pacific Northwest*: U.S. Geological Survey Professional Paper 1560, p. 285–306.
- WDNR (Washington State Department of Natural Resources). 2019. Geology GIS data and databases. Retrieved in June 2019 at <https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases>.
- WSDOT (Washington State Department of Transportation). 2015. *WSDOT Geotechnical Design Manual*.
- WSDOT. 2018. *Standard Specifications for Road, Bridge and Municipal Construction*.
- WSDOT. 2019a. *Bridge Design Manual # M23-50.19*. July.
- WSDOT. 2019b. *Environmental Manual*. M 31-11.21. Engineering and Regional Operations, Development Division, Environmental Services Office. June.

ATTACHMENT A ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
EA	Environmental Assessment
ETL	express toll lane
GP	general purpose
HOV	high-occupancy vehicle
I-405	Interstate 405
MP	milepost
OEO	Office of Equal Opportunity
SR	State Route
TESC	temporary erosion and sediment control
WSDOT	Washington State Department of Transportation
WSTC	Washington State Transportation Commission

ATTACHMENT 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 rise 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
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.
