City of Ferndale

CITY COUNCIL STAFF REPORT

SUBJECT: Ferndale Levee Alternatives

DATE: 6/13/2022

FROM: Kevin Renz – Public Works Director

PRESENTATION BY: Whatcom County Public Works

RECOMMENDATIONS: Review potential alignment for Ferndale Road and levee.

BACKGROUND: Whatcom County has been seeking to make improvements throughout the Nooksack River system with the intent of improving flood protection while simultaneously improving habitat and recreation. As one component of the County's efforts a grant application was made seeking Floodplains by Design funding for design of levee improvement including the levee section within Ferndale city limits. The County was successful in receiving a grant award and selected Reichhardt & Ebe Engineering to provide preliminary design services for the levee.

ANALYSIS: Whatcom County has provided the City with several options for reconfiguring the levee between Cherry Street and Star Park including three options which involve relocating Ferndale Road away from its current location between Pioneer Park and the Nooksack River. City staff have been involved in the process of reviewing the alternatives and desires to provide the alternatives to Council for your consideration.

ALTERNATIVES CONSIDERED: The County will review conceptual designs and discuss the merits of each.

FISCAL REVIEW: Cost estimates have been produced for each of the alternatives. However, City costs have not been developed at this stage. Whatcom County intends to pursue further grant funding for the overall project. No City funds are being obligated at this stage.

EQUITY: Not analyzed during this phase of the project. Realignment of the road section may introduce equity concerns that will be brought forward as the project progresses through design.

LEGAL REVIEW: The City Attorney has not been consulted at this phase of the project.

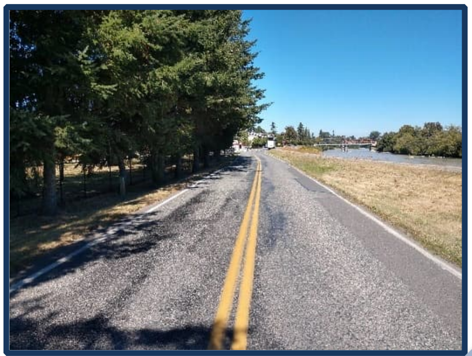
CONCLUSION: City staff have reviewed the proposed alignments and internal discussions have favored Alternative – E which would relocate the road to the west of P-66 ball fields.

FERNDALE ROAD ALIGNMENT ALTERNATIVES ANALYSIS

Source: Bellingham.org

FERNDALE LEVEE IMPROVEMENT PROJECT

FINAL REPORT | MAY 13, 2022



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FERNDALE ROAD
ALIGNMENT ALTERNATIVES ANALYSIS

FERNDALE LEVEE IMPROVEMENT PROJECT

FINAL REPORT

MAY 2022

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41884
5/25/22

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1.0 Introduction:

In August 2020, Reichhardt & Ebe Engineering, Inc. (R&E) was retained by the Whatcom County Flood Control Zone District (County) for design of improvements to the Ferndale Levee and Ferndale Water Treatment Plant Levee along the right bank of the Nooksack River south of downtown Ferndale. The levee system (inside project limits) reduces flood risk along a 1.2 mile stretch of critical infrastructure including the City of Ferndale (City) water treatment plan (WTP) and wastewater treatment plant (WWTP), and Whatcom County Public Utility District (PUD) No. 1 water treatment plant. The levee system also provides protection for residential, recreational and commercial facilities and structures in the City of Ferndale (including Star and Pioneer Parks), and surrounding farmland.

This report documents the analysis of various levee and roadway improvement alternatives for the project portion between Cherry Street and Star Park. The recommendations and findings contained herein are based on preliminary engineering and other studies conducted by the design team, which includes: R&E; GeoEngineers, Inc.; Northwest Hydraulics Consultants (NHC); Transpo Group; Vector Engineering, Inc.; Eccos Design, LLC.; and Drayton Archaeology.

Design and construction of this project is funded through the Washington State Department of Ecology's *Floodplains by Design* grant program and the Whatcom County Flood Control Zone District.

Construction of this project is anticipated to begin in spring of 2025 and be completed by summer of 2026. The final Plans, Specifications, and Estimate (PS&E) package is scheduled for completion in fall of 2024.

1.1 Objective and Assumptions

The primary objectives of this project are to improve flood protection, levee integrity, and riparian habitat for a 1.2 mile stretch of existing levee embankment along Ferndale Road south of Cherry Street. This will be accomplished by raising the levee crest elevation and addressing deficiencies noted in the United States Army Corps of Engineers (USACE) inspection reports (see Section 1.2.1 for levee inspection history). A byproduct of these improvements is the direct impact to the existing roadway (which is either adjacent to or on top of the levee), requiring complete reconstruction. The levee crest will be raised to meet the proposed design water surface elevation with appropriate freeboard intended to address anticipated climate change impacts to future flood levels (see Section 1.3).

It is important to note that the objective of the levee improvements is *not* to seek accreditation by the Federal Emergency Management Agency (FEMA) for National Flood Insurance Program (NFIP) purposes. Also worth noting, is that design or modification to levee segments upstream and downstream of the identified project limits are not within the scope of this project, despite any known or potential deficiencies that may result in landward flooding before or after completion of this project.

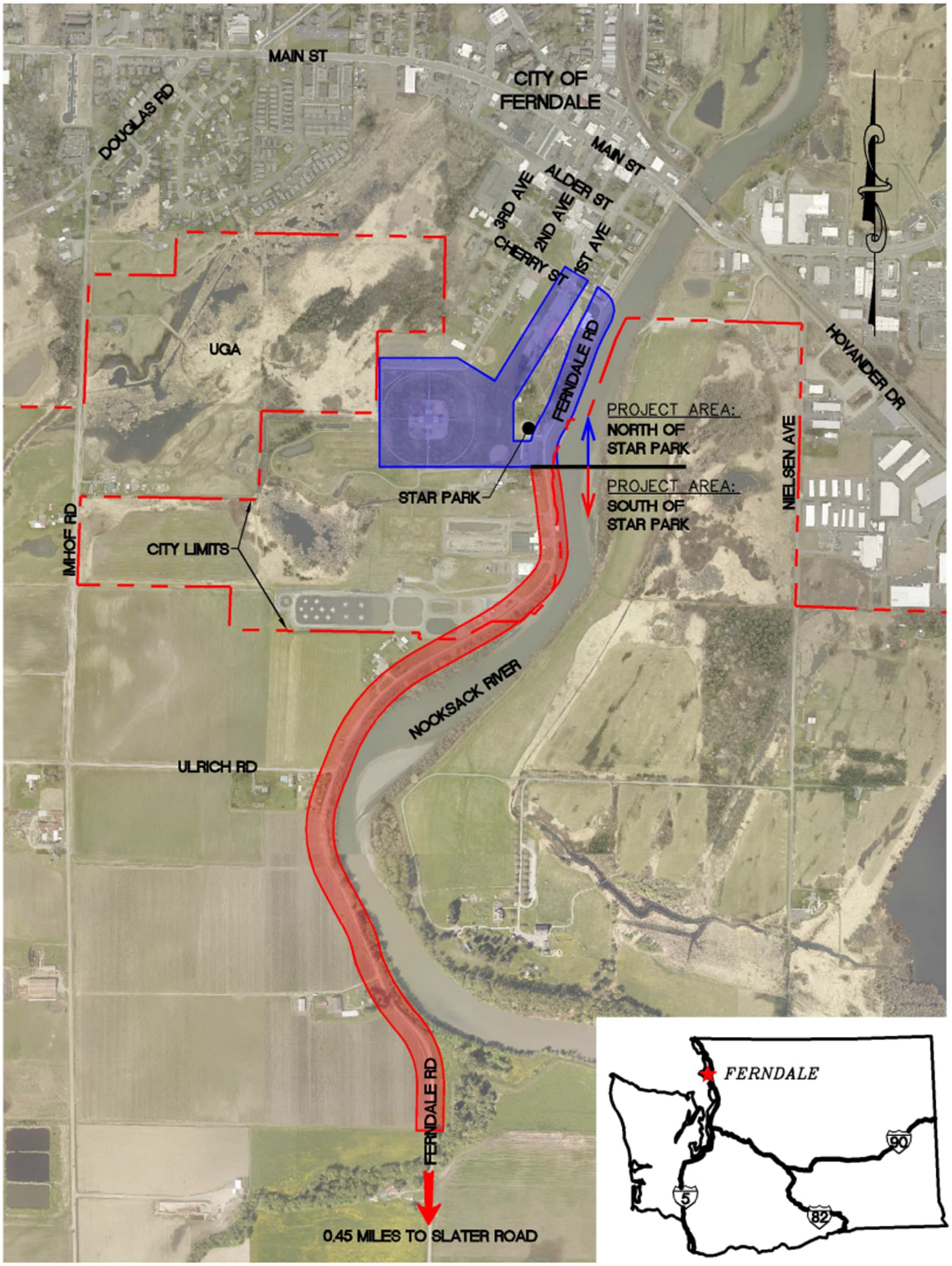


Figure 1: Vicinity Map

For the purposes of this analysis, the levee and roadway design is separated into two regions: south of Star Park and north of Star Park (see Figure 1). Star Park is the dividing line because that is where the road typical section transitions to and from having a shared-use-path (SUP) on the riverward side. For both regions, the road and levee are generally parallel and follow the river. South of Star Park, the reconstructed road and levee is expected to generally follow the existing Ferndale Road Alignment given existing constraints with right-of-way (ROW), existing infrastructure, and river hydraulics, thereby eliminating any unique, feasible realignment alternatives. North of Star Park, despite existing, similar constraints, the road has four feasible alignment alternatives with the levee remaining adjacent to the river in each case. While maintaining the existing roadway alignment may appear to be the logical choice for the reconstructed road, it is complicated by the replacement SUP that must fit inside ROW, in addition to the roadway and associated fill slopes, while accommodating necessary levee and habitat improvements. This geometric constraint leads to consideration of other road alignment alternatives through the park that may be more desirable.

A roadway alignment alternatives memo was submitted to the County in November, 2020 and summarized five possible alternatives for the roadway alignment north of Star Park. The alternatives were simply named A, B, C, D and E. The memo provided justification to why Alternatives B and C should be eliminated from further analysis and proposed evaluation criteria for selecting the preferred alternative. This memo is included as Appendix A. Since submittal of the memo, Alternative B was reinstated for detailed analysis at the request of the County. Alternative C is still currently eliminated from further consideration. This report focuses on evaluation of alternatives A, B, D, and E in the region north of Star Park only.

A similar memo or alternatives analysis discussion regarding design considerations for the road and levee south of Star Park is not included in the scope of this report. All design development and coordination for that region of the project will occur with appropriate stakeholders as necessary.

Project Assumptions:

- The reconstructed roadway will follow current County and City development standards to the extent practicable
- Levee design will follow current USACE minimum standards
- Pioneer Park (historic structures) and Star Park shall not be encroached on
- No utility improvements are included in the project scope with the exception of stormwater management facilities as necessary to meet Department of Ecology requirements for flow control and runoff treatment. Minor utility conflicts and relocations are expected (such as with power and communications) but are not fully evaluated at this time.

It should be noted that all designs and related statements contained herein are conceptual and based on the knowledge and information available to the design team at the time of preparation. As such, while this report attempts to present the most feasible scenarios that meet all project objectives, it does not preclude other alternatives, or variations thereof, from being considered. Final design decisions will be made and communicated during the design phase with opportunities for public and stakeholder outreach.

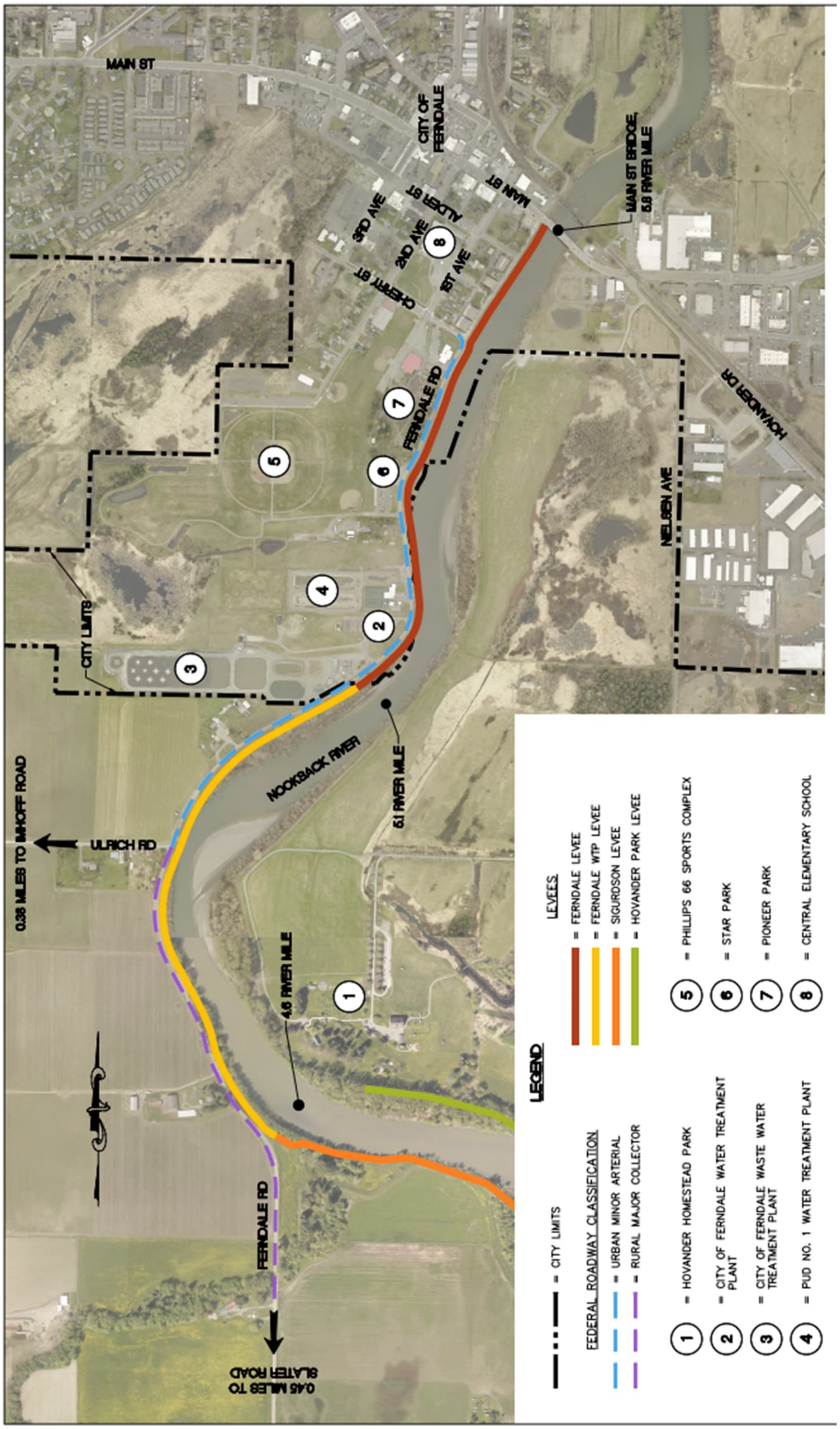


Figure 2: Existing Features Map

1.2 Background

This project is located just south of downtown Ferndale, Washington on Ferndale Road between Slater Road and Cherry Street, corresponding to the right (north and west) bank of the Nooksack River between river mile 4.6 and 5.8. See Figure 2.

Of the five levees that comprise the right bank levee system south of Ferndale (Nooksack River Reach 1), two fall within the project limits: the Ferndale WTP Levee from river mile 4.6 to 5.1, and the Ferndale Levee from river mile 5.1 to 5.8. Note that although the Ferndale Levee extends north beyond the project limits at Cherry Street up to Main Street, this portion of the levee is not within the current project scope and already meets the desired level of protection. These levees are not accredited by the FEMA.

The County and City are local sponsors for the USACE Public Law (PL) 84-99 Rehabilitation and Inspection Program for the Ferndale WTP Levee and Ferndale Levee, respectively (note that Diking District #1 is a co-sponsor for the Ferndale WTP levee). Typically, if a levee segment is rated “Unacceptable” upon inspection, it loses its rehabilitation assistance eligibility. Levees rated as “Minimally Acceptable” have two years to address noted deficiencies before potentially receiving an “Unacceptable” rating and losing eligibility for the program. In these cases, sponsoring agencies have the opportunity to submit a System-Wide Improvement Framework (SWIF) which is a documented approach to addressing levee deficiencies identified during routine USACE inspections and is a mechanism for maintaining rehabilitation assistance eligibility for levee segments needing additional time and coordination effort to implement corrective measures. This project ranked as the highest priority capital project (out of 16 projects) in the 2017 Nooksack River SWIF.

1.2.1 Levee and Flood History

The levees were originally constructed in the 1930s by the Works Progress Administration to improve flood protection for the developing area and have since undergone various modification and improvements. The two subject levees are contiguous with sponsorship responsibilities separated by city limits. Figure 3 below, sourced from the 2017 SWIF, highlights the Reach 1 levees and extents of expected flood inundation during large events.

1.2.1.1 Ferndale Water Treatment Plant Levee

The upstream end of the Ferndale WTP Levee is located at the city limits just south of the WWTP entrance. According to the summary table included in the latest (2021) USACE inspection report, this unarmored levee is 0.66 miles long, 2.5-feet-high, has an average crest width of 12 feet, and has riverward and landward slopes of 2H:1V. It offers protection against the 50-year flood and mainly protects the WWTP, agricultural lands, and farmsteads. There is one, 12-inch culvert penetration. Riparian vegetation is established along most of the levee and consists of trees, shrubs, and sod.

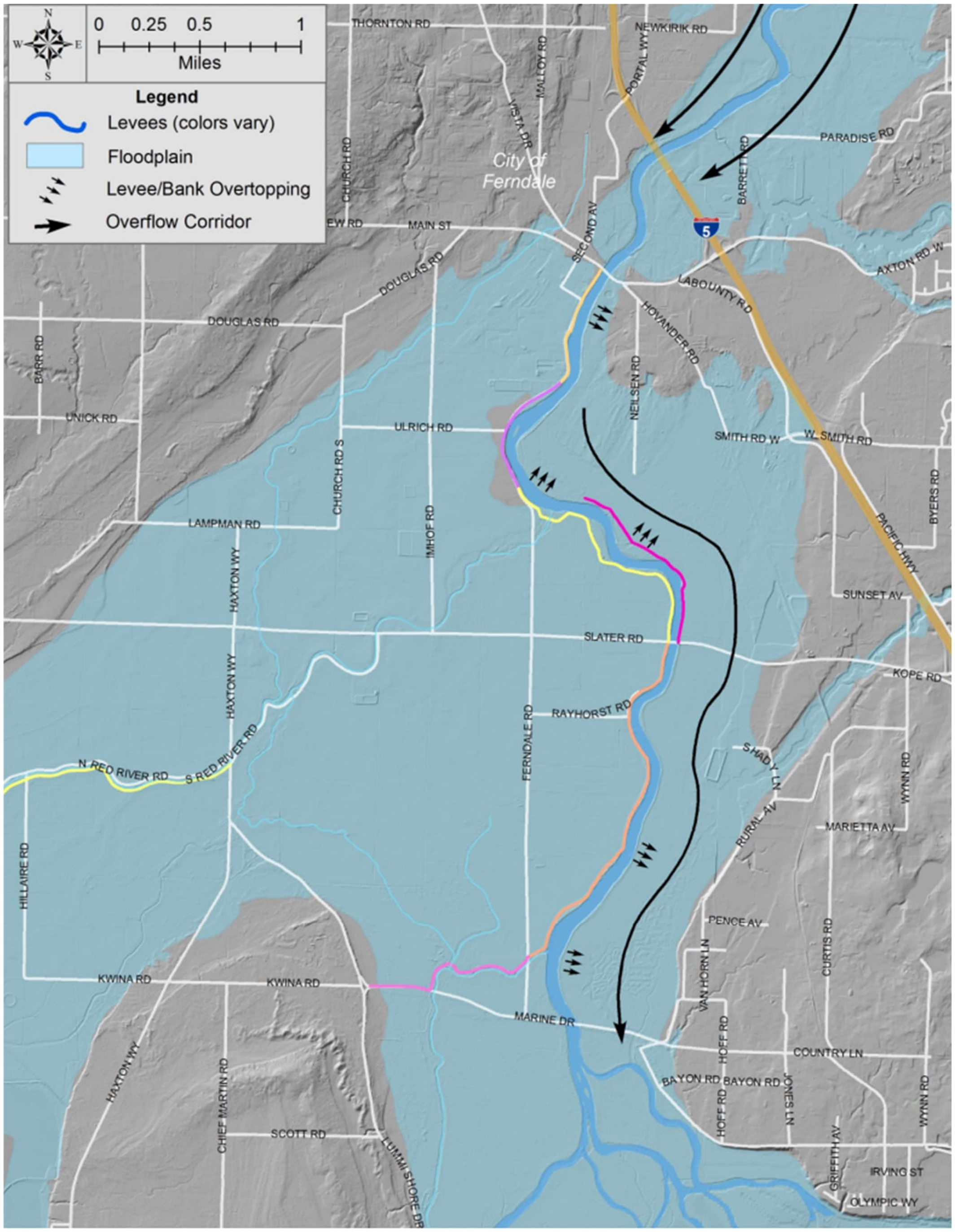


Figure 3: Areas of Frequent Overtopping and Overflow Corridors within Reach 1 (2017 Nooksack SWIF)

Figure 4: Recent inspection and Site Visit Photos of the Ferndale WTP Levee; (a) Unwanted vegetation per USACE standard – at city limits facing SW; (b) Erosion and missing armor – riverbank near Ulrich Road; (c) Unwanted vegetation on backslope – south of Ulrich Road facing south; (d) 12" culvert penetration missing video inspection – Outfall north of Ulrich Road

A routine inspection completed in 2021 by USACE and the County noted multiple deficiencies along the levee needing improvement (see Figure 4 for photos). These include:

- Unwanted vegetation growth
- Missing sod cover
- Utility Encroachments
- Culvert penetrations and seepage
- Uninspected culvert penetration
- Sandbag berm
- Low berm elevation

Given the severity of the deficiencies, this levee received an overall rating of “Unacceptable.”

1.2.1.2 Ferndale Levee

The Ferndale Levee begins at Main Street bridge and ends at the city limits just south of the WWTP entrance where it ties into the Ferndale WTP Levee. According to the summary table included in the latest (2021) USACE inspection report, this armored levee is 0.60 miles long, 3-feet-high, has a crest width of 8 feet, and has riverward and landward slopes of 1.5H:1V and 5H:1V, respectively. With the help of a super sack closure structure south of the PUD intake, the levee crest elevation is above the existing 100-year flood elevation and mainly protects the WTP and WWTP facilities and Pioneer and Star Parks. There are four small culvert penetrations. Riparian vegetation is minimal north of the PUD intake and mainly consists of sod and brush.

(a)

(b)

(c)

(d)

Figure 5: Recent inspection and Site Visit Photos of the Ferndale Levee; (a) Levee and trail across from Pioneer Park – facing south (top) and north (bottom) – narrow crown (b) Erosion and sloughing areas across from Pioneer Park – viewed from land (top) and water (bottom); (c) PUD No. 1 intake structure and super sack closure structure – viewed from road (top) and water (bottom); (d) Culvert penetration across from Star Park

A routine inspection completed in 2021 by the USACE and the City noted multiple deficiencies along the levee needing improvement (see Figure 5 for photos). These include:

- Unwanted vegetation growth
- Narrow crown
- Culvert penetrations
- Super sack berm
- Erosion and sloughing

Given the level of the deficiencies and the result of improvements made to resolve deficiencies noted during the previous inspection, this levee received an overall rating of "Acceptable" with room for minor improvement.

1.2.1.3 Geotechnical Exploration and Levee Soil Composition

Geotechnical composition of both levees is similar. Per subsurface explorations completed in February, 2021 (and documented in Appendix B), soils along the road and levee section consist of:

- Native Fill –
    - Extending 5 to 12 feet below ground surface (bgs)
    - Loose to medium dense silty sand with variable gravel content
- Native Alluvium –
    - 20 to 51 feet bgs
    - Loose to medium dense sand, soft sandy silt, and medium stiff clayey silt with sand
- Glaciomarine Drift –
    - 51 to 61 feet bgs
    - Soft to stiff clay with variable silt and sand content

Groundwater was interpreted to range from 5 to 12 feet bgs based on observed soil saturation. A groundwater monitoring well was installed (as part of the explorations) just east of the Phillips 66 Sports Complex tournament ball fields.

1.2.1.4 Flood History

Six notable floods on the Nooksack have occurred since the year 2000: November 2004, November 2005, January 2009, November 2017, November 2018, and November 2021. Figure 6 below, originally from Appendix C, compares the water surface elevations of the current 100-year event and the 2004 and 2009 flood events (and others as described in the source material) with the existing levee crest elevation (note the November 2021 flood event is too recent for quantitative analysis or inclusion in Appendix C but is qualitatively discussed below for completeness). In addition to major overtopping upstream of the Main Street bridge (where there is no levee or closure structure), the comparison shows some localized areas of overtopping within the project limits for the larger events, notably in 2009. This is consistent with the photos shown in Figure 7 from the 2009 flood event.

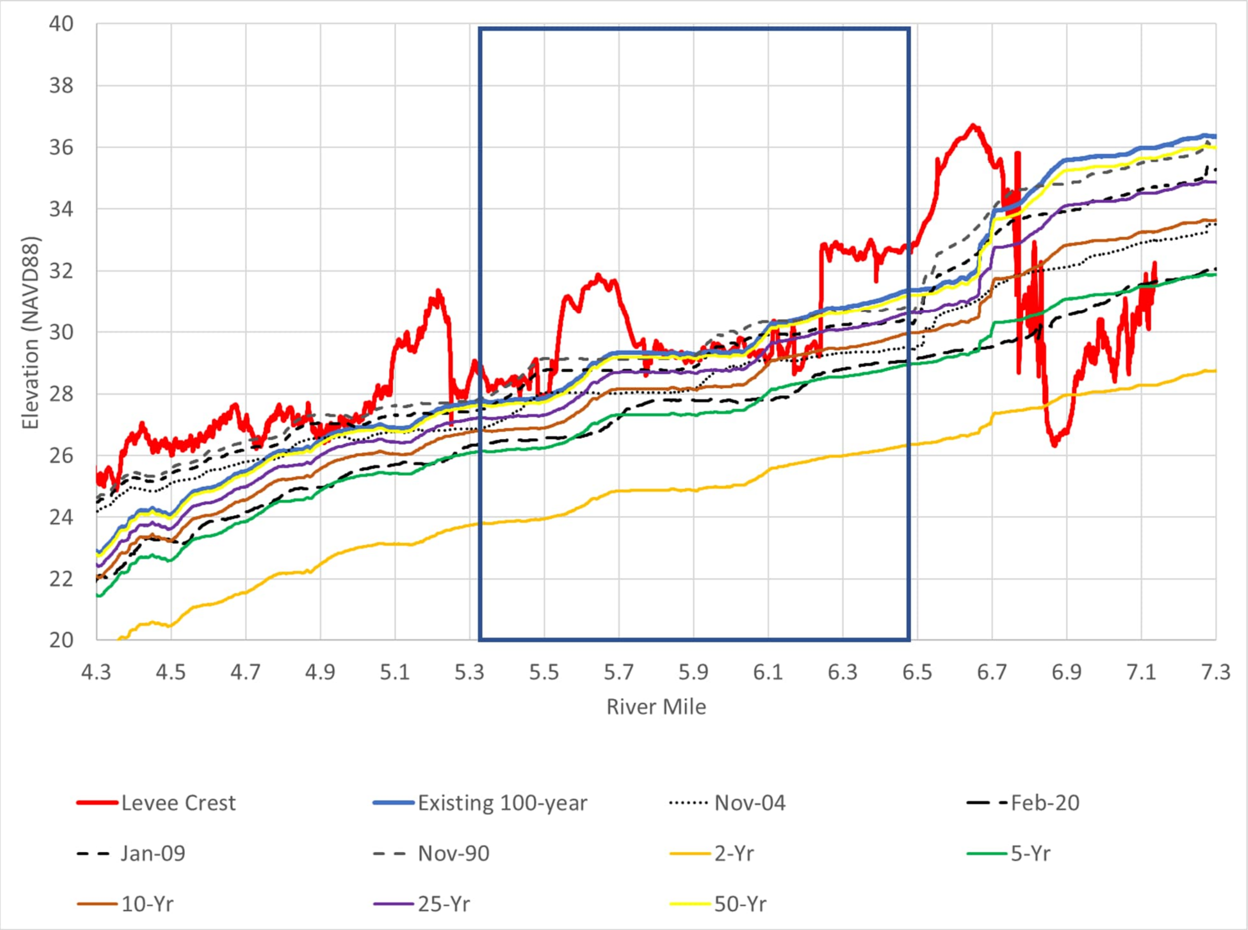


Figure 6: (from Appendix C) Profile of recurrence interval events, calibration events, and levee crest elevation. Blue box indicates project reach. Note November 1990, November 2004, and January 2006 do not use existing condition topography. Note that thalweg WSELs are displayed. Run-up, superelevation, and location conditions may cause variations in WSEL along the levee face (note the river miles used for hydraulic analysis differ by approximately 0.5 miles from the USGS/WDFW river miles and are based on the Lower Nooksack River Geomorphic Assessment, 2019. For reference, overtopping at river mile 6.8 is just north of the Main Street bridge)

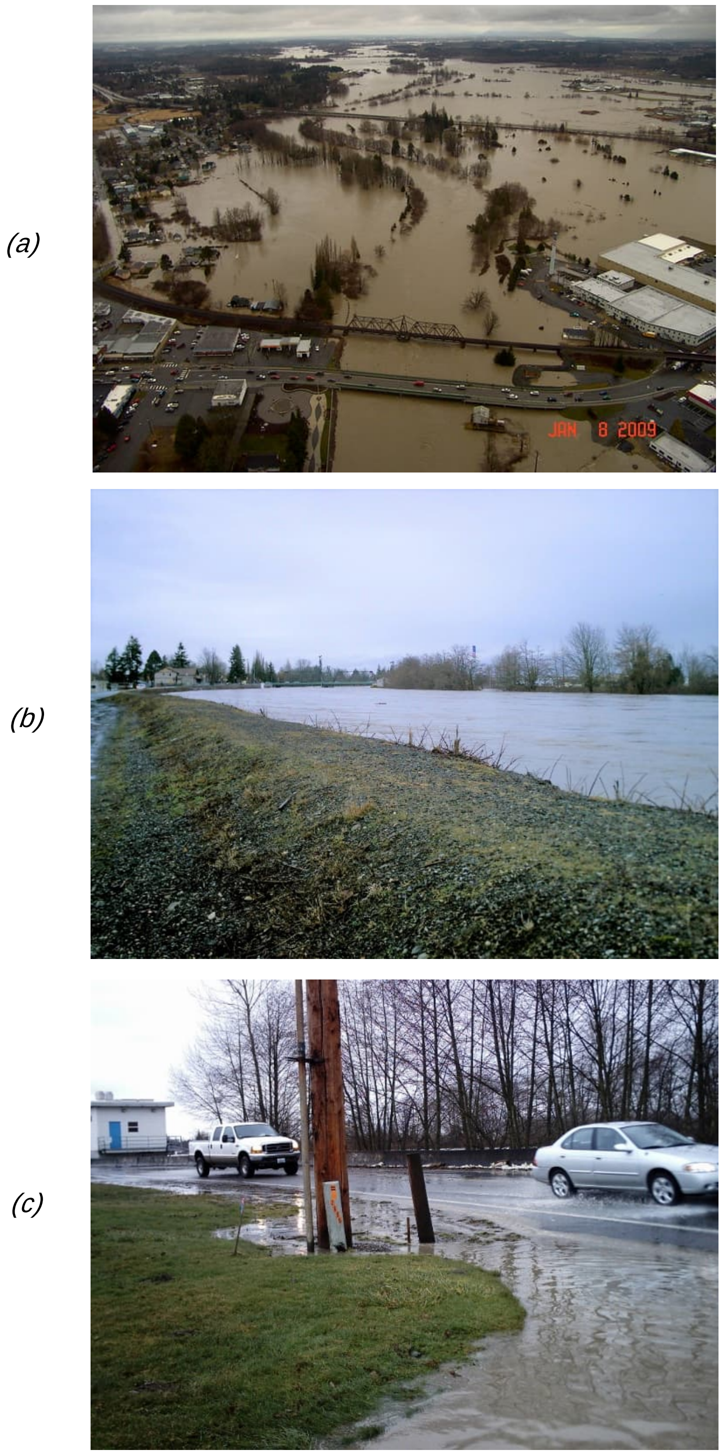


Figure 7: Photos from the January 2009 Flood; (a) aerial image of the Main Street bridge (foreground) facing north towards Interstate-5 (background); (b) Ferndale Levee across from Star Park facing northeast; (c) Flooding on Ferndale Road south of PUD No. 1 intake structure, facing northeast

November 2021 Flood Event Highlights and Fighting Efforts

Between November 14th and November 16th, 2021, record precipitation in Whatcom County produced significant flooding in the Nooksack River. The levee system south of Ferndale was severely stressed during this period, with flood water overtopping the levee system in multiple locations. Flood water reached a maximum gauge height of 23.88 feet at the Ferndale Gauge at approximately 7:52 PM on the evening of 11/16/2021. This stage of flood exceeded the historic flood of November 1990.

During this event, a flood fighting effort was undertaken by Whatcom County, The City of Ferndale, and hundreds of volunteers, local residents, and farmers. Thousands of sandbags were deployed during this flood flight. Floodwaters overtopped the levee system in multiple locations and a significant breach in the levee occurred adjacent to Ferndale Road approximately 1,500 feet south of the Ulrich Road intersection. Whatcom County Staff and volunteer staff were able to plug this breach with sand bagging.

During the afternoon of 11/16/2021, the City of Ferndale requested a voluntary evacuation of all residents and businesses in the area south of Main Street between 4th Avenue and the Nooksack River.

While no levee breaches were observed within the City of Ferndale, significant damaged was observed in multiple locations after the flood. In particular, significant erosion on the face of levee was observed approximately 200 feet north of the PUD No. 1 Intake facility. The US Army Corp repaired these damages at the request of the city of Ferndale. See Figure 8 below for pictures of the flooding and related flood fighting efforts.

This flood event highlights the vulnerabilities of the current levees and the need to reconstruct them to current standards and higher crest elevation.

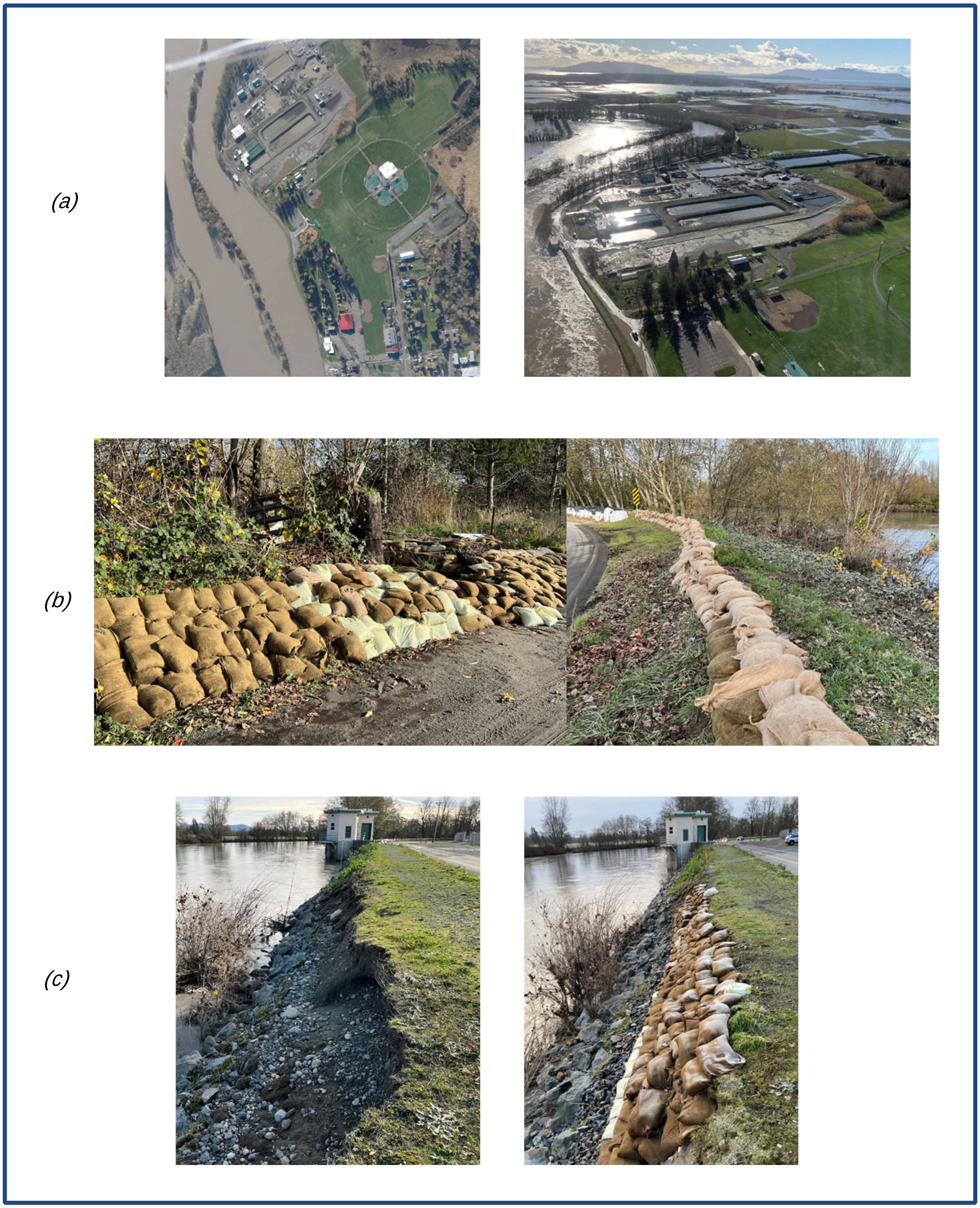


Figure 8: Photos from immediately after the November 2021 Flood; (a) aerial images of The Nooksack River, Pioneer Park, Star Park, Phillips 66 Sports Complex, WWTP and both WTPs (facing south); (b) Emergency sandbagging efforts to contain levee breach (left), and increase crest elevation near WTPs (right); (c) Levee foreslope erosion damage (left) and emergency sandbag repair (right) north of PUD intake structure.

1.2.2 Ferndale Road

Ferndale Road is a two-lane, north-south local road carrying traffic to and from downtown Ferndale between Cherry Street to the north and Slater Road to the south. While Ferndale Road technically transitions to Front Avenue as it heads north along Pioneer Park before intersecting with Cherry Street, this nuance is ignored for the purposes of this project. It has two federal functional classifications within the project limits: rural major collector from Slater Road to Ulrich Road, and urban minor arterial from Ulrich Road to Cherry Street (shown in Figure 2). The City of Ferndale further classifies the length of roadway within City limits as a collector. Traffic volume is considered low relative to the capacity for this road, and while it is projected to increase by nearly three times by 2040, the level of service will not substantially change.

The portion of Ferndale Road within project limits provides exclusive access to Star Park, PUD No. 1 WTP, City of Ferndale WWTP, City of Ferndale WTP, and two residences. A third residence is within project limits but has alternative access via Ulrich Road.

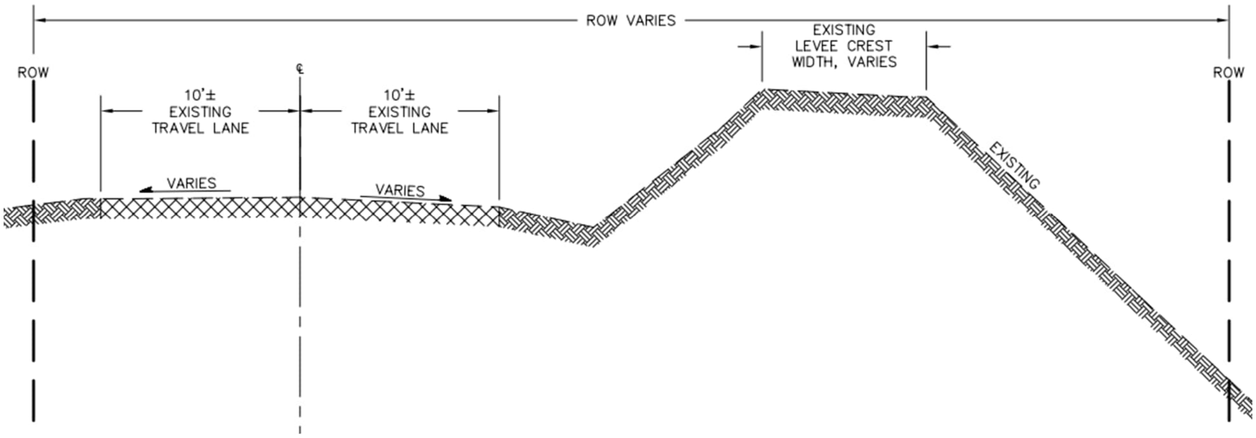


Figure 9: Existing Ferndale Road Typical Section

The existing road typical section is shown in Figure 9 and is approximately 20-feet-wide with little-to-no shoulders. North of Star Park, the top of the levee provides an informal trail extension to the paved Riverwalk path that formally ends at Cherry Street.

Current roadway runoff is unmanaged and sheds to adjacent pervious areas and through culverts that penetrate through the levee and daylight on the levee foreslope.

1.3 Hydraulic Modeling and Levee Design

1.3.1 River Hydraulics

As outlined in the hydrology, hydraulics, and geomorphology analysis report contained in Appendix C, four peak flow scenarios were evaluated to ensure the chosen design flow would result in the most robust flood protection. In addition to existing 100-year flow results from both the Delbert D. Franz, Linsley, Kraeger Associates Full Equation Model (FEQ) and the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) models, the scenarios included two climate change projected flows (with Sumas Overflow), and a worst-case “No Sumas Overflow” scenario. These scenarios were repeated but with assumed 2.60-feet of bed aggradation in the main channel to account for vertical stability (changes as sediment pulses move through the system), a variable to which results were notably sensitive. All scenarios assume overtopping of the left (south and east) bank.

Projected 100-year mean and maximum flows (1.3- and 1.7-times scaling factors, respectively) were determined using industry-accepted climate change projections and assuming a conservative scenario for the project time horizon (year 2080). It should be noted, that changes in the 100-year flow due to anthropogenic climate change are subject to large and unquantifiable uncertainty. As such, the future actual flows will differ, whether greater or smaller, from those used for this analysis.

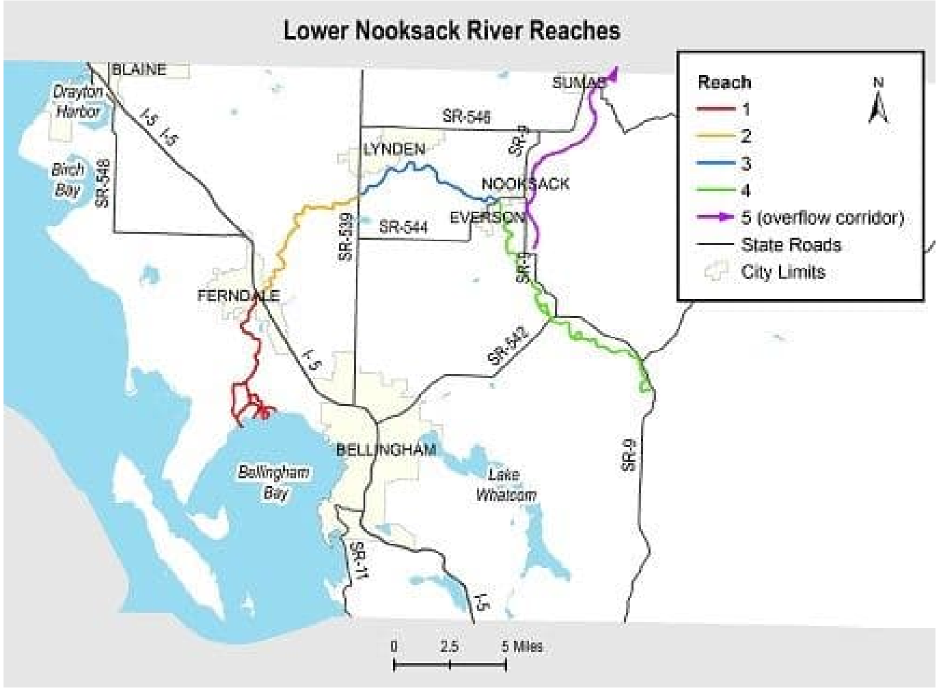


Figure 10: Lower Nooksack River Reaches (Whatcom County government website)

As shown in Figure 10, the Sumas Overflow corridor is Reach 5 of the Nooksack system and receives overflow diverted at multiple locations within roughly four river miles upstream of Everson, WA (end of Reach 4). These floodwaters flow north through Sumas, WA and into Canada. As flow in the Nooksack increases, so too does overflow into Canada. Approximately 14% of flow is overflow at Everson for the 100-year flow. Assuming conditions where no overflow is allowed results in a 36% increase in peak flow in Ferndale (note these flow distributions are based on a 2013 bathymetric survey and LiDAR topography from 2006 and 2015). This scenario accounts for potential changes in the threshold for overtopping flows that may be associated with channel capacity changes due to sediment transport, and potential future management actions that could alter the flow distribution at Everson.

The chosen design water surface elevation (WSEL) is the existing 100-year WSEL. Therefore, the design levee crest elevation is equal to the existing 100-year WSEL plus three feet of freeboard (while not required since this project is not receiving accreditation by the FEMA, the chosen level of freeboard matches the FEMA standards). As shown in Figure 11, this design levee crest elevation captures all evaluated flow scenarios within the project limits. Important to note, however, is it does not contain all scenarios upstream of the Main Street bridge. Levee toe inspection results and discussion of the bathymetric survey are provided in Appendix D.

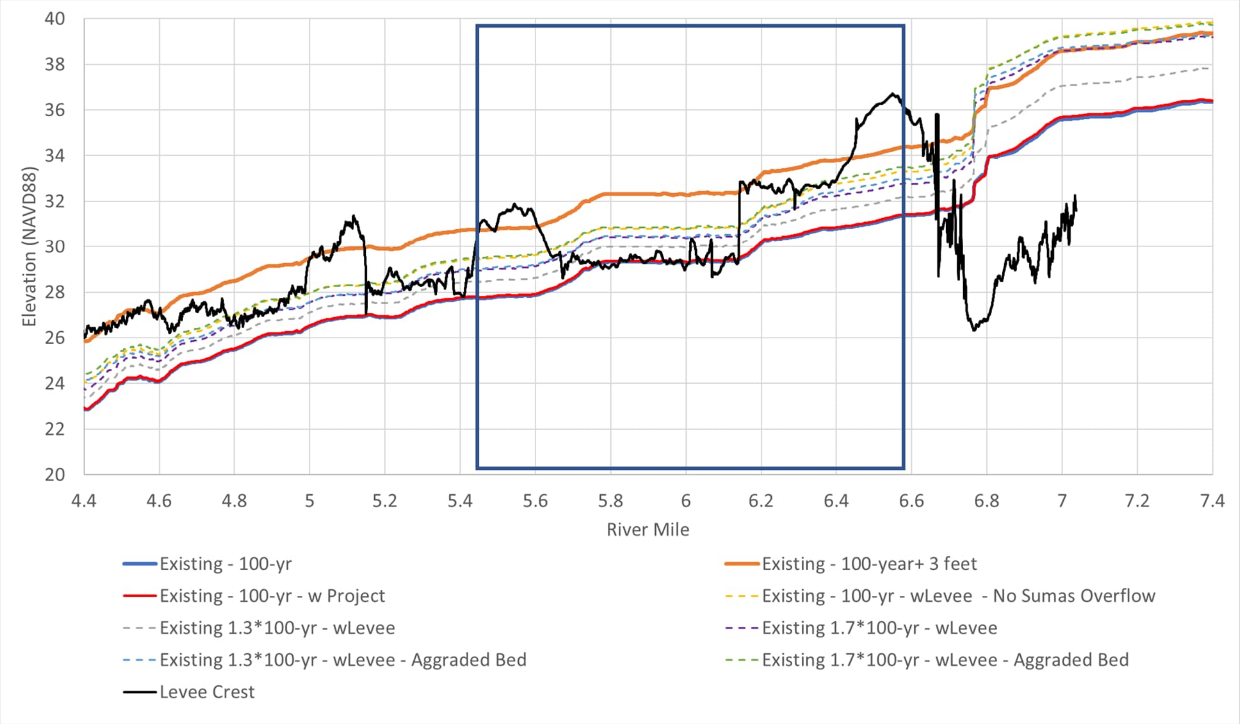


Figure 11: (from Appendix C) Design flow water surface elevation along the Nooksack centerline, blue box indicates project reach (note the river miles used for hydraulic analysis differ by approximately 0.5 miles from the USGS/WDFW river miles and are based on the Lower Nooksack River Geomorphic Assessment, 2019)

1.3.2 Typical Levee Section

The typical levee section, as required by the USACE manual for Design and Construction of Levees, dictates a minimum crest width of 10 feet with no steeper than 2H:1V side slopes. To address project specific soil characteristics and slope stability concerns, more conservative requirements were set by the project geotechnical engineer. The levee design typical section for this project requires a minimum crest width of 15 feet and riverward and landward side slopes of 2H:1V and 3H:1V, respectively. This geometry is critical for designing the reconstructed levee. While the roadway is typically on top of the levee and exceeds the minimum crest width, fitting the fill slopes inside ROW became a challenge after raising the top of levee multiple feet. This combined road and levee section is shown in Figure 12.

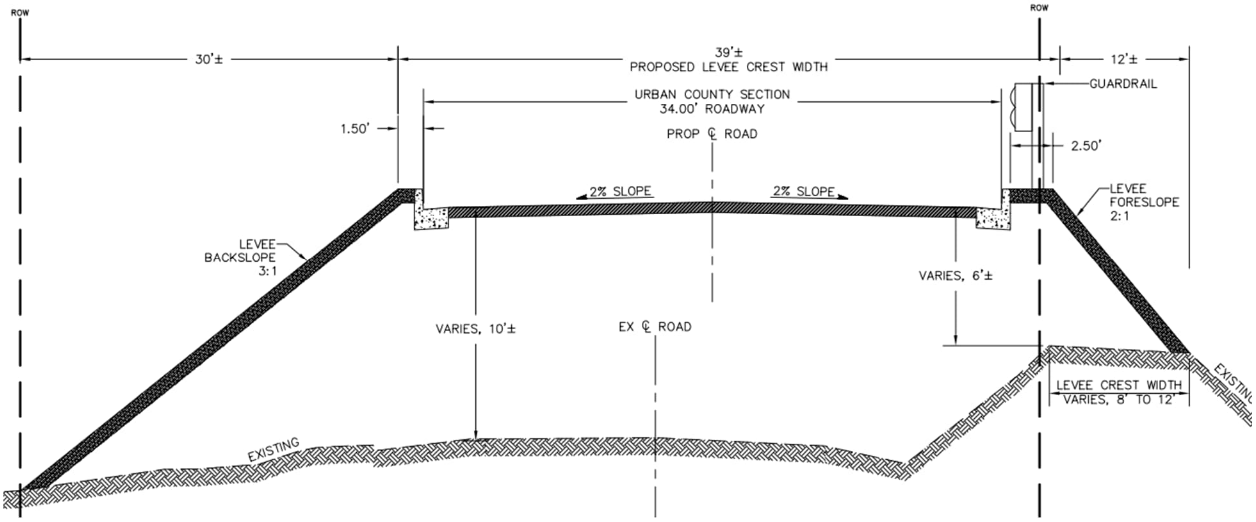


Figure 12: Combined Urban County Road and Levee Typical Section (south of Star Park)

Some portions of the existing levee foreslope are steeper than the 2H:1V limit and were noted as areas of erosion and sloughing in the inspection report. These areas will be addressed with the other levee improvements and mitigated to prevent further erosion (by laying the slope back at a shallower grade if feasible, or riprap armoring). Portions of levee backslope also exceeded the slope limitations and are addressed with the proposed preliminary design.

1.4 Cultural Resources

A cultural resources assessment was completed in October 2020 to locate and identify any cultural, historical, or archaeological materials or sites within the project area. While background review showed a high probability for “cultural and historic properties” in the project area near Pioneer Park, no significant artifacts, or evidence thereof, were found during the current or previous 36 cultural resource surveys completed within a 1 mile radius of the project site. It is suspected that years of disturbance and re-building in the area has diminished the probability of encountering such artifacts. The findings conclude that further archaeological oversight for this project is unwarranted. The complete report can be found in Appendix E.

1.5 Project Stakeholders

This project requires coordination amongst several stakeholders involved with or affected by the management of this reach of the Nooksack River and its resources, and Ferndale Road as a transportation route.

Noted project stakeholders include:

- Whatcom County Flood Control Zone District
- Whatcom County Road Division
- Whatcom County Diking District No. 1
- City of Ferndale
- Whatcom County PUD No. 1
- US Army Corps of Engineers
- Adjacent property owners

- Washington Department of Fish and Wildlife (WDFW)
- Lummi Nation
- Nooksack Indian Tribe
- Franchise utilities
- Central Elementary School
- Nooksack River Floodplain Integrated Planning (FLIP) Team

Prior to 2022, this project was conceptually introduced during planning and development of the 1999 Lower Nooksack Comprehensive Flood Management Plan and the 2017 SWIF which identified the County's plans to improve these levees. As such, agency and tribal stakeholders have been aware of this project and its general scope for many years.

From early 2020 to April 2022, outreach was limited to stakeholders with property or assets on Ferndale Road. Correspondence was through various project meetings, email correspondence, and site visits.

On April 19, 2022, a primary stakeholder workshop took place with the objective of discussing and selecting the preferred roadway alignment alternative for Ferndale Road between Star Park and Cherry Street. It was the first formal stakeholder outreach effort for this project. The workshop is documented and summarized in Section 2.4.

A preliminary public and stakeholder outreach initiative is planned to occur after the alternative selection process is finalized and prior to beginning the 30% Design Phase.

2.0 Alternatives Analysis: North of Star Park

This report analyzes four roadway alignment alternatives for Ferndale Road north of Star Park. As mentioned previously, five feasible alternatives (labeled A – 2nd Avenue Extension, B – 1st Avenue Extension, C – One-Way, D – Existing Alignment, and E – 2nd Avenue Routed West) were originally identified, with Alternative C ultimately excluded from further consideration (this process is documented in Appendix A). The remaining four alternatives are categorized as either following the existing roadway alignment (Alternative D), or following a new alignment (Alternatives A, B, and E) which passes through various parts of Pioneer Park, Star Park, and the Phillips 66 Sports Complex. See Figure 13 below.

Analysis of alignment alternatives A, B, D, and E includes a general description, and a discussion of pros and cons as it relates to specified evaluation criterion. Upon future inclusion of Stakeholder input, this will be followed by a summary and recommendation section which includes a quantitative comparison of the alternatives by assigning a score to each criterion, the total of which will be the basis for recommending a preferred alignment.

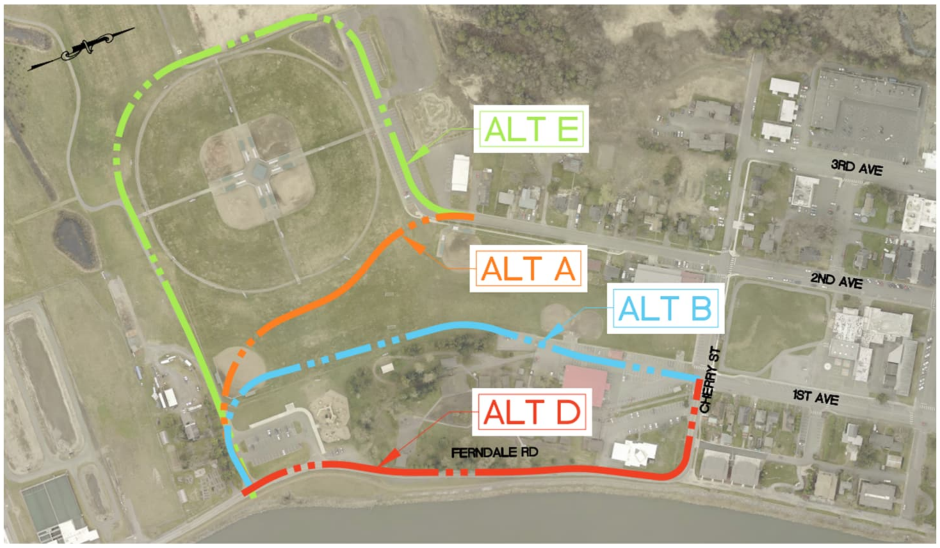


Figure 13: Alignment Alternatives Overview

2.1 Evaluation Criteria

The following is a proposed list of evaluation criteria for consideration by project stakeholders. These criteria are intended to aid with comparing alternatives and selecting the preferred roadway alignment alternative using a weighted scoring system developed as a part of the alternatives analysis process.

- Recreation – Consider park connectivity, recreational opportunities created and/or impacted
- Traffic Flow – Consider traffic impacts and opportunities
- Parking – Consider parking impacts along with options for replacement parking if necessary
- Levee Integrity – Consider the degree to which the desired level of robust flood protection is provided
- Habitat Area – Consider habitat opportunities and impacts including riparian areas and wetlands
- Permitting – Consider the difficulty, cost, and timeframe associated with permitting a particular option
- Right-of-Way – Consider the difficulty, cost, and timeframe associated with needed property rights acquisition, including the willingness of impacted property owners
- Planning – Consider future planning opportunities created and/or impacted
- Maintenance and Operations – Consider short and long-term maintenance and operations costs and responsibilities
- Cost – Consider the capital cost of a particular option

See Section 2.4 for the alternatives summary and documentation of stakeholder feedback and alternative selection process that took place during the primary stakeholder workshop on April 19, 2022. The workshop was a formal effort to collectively select the preferred roadway alignment alternative and involved evaluation criteria weighting and alternatives scoring exercises.

2.1.1 Existing Conditions

To understand the impacts associated with each alternative as they relate to the evaluation criteria, it is necessary to first be familiar with the existing conditions. A brief background is provided below on the current conditions of the project area north of Star Park as it relates to Recreation, Traffic Flow, Parking, Levee Integrity, Habitat Area, Right-of-Way, Planning, and Maintenance and Operations.

2.1.1.1 Recreation

The City of Ferndale currently offers multiple recreation opportunities in the area between 2nd Avenue and Ferndale Road. The main attractions are two designated parks, several recreation fields, a community garden, and a 2/3 mile long trail. See Figure 14 for a map highlighting and labeling the pertinent current parks and recreation areas, facilities, and amenities.

Pioneer Park is the main park area at nearly 13 acres and includes a picnic shelter, small playground, three little league fields, and several historic, settler-era buildings which are showcased at community events. Star Park is the second park which is connected to Pioneer Park and located on Ferndale Road just 0.2 miles south of Cherry Street. Amenities include a parking lot, restroom facility, large wooden playground, and access to Hanadori Trail and the recreation fields. Also worth noting is the Boys and Girls Club facility located on the corner of 2nd Avenue and Cherry Street, and the Pavilion Community Center at the south end of 1st Avenue, which both benefit heavily from the abutting park space.

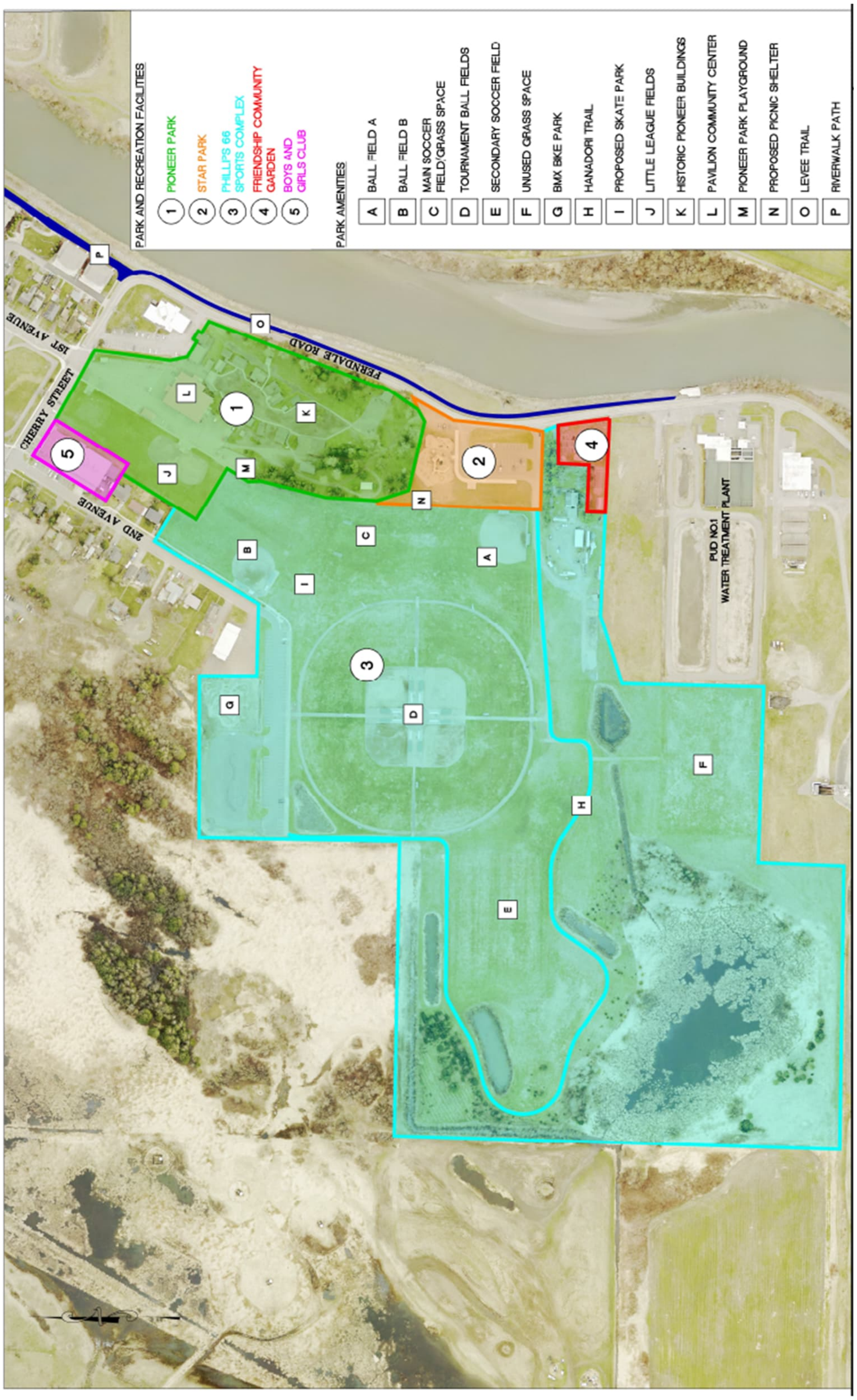


Figure 14: Parks and Recreation Facilities and Amenities

Phillips 66 Sports Complex (formerly known as Tosco Sports Complex), located at the south end of 2nd Avenue and adjacent to Pioneer Park, is home to four tournament-level ball fields, two recreational ball fields, open grass space used as soccer fields and dog walking, a BMX bike park, and a parking lot. The tournament fields, encircled with fencing and designated lighting, hosts annual, regional tournaments. The other fields are less formal and function as first-come-first-served community-level spaces.

In addition to the parks and sports fields is the 0.4 acre Ferndale Friendship Community Garden which is bordered by Star Park to the north and Ferndale Road to the east. The community garden hosts over two dozen family plots, grows food for the local food bank, and hosts a children's garden plot for the nearby Boys and Girls Club.

The 2/3 mile Hanadori Trail connects Star Park and the Phillips 66 Sports Complex parking lots. Starting at the Phillips 66 Sports Complex, the natural surface trail borders the ball fields around the west fence line before heading farther west, passing by wetland mitigation areas. The trail eventually turns east leading to Star Park. In addition, an unsanctioned, natural surface trail on top of the levee starts at the south terminus of the Riverwalk path and ends near the PUD No. 1 intake structure.

The City is currently in the planning stages for two known park improvements: a picnic shelter for Star Park situated immediately west of the playground, and a skatepark at the end of 2nd Avenue northeast of Phillips 66 Sports Complex (for which grant funding was awarded). Included in the City's trail master plan is formalization of the levee trail with a connection to the Hanadori Trail.

2.1.1.2 Traffic Flow

Baseline traffic conditions for the project area are documented in Appendix F which includes discussion on traffic volumes, collision history, considerations for Central Elementary School, and pedestrian activity. That discussion is summarized herein for convenience.

Ferndale Road is currently, and projected to remain, a low volume road, well below the typical capacity for a two-lane roadway. This is indicated by the most recent traffic counts from 2014, showing weekday daily volume of 1,190 trips, and future projections to the year 2040 with volumes growing to 3,080 trips. Any increase in traffic volumes between 2014 and 2021 are assumed to be very minor given limited changes to land use and traffic conditions in the area. Traffic volume between Ferndale Road and Main Street is evenly divided between the 1st and 2nd Avenue routes. Ferndale Road is not considered a major trucking route, with minor truck activity mainly consisting of deliveries to the WTP and WWTP facilities.

There were 16 documented collisions in the project area (Ferndale Road, Cherry Street, 1st and 2nd Avenues) between 2015 and 2019, with very few involving injuries. Most collisions were related to parking and occurred on 1st and 2nd Avenues, and only one accident occurred on Ferndale Road. There was a double-fatality incident in 2021 involving a vehicle that drove over the levee near Cherry Street and entered the Nooksack River (note that proposed design alternatives for this project will include mitigation measures to address this accident).

Central Elementary School is located on Alder Street between 1st and 2nd Avenues and has an enrollment of nearly 500 K-5 students. The primary entrance, with a bus drop-off and pick-up zone, is on 2nd Avenue, whereas parent drop-off/pick-up is on 1st Avenue. School parking is located on Alder Street and 2nd Avenue.

There is moderate pedestrian activity, mainly at and between the various park and recreation areas. Crosswalks surrounding the school are used at varying levels by students in the mornings and evenings.

2.1.1.3 Parking

There are currently three separate designated parking areas, with a lot serving each of the Pioneer Park, Star Park, and Phillips 66 Sports Complex.

The Pioneer Park parking lot is located at the intersection of 1st Ave and Cherry Street and has 103 stalls that serve the Pavilion Community Center in addition to park users.

Star Park's 43-stall parking lot serves park and garden users and is located on Ferndale Road between the community garden and the playground.

Located at the south terminus of 2nd Ave is a 103-stall parking lot which mainly serves the Phillips 66 Sports Complex but is also in proximity of adjacent park and recreation areas. Additional overflow parking (up to another 60 vehicles) is accommodated by an adjacent, parallel gravel lot to the north.

2.1.1.4 Levee Integrity

The condition and performance of the levee are the main factors for evaluating levee integrity. As discussed previously in the levee and flood history Section 1.2.1, the existing levees have multiple areas needing improvement to meet USACE levee design and performance standards (including but not limited to crest width, front and back slopes, encroachments, sloughing, and penetrations).

2.1.1.5 Habitat Area

There are no established habitat areas (riparian, upland, or otherwise) within the existing Ferndale Road corridor north of Star Park. The park areas are fully sodded with selectively maintained mature trees in the fenced limits of Pioneer Park.

Mature riparian habitat once existed along this section of Ferndale Road but was entirely removed during levee reconstruction from 2009 to 2011, as shown in historical satellite images in Figure 15 below. Since then, no reestablishment of larger, woody vegetation (trees and shrubs) has occurred, and only grasses and patches of overgrown vegetation are currently growing on the levee foreslope (also shown in Figure 15). When added to the remaining Ferndale Levee section between Cherry Street and the Main Street bridge (along the Riverwalk path), there is a 0.5 mile stretch of poorly vegetated riparian area along the west bank.

It is worth noting, that per levee vegetation restrictions detailed in the County's Nooksack River Levee Vegetation Management Plan (an appendix to the SWIF), only sod is allowed on the backslope, crest width, or within the top 5 to 15 feet of the levee foreslope for maintenance and inspection purposes (see Figure 16 below). While this limits the ability for certain vegetation growth, it is not intended to prevent establishment of habitat areas in the vicinity of the levee embankment.

(a)

(b)

Figure 15: Existing Habitat Area; (a) Left : Levee foreslope with riparian habitat between Star Park and Cherry Street in 2006, Right: Levee foreslope with no riparian habitat after reconstruction in 2011, representative of current conditions; (b) Left & Right: Current vegetation on levee foreslope

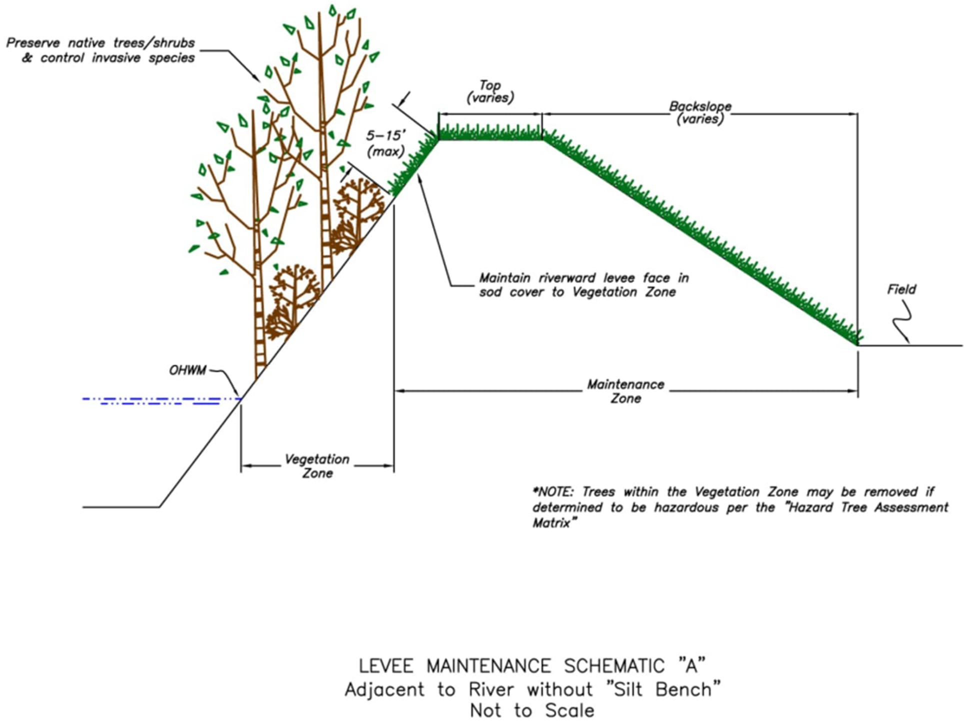


Figure 16: Levee vegetation management plan from 2017 Nooksack SWIF

2.1.1.6 Right-of-Way

Existing ROW north of Star Park is 60-feet-wide and parallels the road centerline. West of the road centerline, the ROW boundary encompasses some underground utilities (power and communication), portions of the Star Park parking lot entrances and median, the Pioneer Park fence, several mature trees, approximately six feet of the Pioneer Park bandshell, and portions of the Senior Center parking lot entrance and grass area. East of the road centerline, the ROW boundary mainly encompasses the levee embankment out to the top of levee on the riverward side. However, there is a 400-foot-long segment where the levee crest width extends outside of ROW up to 25 feet. The Riverwalk path is also within ROW.

2.1.1.7 Planning

As mentioned previously, the City has a picnic pavilion and skatepark planned for future park amenities. Other known improvements and amenities include a formalized path on top of the levee that connects to Star Park.

To the west of park limits is an adjacent Urban Growth Area (UGA) currently zoned for residential development. Such development may be influenced by proximity to Pioneer Park and expand access or recreational opportunities in the area.

To the south of park limits, PUD No. 1 has future improvements planned for their WTP which are expected to occupy the undeveloped area immediately south of the community garden. Other improvements include utility crossings below Ferndale Road to the intake structure.

2.1.1.8 Maintenance and Operations

Levee maintenance and operations (M&O) are the responsibility of the respective sponsoring agency. Whatcom County Flood Control Zone District and Whatcom County Diking District No. 1 co-sponsor the Ferndale WTP Levee, and the City of Ferndale sponsors the Ferndale Levee.

Maintenance items noted in the inspection reports become the agency's responsibility to address, ideally before the next routine inspection. Typical maintenance items include: vegetation removal, filling animal burrows, maintaining super sacks or other closure structures, and erosion repair.

Operations include routine inspection of culvert penetrations, monitoring the levee during and after high-water events, following flood fighting procedures when necessary, and participating in the USACE routine inspections.

While the road provides convenient access to the levee, there are no available equipment and material staging areas on the levee side of the roadway given the congested ROW.

Roadway maintenance and operations consist of paving and patching, crack sealing, street cleaning, and shoulder work. The existing length of Ferndale Road between Star Park and Cherry Street is 0.20 miles.

2.2 Existing Roadway Alignment: Alternative D

Alternative D follows the existing Ferndale Road between Star Park and Cherry Street with no major changes in horizontal alignment or vertical profile. This alternative has the added constraints of fitting a wider roadway, a SUP (to maintain existing trail access), and fill slopes resulting from raising the top of levee, all within existing ROW limits. The most practical solution to this geometric constraint, while attaining the desired flood protection, is constructing approximately 1,535 feet of floodwall between Cherry Street and the PUD No. 1 intake structure. The main drawbacks to this alternative are the cost of the floodwall, increased maintenance cost and repair difficulty, the potential for erosion and sloughing to reduce the integrity of the flood wall, and lesser improvement of riparian habitat (compared to Alternatives A, B, and E). The major benefit is it does not impact any park or recreational facilities, as shown in Figure 18.

Figure 17: Location of Alternative D – Ferndale Road north of Star Park facing north

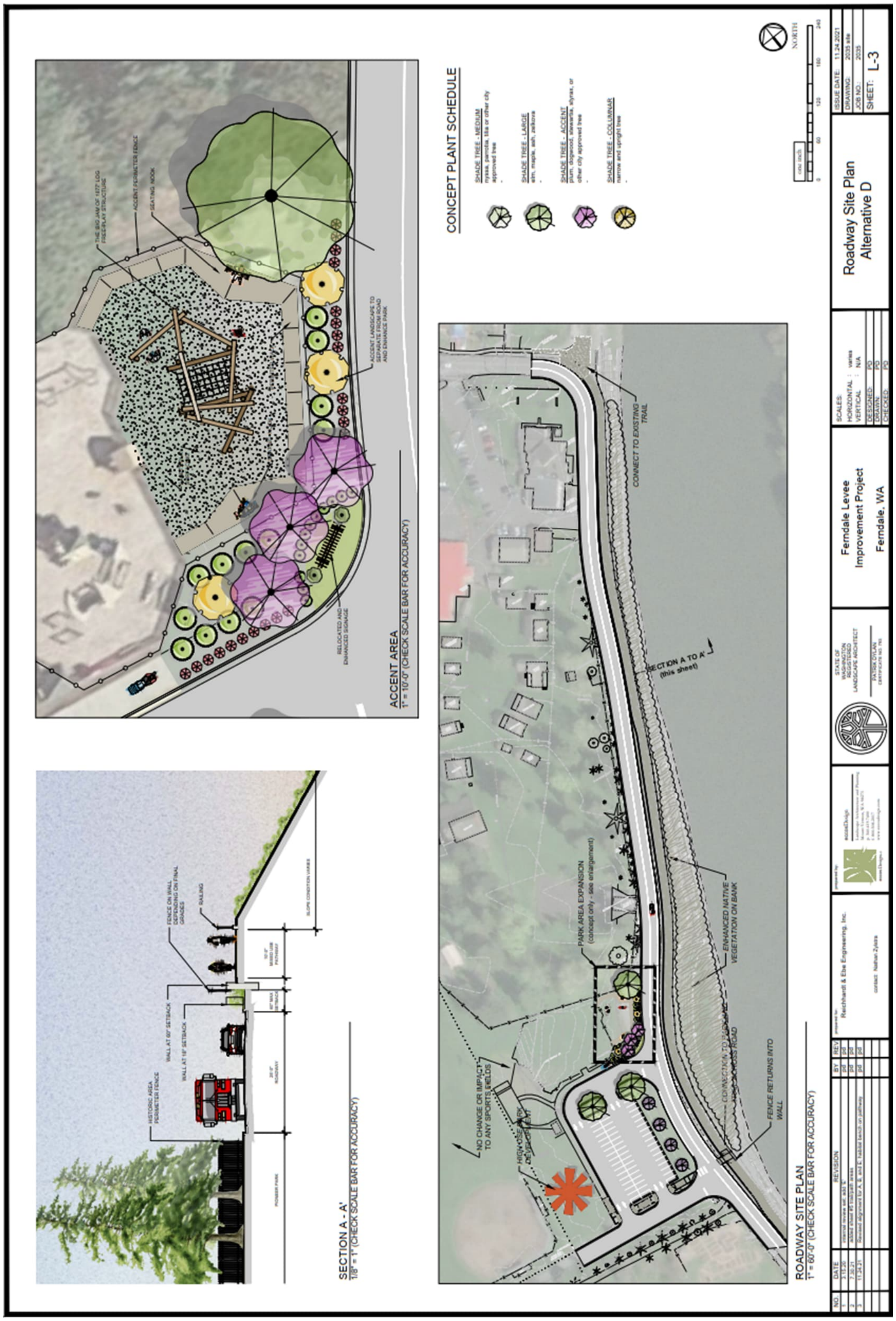


Figure 18: Alternative D Landscape Plans

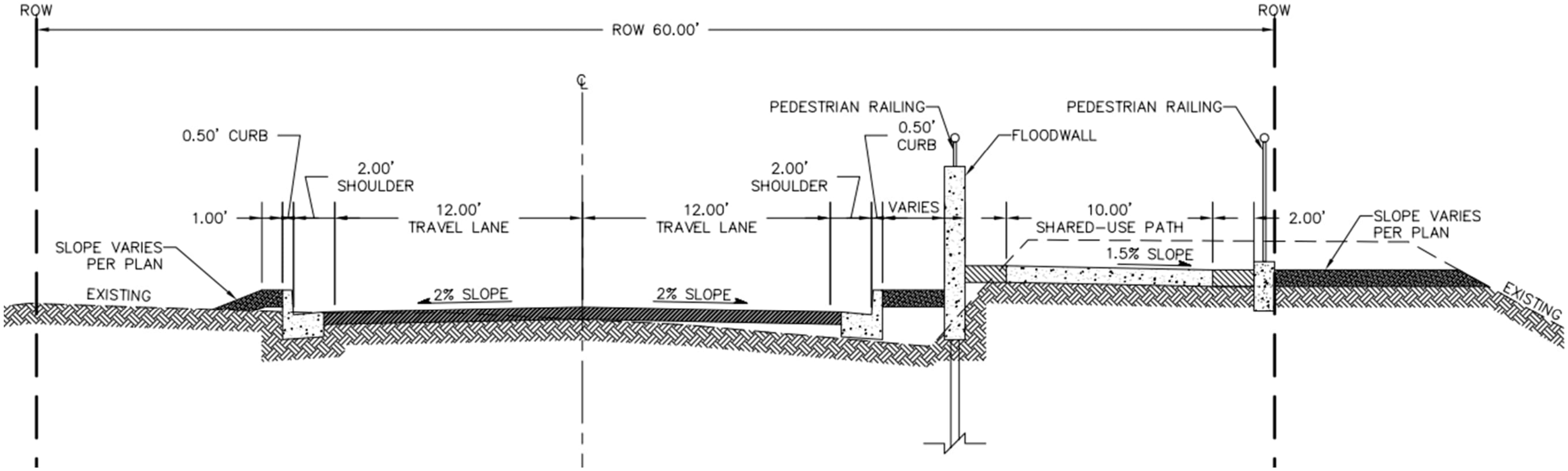


Figure 19: Alternative D Typical Road Section

Figure 18 and Figure 19 and show the proposed road typical section for Alternative D with the SUP on the riverward side of the floodwall. The Ferndale Typical Section detail matches the City of Ferndale standard section for arterials and collectors except for a reduced roadway width and the inclusion of a SUP in lieu of sidewalks.

The justification for constructing a floodwall for flood protection, rather than increasing the levee embankment height using fill, is twofold. First, there is not sufficient ROW to fit the combined width of proposed road and path sections and levee embankment fill slopes (with the caveat that no fill is allowed on the existing levee foreslope). Second, it is not practical to raise the road profile (to the design levee crest elevation) between Cherry Street and the WWTP entrance, which would be the case with the road on top of the raised levee. This is because doing so would require retaining walls along portions of the landward side of the road to contain fill within ROW, and it greatly complicates connecting into driveway entrances to Star Park and the WTP and WWTP facilities (requiring modifications outside ROW). Acquisition of additional ROW to accommodate the levee embankment fill option (in lieu of a floodwall) was not considered as doing so encroaches on Pioneer and Star Parks.

Stormwater runoff management consists of sheet flow and pipe conveyance to various tree and planter boxes for treatment before discharging to either the Nooksack River or potentially the existing City of Ferndale stormwater conveyance system (to be verified during the design phase). Existing culvert penetrations through the Ferndale Levee provide permitted discharge locations. This reach of the Nooksack is flow control exempt and requires only basic water quality treatment.

2.2.1 Evaluation Criteria

2.2.1.1 Recreation

As shown in Figure 18, Alternative D SUP formalizes the existing levee trail with improved connectivity and accessibility along the river between the Riverwalk Plaza and Star Park. While there is limited space available, the path can include smaller amenities like benches and a river viewing nook to tie-in with the existing Riverwalk path farther upstream.

For this Alternative, there are no impacts to the Phillips 66 Sports Complex, Pioneer Park, Star Park, the community garden, or the proposed skatepark location. All existing park operations and programming are unaffected.

2.2.1.2 Traffic Flow

As this alternative maintains the status quo, there are no identified impacts or benefits as it relates to changes in traffic conditions. While it is a rare occurrence, the proposed floodwall can act as a traffic barrier and prevent errant vehicles from going over the levee and into the river.

2.2.1.3 Parking

This alignment alternative does not impact existing parking lot capacity. Only minor modification to the parking lot entrances at Star Park are needed to provide safe access points and a crosswalk for the SUP. These modifications are also shown in Figure 18.

2.2.1.4 Levee Integrity

Rather than a levee fill embankment, Alternative D relies on a floodwall with sheet pile cutoff for flood protection. The exposed portion of the wall extends upward to the design levee crest elevation to prevent overtopping while the sheet pile cutoff extends below ground far enough (approximately 20 feet) to reduce seepage through the remaining levee embankment. Using a floodwall has the advantage of a reduced footprint compared to an embankment levee. Under Alternative D, the sheet pile wall improves global slope stability (i.e. reduces the risk of a geotechnical failure extending to the landward side of the structure) but does not reduce risk of local slope failures (erosion and sloughing) riverward of the wall.

Ensuring levee integrity is expected to require more active flood inspection and response effort and higher maintenance costs than the other alternatives for several reasons:

- Because the alternative does not propose to address the over-steepened bank, continued failures on the bank as has historically occurred, and potentially failures up to the proposed trail, can be expected. These issues would continue to be noted in the USACE inspection reports as deficiencies, potentially impacting the levee rating.
- The design relies on buttressing of the sheet pile by the riverside levee prism so localized sloughs and erosion failures that are expected to continue due to the over-steepened bank will be required to be addressed promptly.
- Equipment access riverward of the floodwall will be more difficult, especially during a flood. Equipment must either use the relatively narrow trail or work across the floodwall. Work from the trail will require entering through floodwall openings. Once on the trail there will be limited room to maneuver, and equipment will have to work close to top of slope. Working across the floodwall will likely create reach issues and only allow work on the top of the slope unless a crane is used.

2.2.1.5 Habitat Area

There are no identified impacts with this alternative as it relates to habitat area. And while no new opportunities are created, improvements will be made to the existing riparian area with plantings on the levee foreslope which benefits both slope stability and habitat.

2.2.1.6 Permitting

There are no identified impacts or benefits with this alignment as it relates to permitting. Standard project and construction permitting for a new roadway and levee is anticipated.

2.2.1.7 Right-of-Way

Right-of-way acquisition is not anticipated for this alternative as the road, levee, and SUP improvements remain inside existing ROW limits (with the construction of a floodwall). Avoiding encroachments or impacts to Pioneer and Star Parks is a design constraint which precludes acquiring ROW in those areas.

2.2.1.8 Planning

This alignment does not impact any existing parks and recreations spaces, nor impact known future improvements. This ensures that all future City planning efforts are unaffected. Rather, the levee SUP accomplishes the City’s identified Master Plan project to formalize the levee trail and connect it to Hanadori Trail.

2.2.1.9 Maintenance and Operations

Access for levee maintenance and operations for Alternative D is limited and inconvenienced by the adjacent roadway and the proposed floodwall. While the road provides convenient access to the levee, there are no available equipment and material staging areas on the levee side of the roadway given the congested ROW and physical barrier to the levee created by the floodwall. This means that staging areas will occupy either nearby park and pedestrian areas or the roadway, requiring temporary traffic control with partial lane closures. With a floodwall separating the road and levee, equipment access and space for maneuvering is constricted. To improve this, designated access points to the path are provided at the wall end at Cherry Street and the proposed crosswalk at Star Park. Note that it is possible to add an intermediate access point if desired, and that wall openings are detailed to accommodate stop log barriers for rapid installation during high-water events, providing uniform protection with the floodwall.

The floodwall adds potential maintenance, operations, and inspection items to the City's current sponsoring efforts. Such items may include graffiti removal, debris clearing, and structural inspection and repair to prevent seepage and ensure stability. The key addition to the City's operations responsibilities is deploying stop logs at the wall openings during flood events and checking for seepage.

The floodwall eases potential maintenance and operations by allowing the top of the proposed trail surface to be up to four feet lower compared to the top of a conventional embankment levee of the same crest elevation. This reduces levee surface area and makes it easier to reach lower portions of the levee foreslope with equipment. Repairs closer to the levee toe typically require benching and excavating down for access. In this case, and depending on the excavation depth, the floodwall can double as shoring.

In addition to flood protection, the sheet pile floodwall improves global slope stability of the existing over-steepend levee embankment. Per analysis to-date, improvements to flatten the existing levee foreslope to 2H:1V are not necessary within the limits of the wall to achieve global stability. However, localized areas of erosion will still likely occur and require attention.

2.2.1.10Cost

Based on the current concept-level design of the 0.2 mile-long existing roadway alignment alternative described here-in, the estimated construction cost, with a 15% contingency, is $6.57 million. This includes all needed levee, slope protection, riparian planting, roadway, stormwater management, SUP, landscaping, and floodwall related improvements identified at this time. A detailed cost estimate is provided in Appendix G. Items omitted or not in scope of this design include general utility improvements, park facility improvements (other than modification to the Star Park parking lot), and optional path accent areas or amenities as desired for development on or near the levee SUP.

2.3 New Roadway Alignment: Alternatives A, B, E

Alignment Alternative A – 2nd Avenue Extension

As shown in the landscape plans of Figure 23, Alternative A routes the roadway on 2nd Avenue then through parts of the Phillips 66 Sports Complex recreational fields before reconnecting with Ferndale Road in the vicinity of the Star Park parking lot, all at existing grade. The major benefits, like Alternatives B and E, are flexibility in the levee and path design and increased area to restore riparian habitat between Star Park and Cherry Street, while the major impacts are conflicts with existing and proposed recreational facilities.

Figure 20: Location of Alternative A – Standing on Field A facing northwest

Alignment Alternative B – 1st Avenue Extension

Alternative B routes the roadway on 1st Avenue through the existing Pioneer Pavilion Community Center parking lot and through parts of the Phillips 66 Sports Complex recreational fields before reconnecting with Ferndale Road in the vicinity of the Star Park parking lot. The major benefits, like Alternatives A and E, is flexibility in the levee and path design and increased area to restore riparian habitat between Star Park and Cherry Street, while the major impacts include reduced Pioneer Pavilion parking, conflicts with existing recreational facilities, and routing traffic to the 1st and Main Street intersection where there is no traffic signal. This alignment is shown in the landscape plans of Figure 24.

Figure 21: Location of Alternative B – Standing on Field A facing north

Alignment Alternative E – 2nd Avenue Routed West

Alternative E routes the roadway on 2nd Avenue, through the Phillips 66 Sports Complex parking lot, and then to the west around the Phillips 66 Sports Complex, eventually turning east and connecting with Ferndale Road in the vicinity of the Star Park parking lot. The major benefits, like Alternatives A and B, are flexibility in the levee and path design and increased area to restore riparian habitat between Star Park and Cherry Street while also not impacting the recreational facilities. The biggest impact is to existing wetlands to the west. See Figure 25 for a plan view detail of this alignment.

Figure 22: Location of Alternative E – Standing on Hanadori Trail near Field A facing west

Figure 26 and Figure 27 show the proposed road typical sections for Alternatives A, B, and E. The Shared-Use Path Typical Road Section detail matches the City of Ferndale standard section for arterials and collectors except for a reduced roadway width and the inclusion of a SUP in lieu of sidewalks. The Boulevard Typical Road Section, included for Alternatives A and B only, does not follow a specific City standard but is proposed as a means of enhancing the roadway through the park setting, as shown in the landscape plans. Enhancements offered by the center median include traffic calming, pedestrian refuge at crossings, and improved aesthetics from added trees and vegetation.

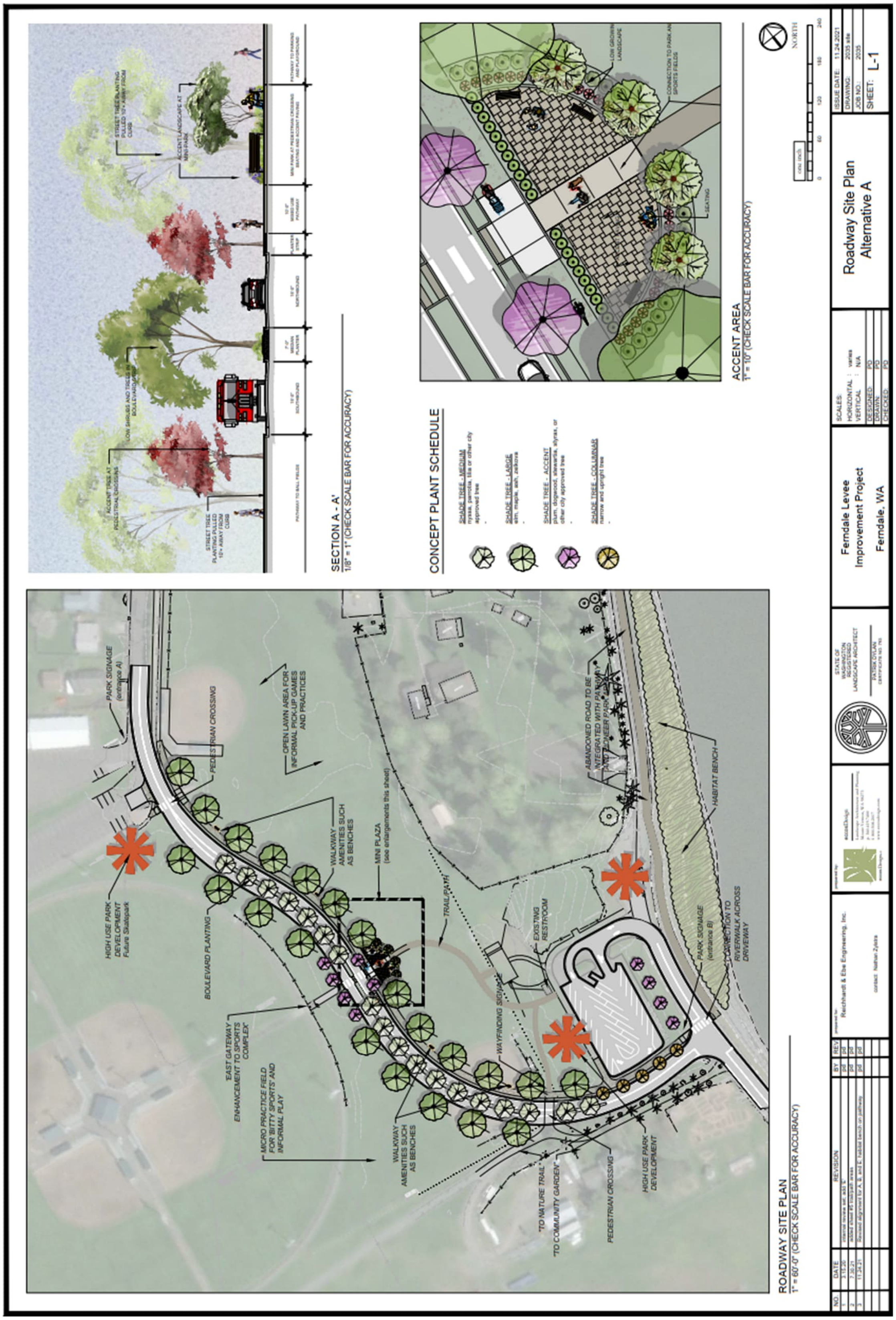


Figure 23: Alternative A Landscape Plans

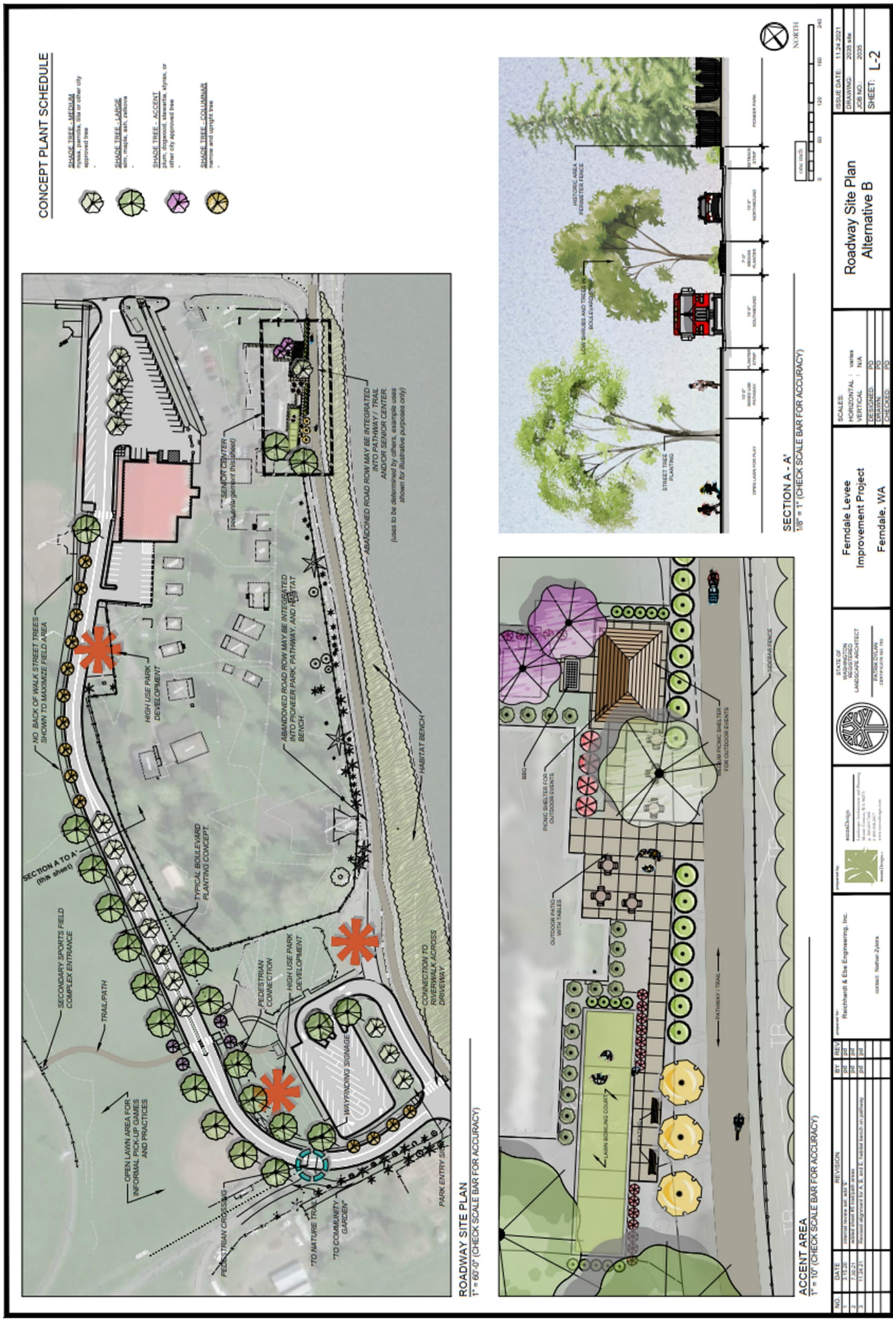


Figure 24: Alternative B Landscape Plans

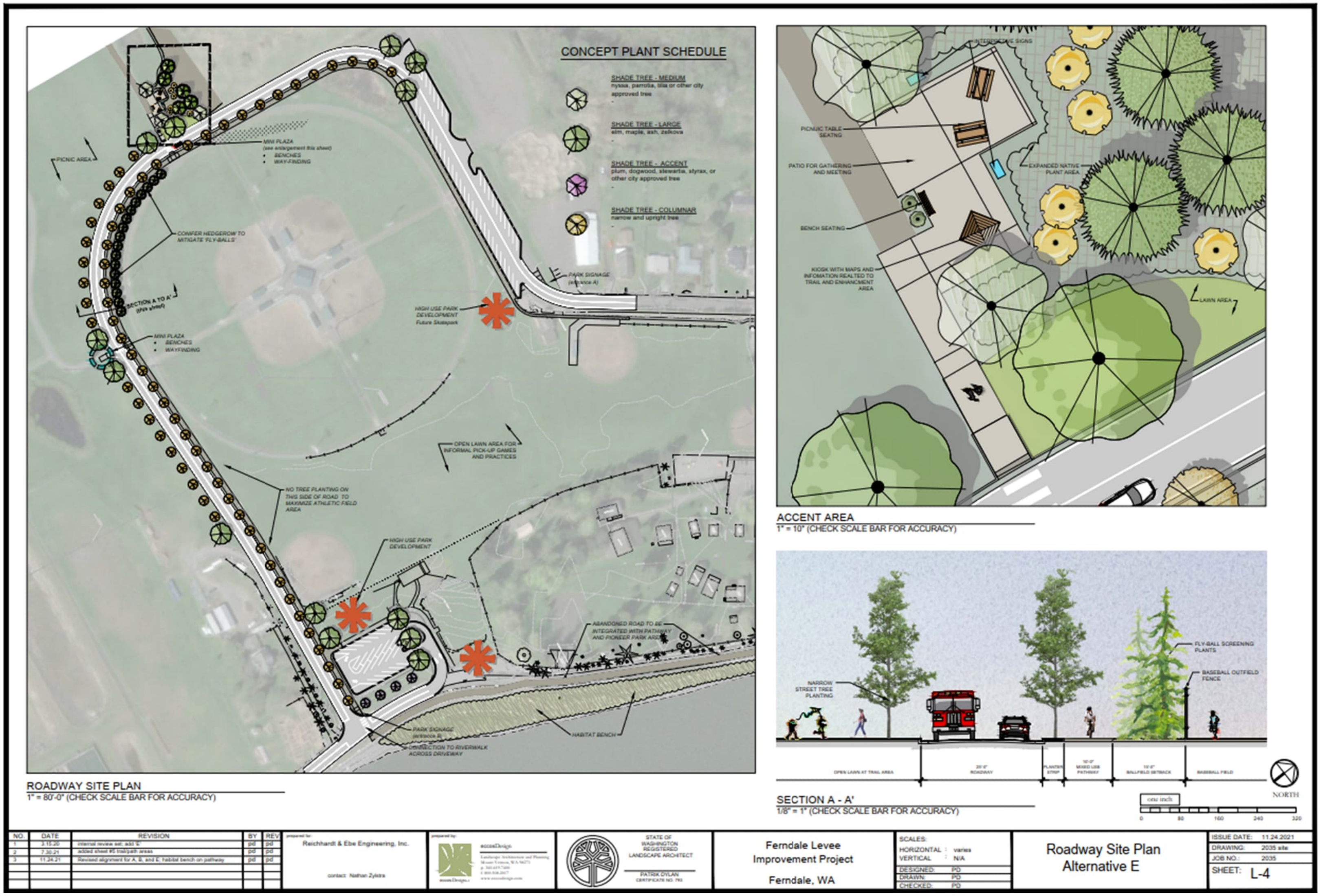


Figure 25: Alternative E Landscape Plans

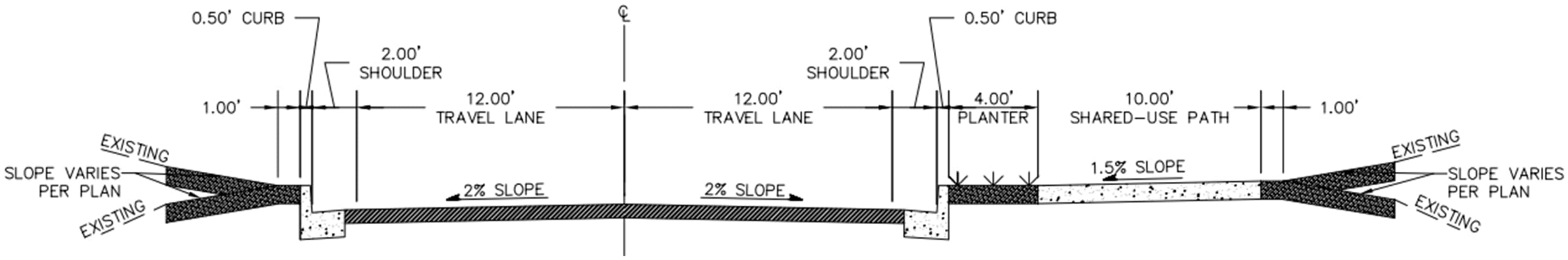


Figure 26: Alternative A and B - Boulevard Typical Road Section

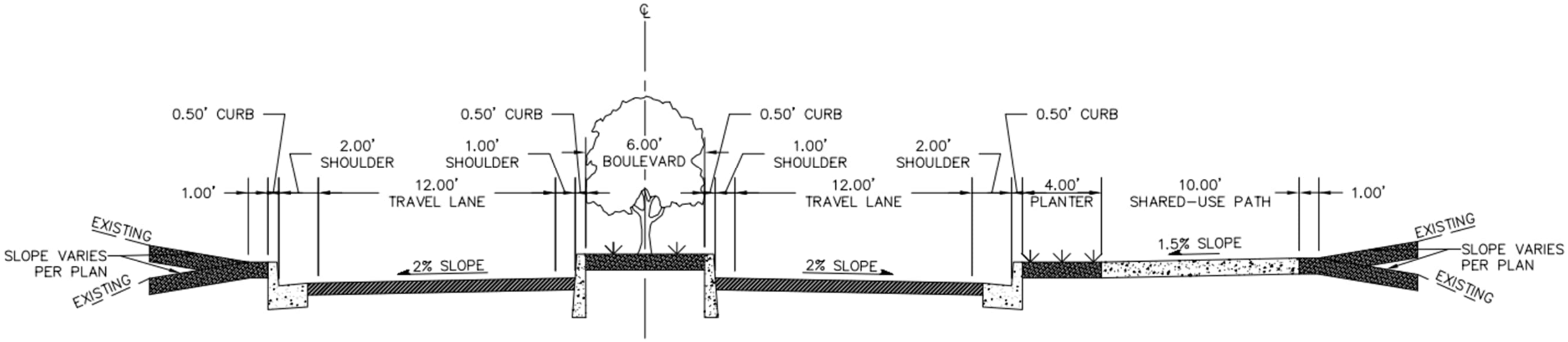


Figure 27: Alternative A, B, and E - Shared-Use Path Typical Road Section

In addition to a SUP parallel with the alternative road alignment, formalization of the existing levee trail into a SUP is proposed with each alternative. The SUP is integrated with the raised levee embankment. Figure 28 and Figure 29 show the path typical section and landscape plans, respectively.

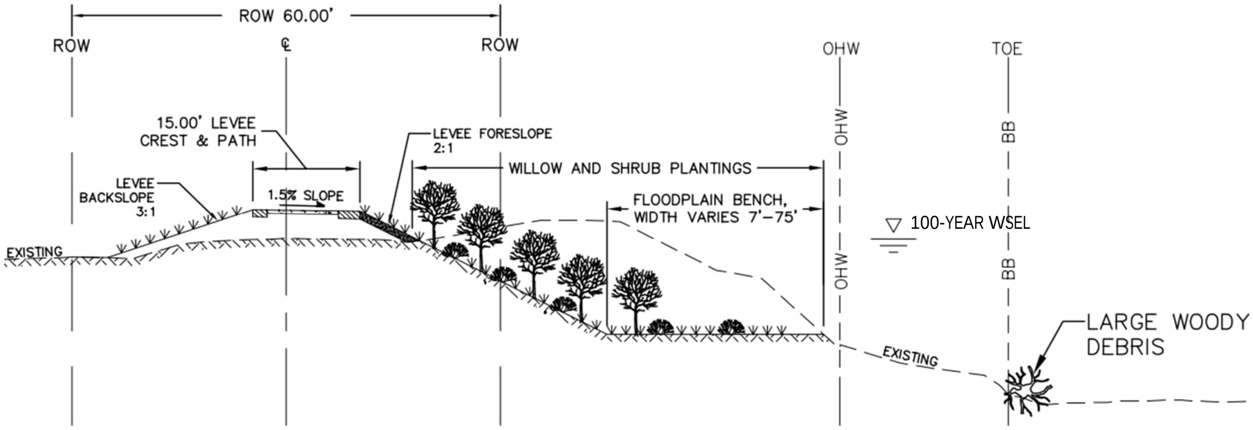


Figure 28: Shared-Use Path Section Paired w/ Alternatives A, B, and E

As mentioned for Alternative D, stormwater runoff management for these alternatives consists of sheet flow and pipe conveyance to various tree and planter boxes for treatment before discharging to either the Nooksack River or potentially the existing City of Ferndale stormwater conveyance system (to be verified). Existing culvert penetrations through the Ferndale Levee provide permitted discharge locations. This reach of the Nooksack is flow control exempt and requires only basic treatment.

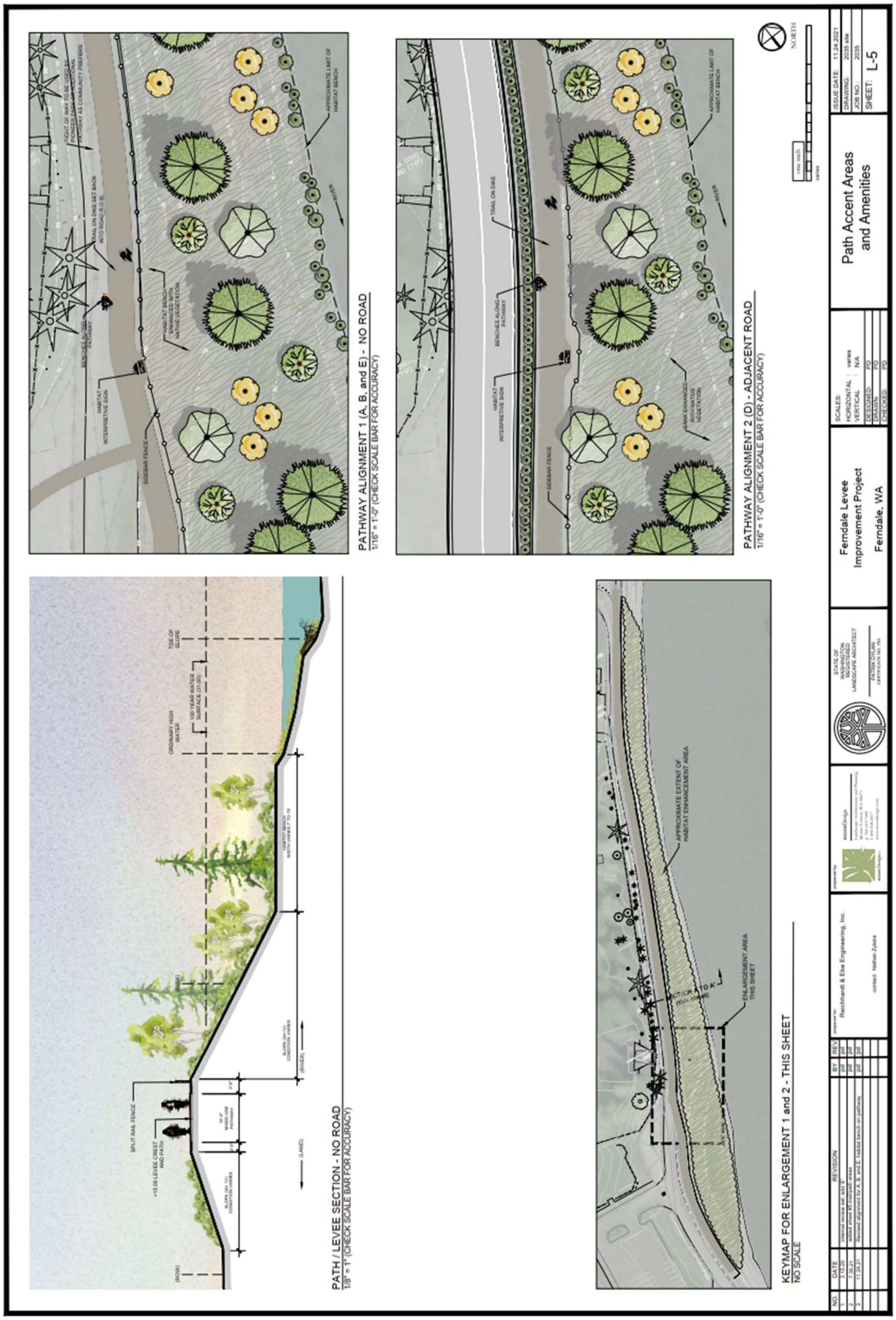


Figure 29: Shared-Use Path Landscape Plans

2.3.1 Evaluation Criteria

2.3.1.1 Recreation

Alignment Alternative A – 2nd Avenue Extension
With the alignment essentially extending 2nd Avenue to the Star Park parking lot, there are obvious impacts to the Phillips 66 Sports Complex recreation fields. The main drawbacks are: ball Field A is entirely eliminated, the open grass and soccer field area is bisected, and the road passes very close to the proposed site of the future skatepark. While there is not adequate remaining park space to fit a replacement Field A or the soccer field, there are opportunities for relocating the skatepark elsewhere along the proposed corridor. Having a road in such proximity to the skatepark benefits monitoring efforts by increasing public visibility of the space and users.

At the current level of design, there are no anticipated impacts to the Phillips 66 Sports Complex tournament ball fields, Field B, Star Park, or the community garden.

Alignment Alternative B – 1st Avenue Extension
Extending 1st Ave through Pioneer Park causes direct impacts to the Phillips 66 Sports Complex recreation fields. The main drawbacks to existing facilities are: ball Field A and the Pioneer Park playground are entirely eliminated, and the open grass and soccer field area and outfield for Field B are encroached upon. As for impacts to proposed recreation facilities, this alignment passes in close proximity (within 25 feet) to the planned picnic shelter at Star Park. While there is adequate remaining park space to maintain the open grass and soccer fields and replace the playground, there is not sufficient area to rearrange or replace Fields A and B to their original size.

At the current level of design, there are no anticipated impacts to the Phillips 66 Sports Complex tournament ball fields, Pioneer Park sports fields, Star Park, the proposed skatepark, or the community garden.

Alignment Alternative E – 2nd Avenue Routed West
By routing around the Phillips 66 Sports Complex, nearly all impacts to existing and proposed parks and recreation facilities are avoided. The only identified conflict is with the south dugout of Field A which requires just minor shifting of the field to the northeast to mitigate. While the corridor creates a division with open park area to the south and west, these areas are not as frequently used. Improved access to these areas, as provided by this alternative, may increase use.

At the current level of design, there are no anticipated impacts to the Phillips 66 Sports Complex tournament ball fields, Pioneer Park sports fields, Star Park, the proposed skatepark, or the community garden.

As shown in the landscape plans, the SUP parallel to each alternative and the various side trails provide greater connectivity and accessibility between the parks and recreation areas and enhances the existing trail network around Pioneer Park. Minor amenities like benches and river viewing nooks offer simple enhancements for trail users to view and appreciate the river scenery while still prioritizing riparian restoration efforts. Additional optional accent areas are possible and include amenities like picnic shelters, patios, and other small activity and gathering areas.

2.3.1.2 Traffic Flow

A Traffic impact analysis of each alternative was completed and is documented in Appendix F. Analyses focused on qualitative impacts to traffic patterns and multimodal safety, the main findings of which are summarized here for convenience. Note that impacts related to roadway capacity and level of service were excluded as future expected traffic volumes are relatively low and unchanged from current conditions.

Alignment Alternative A – 2nd Avenue Extension

Because this alternative directly links Ferndale Road and 2nd Avenue, it is expected that traffic volume on 2nd Avenue between Main Street and the Phillips 66 Sports Complex will increase, and traffic volume on 1st Avenue between Main Street and Cherry Street will decrease.

The repeated reverse curve alignment creates natural traffic calming, a safety mitigation strategy for the increased pedestrian crossings between park areas.

Alignment Alternative B – 1st Avenue Extension

Alternative B is expected to have the opposite effect on traffic volumes compared to Alternative A. With a direct connection of Ferndale Road and Main Street via 1st Avenue, more volume will be serviced by 1st Avenue. A previous project removed a traffic signal at the Main Street and 1st Avenue intersection to alleviate traffic congestion on Main Street. While routing all Ferndale Road traffic down 1st Avenue runs counter to that effort, the increase in volume does not warrant reinstalling the traffic signal.

Increased traffic and potential congestion at Pioneer Pavilion Community Center parking lot may cause confusion and hazards for drivers and pedestrians alike. Maintaining the stop-controlled movement at the Cherry Street intersection may be necessary to control speeds through the parking lot and past the school. Given longer straight sections in the alignment, maintaining line of sight and a reduced speed limit are important mitigation strategies for northbound traffic entering the parking area.

Alignment Alternative E – 2nd Avenue Routed West

While this alternative is expected to effect traffic in a similar manner as Alternative A (since it also directs all traffic down 2nd Avenue), the longer, circuitous alignment is anticipated to dissuade drivers from taking this route, leading to reduced traffic volume. As with Alternative B, this alignment has longer, straight sections, and passes through a parking lot, thereby requiring a reduced speed limit to mitigate the increased pedestrian and vehicle hazards.

Overall, of these three new roadway alignment alternatives, Alternative A has the least amount of traffic and safety impacts, whereas Alternative E has the most.

2.3.1.3 Parking

Alignment Alternative A – 2nd Avenue Extension

This alignment alternative does not impact existing parking lot capacity. Only minor modification to the parking lot entrances at Star Park and the Phillips 66 Sports Complex are needed to provide safe access points. These modifications are also shown in Figure 23. While not shown, it is possible to add pocket parking along the northbound side of the boulevard section for convenient park access.

Alignment Alternative B – 1st Avenue Extension

This alignment alternative eliminates up to 50 parking stalls from the Pioneer Park parking lot in front of the Pioneer Pavilion Community Center. It does not impact existing parking lot capacity at Star Park but does require minor modification to the parking lot entrance to provide safe access points. This modification is also shown in Figure 24. While not shown, it is possible to replace some eliminated parking and create convenient park access by developing the existing road segment near the Cherry Street and Ferndale Road intersection into a parking lot, or adding pocket parking along the southbound side of the boulevard section. Note that replacing all eliminated parking results in further impacts elsewhere. A lower speed limit through the community center parking lot area is necessary to reduce hazards to pedestrians or parking vehicles, especially since parking collisions are already common.

Alignment Alternative E – 2nd Avenue Routed West

Despite this alignment alternative going directly through the Phillips 66 Sports Complex parking lot, it does not impact parking lot capacity. The only changes to the parking lots are orienting the stalls diagonally and minor modification of entrances to both parking lots to provide safe access points. These modifications are also shown in Figure 25. As with Alternative B, a lower speed limit through the parking lot is necessary to reduce hazards to pedestrians or parking vehicles, especially since parking collisions are already common.

2.3.1.4 Levee Integrity

With only the SUP section needing to fit inside the existing ROW between Star Park and Cherry Street, there is ample space to flatten the foreslope to improve stability and raise the levee embankment to the design levee crest elevation with additional fill (in contrast, Alternative D must fit the SUP and road section within ROW). Raising the levee in such a fashion results in consistency with the existing levee, meaning the same performance and conditions can be expected. An embankment levee is the most common and traditional type of flood protection for the surrounding area and historically offers straightforward design, construction, and reliability. Embankment levees are typically the most cost-effective levee type as well.

2.3.1.5 Habitat Area

The absence of a road corridor between the river and Pioneer Park allows space for substantial riparian habitat improvements. Such improvements include addition of a floodplain bench for sediment deposition, large woody debris (LWD) to enhance aquatic habitat and restore stream processes, and planting shrubs and willows to stabilize the bench and embankment slope. Each of these improvements adds critical value and function to restoring the natural riparian habitat currently missing from this section of the riverbank.

Figure 30 shows a typical section of the levee embankment with proposed riparian habitat restoration (as shown above in Figure 29 and separately shown below for emphasis). By shifting the existing levee crest towards Pioneer Park, additional room is created for the floodplain bench. The bench is located at the maximum mean annual WSEL (~5,000 cubic feet per second) which is wet approximately 20% of the year on average, primarily during higher winter and spring flows. Proposed plantings meet the SWIF vegetation management plan requirements allowing only sod on the levee backslope, crest, and top 5-15 feet of foreslope. Addition of LWD improves bank stability when placed along the bank toe and oriented with the rootwad directed upstream. The satellite images of Figure 31 below are an example of stream restoration incorporating LWD on the Green River near Tukwila, WA.

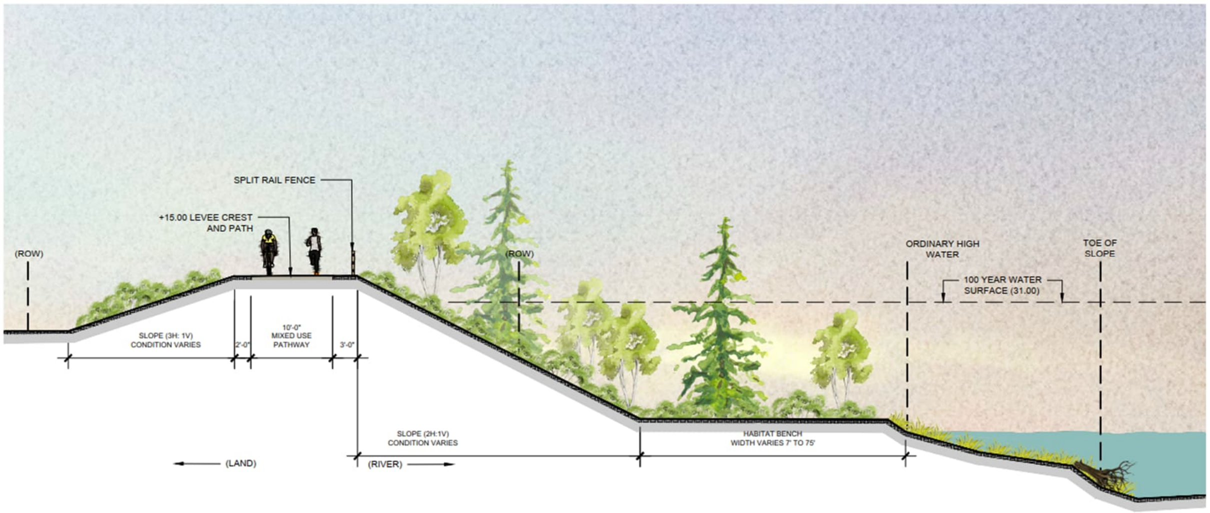


Figure 30: Levee and Riparian Restoration Typical Section (from Shared-Use Path Landscape Plans)

Figure 31: Stream Restoration on the Green River Incorporating Large Woody Debris; (a) As shown after original installation in 2009; (b) As shown in 2018, representative of current conditions

While there are no habitat impacts for Alternatives A or B, Alternative E has the drawback of impacting approximately 0.20 acres of existing wetland area immediately west of the Phillips 66 Sports Complex.

2.3.1.6 Permitting

There are no identified impacts or benefits for Alternatives A and B as they relate to permitting. Standard project and construction permitting for a new roadway and levee is anticipated. For Alternative E, additional permitting is necessary to address the 0.20 acres of anticipated wetland impacts immediately west of the Phillips 66 Sports Complex. Such impacts require a USACE permit and mitigation or enhancement at a 3:1 mitigated-to-impacted area ratio. The County has identified an available mitigation site to address this concern. These three alternatives will likely be less cumbersome to permit than Alternative D as there is more flexibility with their designs to meet no-rise requirements, as well as the increased riparian habitat.

2.3.1.7 Right-of-Way

Right-of-way acquisition is necessary for the full length of each of the proposed roadway alignments since they entirely deviate from the existing road and county ROW. For the proposed widths of 46 feet and 56 feet for the Ferndale and Boulevard road sections, respectively, a typical 60-foot ROW width is sufficient. The 1,250-feet-long Alignment A, 1,710-feet-long Alignment B, and 2,675-feet-long Alignment E, equates to 1.20, 2.35, and 3.70 acres of new ROW, respectively. The needed ROW for Alternatives A, B, and E, are currently open park space owned by the City of Ferndale, a noted stakeholder of the project. It is possible that the ROW being acquired can be interchanged with the existing Ferndale Road ROW that is no longer needed (with equitable adjustment as necessary). A small portion of ROW area needed for Alternative E is currently designated as wetland mitigation which requires replacing where impacted.

2.3.1.8 Planning

These new alignments occupy and divide various park and recreation spaces, complicating future use planning and development efforts for the existing park areas. However, relocating the roadway creates new, recreation opportunities along the river that may benefit other users.

A potential (long-term) benefit specific to Alternative E, is that its alignment farther to the west lends itself to providing access to future development of the current UGA located to the west of the park area.

2.3.1.9 Maintenance and Operations

Existing levee maintenance, operations, and inspection are not impacted by these alternatives given the new levee is of the same type (embankment) and in the same location. However, it may be worth noting that the increase in levee height directly increases the levee surface area and could result in minor added maintenance costs.

There is a -20%, +8%, and +70% change in road length and -6%, +50%, and +66% change in pavement area for Alternatives A, B, and E, respectively, compared to the existing road. Further, the road alignments have a SUP in addition to the proposed SUP on top of the levee. This increase in infrastructure is expected to add minor long-term maintenance costs.

A significant advantage to separating the road and levee alignments is that it simplifies and provides more room for equipment access for repair and improvement efforts to the levee.

2.3.1.10 Cost

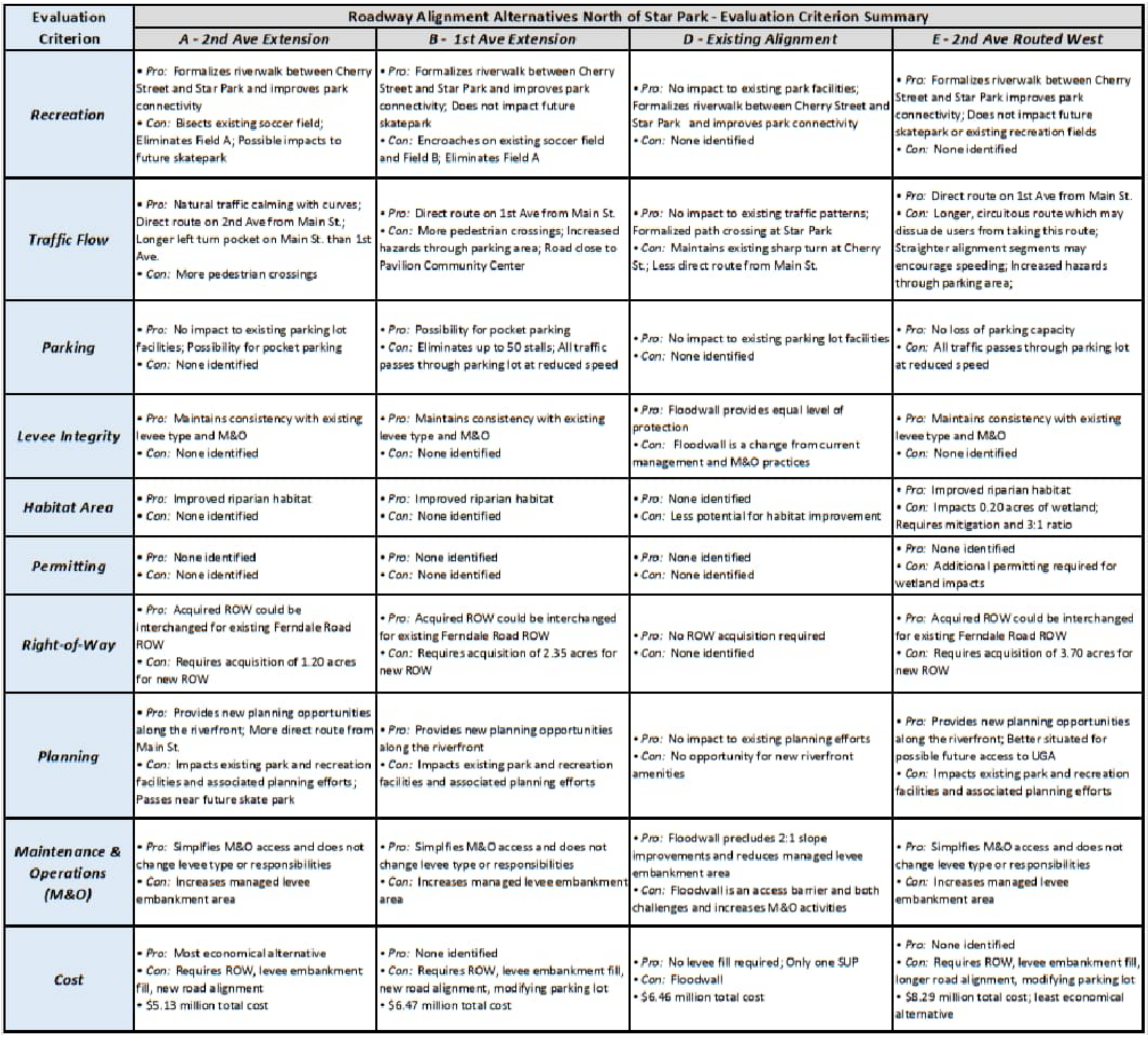
Based on the current concept-level design of the new roadway alignment alternatives described here-in, the estimated construction cost, with a 15% contingency, is $5.42 million, $6.86 million, and $8.65 million for Alternatives A, B, and E, respectively. This includes all needed levee, slope protection, riparian restoration, roadway, ROW acquisition, stormwater management, wetland mitigation (Alternative E only), SUP, and landscaping related improvements identified at this time. Detailed cost estimates are provided in Appendix G. Items omitted or not in scope of this design include general utility improvements, park facility improvements other than modification to the existing parking lots as applicable, and optional path accent areas or amenities as part of desired development on or near the levee SUP.

2.4 Summary and Selection of Alternatives

2.4.1 Alternatives Comparison

Alternative D follows the existing roadway whereas the remaining alternatives pass through the park areas. The benefits of following the existing road are that it does not impact current park use or planning, needs no ROW acquisition, and maintains existing established traffic patterns. The downsides are the added cost for a floodwall as flood protection, lack of improved over-steepened foreslopes or riparian habitat, and the restrictive access for maintenance and repair it creates. The benefits to an alignment through the park are the restored riparian habitat, simplified levee construction, reduced erosion potential, and improved access for maintenance and repair needs. The drawbacks to these varying alternatives are the necessary ROW acquisition and disruption to current parks usage and future planning. The pros and cons of each alternative, categorized by the established evaluation criteria, are summarized in Table A below. Note that there is minimal difference between impacts for the permitting and planning criterion.

Table A: Alignment Alternatives Summary Comparison



Evaluation Criterion	Roadway Alignment Alternatives North of Star Park - Evaluation Criterion Summary			
	A - 2nd Ave Extension	***B - 1st Ave Extension***	***D - Existing Alignment***	***E - 2nd Ave Routed West***
Recreation	• *Pro:* Formalizes riverwalk between Cherry Street and Star Park and improves park connectivity • *Con:* Bisects existing soccer field; Eliminates Field A; Possible impacts to future skatepark	• *Pro:* Formalizes riverwalk between Cherry Street and Star Park and improves park connectivity; Does not impact future skatepark • *Con:* Encroaches on existing soccer field and Field B; Eliminates Field A	• *Pro:* No impact to existing park facilities; Formalizes riverwalk between Cherry Street and Star Park and improves park connectivity • *Con:* None identified	• *Pro:* Formalizes riverwalk between Cherry Street and Star Park improves park connectivity; Does not impact future skatepark or existing recreation fields • *Con:* None identified
Traffic Flow	• *Pro:* Natural traffic calming with curves; Direct route on 2nd Ave from Main St.; Longer left turn pocket on Main St. than 1st Ave. • *Con:* More pedestrian crossings	• *Pro:* Direct route on 1st Ave from Main St. • *Con:* More pedestrian crossings; Increased hazards through parking area; Road close to Pavilion Community Center	• *Pro:* No impact to existing traffic patterns; Formalized path crossing at Star Park • *Con:* Maintains existing sharp turn at Cherry St.; Less direct route from Main St.	• *Pro:* Direct route on 1st Ave from Main St. • *Con:* Longer, circuitous route which may dissuade users from taking this route; Straighter alignment segments may encourage speeding; Increased hazards through parking area;
Parking	• *Pro:* No impact to existing parking lot facilities; Possibility for pocket parking • *Con:* None identified	• *Pro:* Possibility for pocket parking • *Con:* Eliminates up to 50 stalls; All traffic passes through parking lot at reduced speed	• *Pro:* No impact to existing parking lot facilities • *Con:* None identified	• *Pro:* No loss of parking capacity • *Con:* All traffic passes through parking lot at reduced speed
Levee Integrity	• *Pro:* Maintains consistency with existing levee type and M&O • *Con:* None identified	• *Pro:* Maintains consistency with existing levee type and M&O • *Con:* None identified	• *Pro:* Floodwall provides equal level of protection • *Con:* Floodwall is a change from current management and M&O practices	• *Pro:* Maintains consistency with existing levee type and M&O • *Con:* None identified
Habitat Area	• *Pro:* Improved riparian habitat • *Con:* None identified	• *Pro:* Improved riparian habitat • *Con:* None identified	• *Pro:* None identified • *Con:* Less potential for habitat improvement	• *Pro:* Improved riparian habitat • *Con:* Impacts 0.20 acres of wetland; Requires mitigation and 3:1 ratio
Permitting	• *Pro:* None identified • *Con:* None identified	• *Pro:* None identified • *Con:* None identified	• *Pro:* None identified • *Con:* None identified	• *Pro:* None identified • *Con:* Additional permitting required for wetland impacts
Right-of-Way	• *Pro:* Acquired ROW could be Interchanged for existing Ferndale Road ROW • *Con:* Requires acquisition of 1.20 acres for new ROW	• *Pro:* Acquired ROW could be interchanged for existing Ferndale Road ROW • *Con:* Requires acquisition of 2.35 acres for new ROW	• *Pro:* No ROW acquisition required • *Con:* None identified	• *Pro:* Acquired ROW could be interchanged for existing Ferndale Road ROW • *Con:* Requires acquisition of 3.70 acres for new ROW
Planning	• *Pro:* Provides new planning opportunities along the riverfront; More direct route from Main St. • *Con:* Impacts existing park and recreation facilities and associated planning efforts; Passes near future skate park	• *Pro:* Provides new planning opportunities along the riverfront • *Con:* Impacts existing park and recreation facilities and associated planning efforts	• *Pro:* No impact to existing planning efforts • *Con:* No opportunity for new riverfront amenities	• *Pro:* Provides new planning opportunities along the riverfront; Better situated for possible future access to UGA • *Con:* Impacts existing park and recreation facilities and associated planning efforts
Maintenance & Operations (M&O)	• *Pro:* Simplfies M&O access and does not change levee type or responsibilities • *Con:* Increases managed levee embankment area	• *Pro:* Simplfies M&O access and does not change levee type or responsibilities • *Con:* Increases managed levee embankment area	• *Pro:* Floodwall precludes 2:1 slope improvements and reduces managed levee embankment area • *Con:* Floodwall is an access barrier and both challenges and increases M&O activities	• *Pro:* Simplfies M&O access and does not change levee type or responsibilities • *Con:* Increases managed levee embankment area
Cost	• *Pro:* Most economical alternative • *Con:* Requires ROW, levee embankment fill, new road alignment • $5.13 million total cost	• *Pro:* None identified • *Con:* Requires ROW, levee embankment fill, new road alignment, modifying parking lot • $6.47 million total cost	• *Pro:* No levee fill required; Only one SUP • *Con:* Floodwall • $6.46 million total cost	• *Pro:* None identified • *Con:* Requires ROW, levee embankment fill, longer road alignment, modifying parking lot • $8.29 million total cost; least economical alternative

2.4.2 Stakeholder Workshop and Alignment Selection Process

Primary stakeholders met for an in-person workshop on April 19, 2022 with the objective to collectively select a preferred roadway alignment alternative north of Star Park. The workshop took place at the Ferndale Public Library and was set-up as an informal, conference room setting with facilitation and presentations by R&E. After brief presentation of project background and summary of the alignment alternatives, the workshop objective was accomplished through stakeholder participation in a scoring process intended to promote group discussion and collaborative decision making. The scoring process involved three main steps: 1) Weighting of evaluation criteria, 2) Scoring of alignment alternatives, and 3) Ranking and selection of alternatives. Discussion highlights from the workshop, the scoring process, and the outcome are covered in detail below.

A complete agenda and list of attendees can be found in Appendix H.

Primary project stakeholders in attendance were:

- Whatcom County Flood Control Zone District
- City of Ferndale
- Whatcom County PUD No. 1
- Washington Department of Fish and Wildlife (WDFW)
- Lummi Nation
- Nooksack Indian Tribe

2.4.2.1 Workshop Highlights

The list below provides an abbreviated summary of notable proceedings and discussion:

Proceedings

- R&E facilitated the workshop and discussions but did not participate in the scoring exercise
- The County and City had equal representation with each having three participants, while the other stakeholder groups had one
- While not a stakeholder group, two design team engineers from NHC were in attendance and participated in the discussion but did not participate in scoring exercises
- The weighting and scoring process gave each participant equal contribution, rather than each stakeholder group having one collective “voice”
- The City requested additional stormwater management information for the alternatives
- Given the workshop location was near the project area, participants were able to walk the existing and proposed Ferndale Road alignments to aid in their understanding of project benefits and drawbacks

Alternatives Discussion

- Alternative D provides the least opportunity for habitat improvement but has no parks impacts
- Alternatives A, B, and E provide opportunity for increased habitat improvement through a varied width habitat bench but have varying degrees of parks impacts
- Alternatives A and B have high impacts to Field A which is the City’s only Pony League baseball field
- The City confirmed their new skatepark project is still moving forward with anticipated construction in 2022 and that its proposed location is in direct conflict with Alternative A

- The City confirmed the Star Park picnic shelter is completed and is in close proximity to Alternative B
- Although B has large impacts (up to 50 stalls) to the Pioneer Pavilion parking lot, there seemed to be willingness and/or desire from the City to look at reconfiguring the Pioneer Pavilion and Senior Center parking lots as well as looking at additional opportunities to mitigate parking loss
- There was consensus that the choice between alternatives was a choice between opportunities for habitat improvement versus impacts to parks facilities
- The City of Ferndale expressed the most concern over parks impacts while the County expressed concern over levee integrity, and the WDFW, the Lummi Tribe, and Nooksack Tribe expressed the most concern over habitat
- The WDFW stated that the potential habitat improvements offered by Alternatives A, B, and E is limited and small in area, but that if possible, should be maximized to the greatest extent feasible
- Since the cost range of the alternatives is marginal, it was agreed that cost was less of a factor in weighting and scoring the alternatives
- The County relayed the USACE's preference of a levee embankment over the use of a floodwall as it relates to the concerns noted in section 2.2.1.42.2.1.4 Levee Integrity.
- There was discussion regarding how the floodwall works with respect to access and the use of sheet piles as a seepage cutoff
- The site walk made it very apparent that the existing levee is over-steepened on the water side

2.4.2.2 Evaluation Criteria Weighting

The scoring process started with each workshop attendee (evaluator) – except NHC and R&E who facilitated the workshop – individually assigning a subjective weight (numerical value) to each evaluation criterion (originally introduced in Section 2.1). The value of the weight indicated the criterion's perceived level of importance (which could not be less than 1) and were allocated such that the sum of the weights equaled 100.

This weighting process was repeated a second time after group discussion and review of the first round of weighting. Three rounds of the weighting exercise were expected with the intent that weights for each criterion would converge, indicating group consensus.

The largest range of weights from the first round was for Habitat Area. This evaluation criteria became the focus of discussion where evaluators shared their opinion and perspective as to why they decided their weight. This led to some evaluators lowering their weights for Habitat Area whereas others increased theirs, narrowing the range of weights. Results of the first round of weighting are presented in Error! Reference source not found.with the numbered column headings representing each evaluator.

Table B: Evaluation Criteria Weighting - Round 1

	ROUND 1 WEIGHTING EXERCISE - Roadway Alignment Alternatives North of Star Park											
Evaluation Criterion	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Range*	*Average*
Recreation	10	15	10	10	10	15	15	10	10	15	5.0	12.0
Traffic Flow	10	10	5	10	10	10	10	10	10	5	5.0	9.0
Parking	5	5	5	5	5	10	10	5	10	5	5.0	6.5
Levee Integrity	25	20	25	20	20	10	15	20	20	20	15.0	19.5
Habitat Area	10	10	25	15	10	10	5	5	10	20	20.0	12.0
Permitting	5	5	3	10	5	5	5	5	5	5	7.5	5.3
Right-of-Way	5	5	3	5	10	5	10	5	5	5	7.5	5.8
Planning	5	5	5	5	10	15	5	5	10	5	10.0	7.0
Maintenance & Operations	10	10	10	10	10	5	10	15	10	10	10.0	10.0
Cost	15	15	10	10	10	15	15	20	10	10	10.0	13.0
Weights Total	100	100	100	100	100	100	100	100	100	100	-	100.0

The second round of weighting resulted in near convergence for most of the evaluation criteria. Discussion followed on whether evaluators were in agreement with the results and if choosing the average weight for each criterion was acceptable for reaching consensus on the weights. All evaluators agreed to using the average weights of the group for the scoring process. Results of the second and final round of weighting are presented in Table C.

Table C: Evaluation Criteria Weighting - Round 2

	ROUND 2 WEIGHTING EXERCISE - Roadway Alignment Alternatives North of Star Park											
Evaluation Criterion	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Range*	*Average*
Recreation	10.0	15.0	10.0	10.0	10.0	10.0	15.0	20.0	15.0	15.0	10.0	13.0
Traffic Flow	10.0	10.0	5.0	10.0	10.0	10.0	10.0	5.0	10.0	10.0	5.0	9.0
Parking	5.0	5.0	5.0	5.0	10.0	5.0	5.0	5.0	5.0	5.0	5.0	5.5
Levee Integrity	20.0	20.0	25.0	20.0	20.0	20.0	15.0	20.0	20.0	15.0	10.0	19.5
Habitat Area	15.0	15.0	20.0	10.0	15.0	10.0	10.0	15.0	15.0	10.0	10.0	13.5
Permitting	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.0	5.0
Right-of-Way	5.0	5.0	5.0	10.0	5.0	5.0	10.0	5.0	5.0	5.0	5.0	6.0
Planning	5.0	5.0	5.0	10.0	10.0	5.0	5.0	5.0	5.0	10.0	5.0	6.5
Maintenance & Operations	10.0	10.0	10.0	10.0	10.0	15.0	10.0	10.0	10.0	10.0	5.0	10.5
Cost	15.0	10.0	10.0	10.0	5.0	15.0	15.0	10.0	10.0	15.0	10.0	11.5
Weights Total	100	100	100	100	100	100	100	100	100	100	-	100.0

2.4.2.3 Alternatives Scoring

Upon completion of criteria weighting, each evaluator was tasked with assigning a score of 1 to 5 (1 being poor and 5 being excellent) to each evaluation criterion for every alternative. The weighted average score for each alternative (and for each evaluator) was then calculated by multiplying the criterion score by the criterion weight, summing the total weighted scores, and dividing by the sum of the weights. Weighting the criteria was completed prior to scoring the alternatives to eliminate potential biases otherwise introduced by weights being intentionally assigned to achieve a desired outcome. Similarly, the final weights were not displayed during the scoring process to mitigate intentional bias in scoring.

A single, composite weighted average score for each alternative was calculated by averaging the scores of each evaluator.

2.4.2.4 Ranking and Alternative Selection

The alternatives were compared and ranked based on the final calculated scores, with the highest score indicating the collectively preferred alternative. Table D and Table E below show the results of the scoring exercise, including how many evaluators scored each alternative as their highest. Alternative A scored the highest and Alternative D scored the lowest.

Table D: Alternatives Scoring Results – Final Composite Score

		FINAL SCORING			
Evaluation Criterion	Weight	*A*	*B*	*D*	*E*
Recreation	13.0	2.00	3.00	4.30	4.40
Traffic Flow	9.0	3.70	3.40	3.60	2.80
Parking	5.5	3.80	2.40	4.30	3.40
Levee Integrity	19.5	4.80	4.80	2.80	4.80
Habitat Area	13.5	4.50	4.50	2.00	4.20
Permitting	5.0	3.80	3.80	3.30	2.10
Right-of-Way	6.0	3.00	2.90	4.50	2.40
Planning	6.5	2.40	3.10	3.30	3.10
Maintenance & Operations	10.5	3.90	4.00	2.60	3.40
Cost	11.5	4.30	3.40	3.50	1.80
Weighted Average	100.0	*3.78*	3.75	3.26	3.53

Table E: Alternatives Scoring Results - Evaluator Scores

	SCORING EXERCISE - CALCULATED SCORES											
Alternative	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Average*	*Count*
A	4.21	3.61	2.91	3.44	3.90	3.25	4.26	3.64	4.26	4.31	3.78	4
B	4.04	3.74	2.98	3.64	3.63	3.22	4.26	3.67	4.00	4.33	3.75	3
D	2.44	3.61	3.41	3.42	3.74	2.44	3.95	3.55	2.97	3.10	3.26	1
E	3.58	3.33	2.55	3.37	3.40	3.33	3.66	3.55	4.14	4.40	3.53	2
Highest Scoring	A	B	D	B	A	E	A	B	A	E	-	A

Although Alternative A scored the highest, given how close the scores for Alternatives A and B were, it was understood that it was a numerical tie (even though Alternative A, as presented, was the least desirable option by the City because it interferes with the future skatepark). However, since Alternative A scored the highest by more evaluators, it is considered the preferred alternative. It was also understood that since Alternative D scored in last place, that the preferred roadway alignment alternative should not follow the existing roadway, and that some variation of Alternatives A and B is likely best as indicated by the scores. However, Alternative E is a possibility as well given it accomplishes the same levee and habitat objectives as Alternatives A and B while minimizing park impacts.

After completing the first round of scoring, workshop attendees walked out to the project site to see the levee and park areas and envision what the alignment alternatives would look like. The evaluators declined to re-score the alternatives after the walk, agreeing that their scores were unchanged after seeing the alignment locations first-hand.

3.0 Conclusion

In August, 2020, R&E was hired by the County to begin preliminary design and alternatives analysis for improvements to the Ferndale Levee and Ferndale Water Treatment Plant Levee south of downtown Ferndale. The primary objectives of this project are to improve flood protection, levee integrity, and riparian habitat for the 1.2 miles of levee located south of Cherry Street.

The design team, in cooperation with the County, identified four alternatives between Cherry Street and Star Park for evaluation as presented in Section 2.0. Primary stakeholders were invited to participate in a workshop on April 19, 2022 and provide feedback and perspective on the identified alternatives with the objective of collectively choosing the preferred alignment (see Section 2.4.2 for documentation of the workshop highlights and scoring process). Stakeholders scored Alternative A and B the highest (numerical tie) with Alternative E in third, and Alternative D as the lowest scoring. Since selecting Alternative A is complicated by the location of the impending City skatepark, the main outcome of the scoring process was that the preferred alignment is separated from the levee to provide improved habitat opportunities and maintain an embankment type levee. Further discussion between the County and City is anticipated in the near future with the aim to agree on a final alignment.

Alternatives identified for the portion of the project south of Star Park are not included in the scope of this report, but improvements to the levee and Ferndale Road for this section include raising the levee elevation to protect against the design flood event and reconstructing the roadway to County standards. Such improvements come at an estimated cost of $14.20 million, resulting in a total project estimated cost of $19.33 million to $20.67 million when including Alternative A or B, respectively.

Following selection of the agreed upon alternative between the County and City, the design team will formally begin the design process, starting with preliminary plans. Current project scope includes 30% level of design with County funding allocated for completing 60% level of design. Final design and construction funding will be pursued by the County during the early design phases. Anticipated start of construction is spring 2025.

Appendix A: Conceptual Roadway Alignment Alternatives Memo

Reichhardt & Ebe
ENGINEERING INC

MEMORANDUM

TO: Daniel Goger, P.E.	FROM: Nathan Zylstra, P.E.
COMPANY: Whatcom County River & Flood Division	DATE: 11/20/2020
ADDRESS: 322 North Commercial Street, Suite 120 Bellingham, WA 98225	TOTAL NO. OF PAGES INCLUDING COVER: 9

RE:

Ferndale Levee Improvements
Conceptual Roadway Alignment Alternatives

Introduction

The Whatcom County Flood Control Zone District (WCFCZD) and the design team are in the early stages of the conceptual design for the Ferndale Levee Improvement Project. Thus far, the design team has been working on data collection, mapping, background research, early analysis, and planning meetings with staff from Whatcom County, Public Utility District No. 1, and City of Ferndale.

The project scope of work includes an analysis of alternative roadway alignments. Currently, the levee is adjacent to the Nooksack River with the roadway immediately behind it. In some locations, the riverward slope of the levee is over-steepened and the levee geometry does not meet the USACE's minimum crest width and side slope standards. Along much of the levee, there is little to no riparian vegetation or habitat structure. The levee is used informally as a trail and sloughing of the levee material results as people climb the steepened backslope up to the levee crest. The alternatives analysis will review various options for the levee, wall structures, habitat components, trail features, utility components, and transportation alternatives to meet the project objectives. The focus of this memorandum is to summarize the transportation alternatives – namely the roadway alignment alternatives – that will be evaluated in further detail.

Ferndale Road is currently located along the west bank of the Nooksack River from Cherry Street south for approximately 1.25 miles before heading due south to intersect with Slater Road. The described limits of Ferndale Road from Cherry Street to the point where it turns due south are coincident with the Ferndale Levee project limits. The roadway alignment conceptual alternatives, which are the focus of this memorandum, are located between Cherry Street and the vicinity of the south side of the Star Park parking lot, within the Ferndale City Limits. The remainder of Ferndale Road south of the vicinity of the Star Park parking lot will generally follow the existing Ferndale Road alignment.

Conceptual Roadway Alignment Alternatives

During the scoping phase and recent planning meetings, five roadway alternative alignments have been considered. Each of the roadway alignments along with a bulleted list of benefits and impacts are depicted in the attachments to this memo. The purpose of this memo is to document the rationale for reducing the number of alternative alignments from five to three, and to present the evaluation criteria which will be used to evaluate the remaining three alternatives before a preferred alternative is recommended.

The City of Ferndale and Whatcom County are the two primary stakeholders with respect to the roadway alignment alternatives. The alternatives are located within the Ferndale City limits and all have varying levels of benefits and impacts to City facilities. Whatcom County is a primary stakeholder in that each of the alternatives will affect the proposed levee improvements including geometry and habitat components.

Each of the five alternatives are briefly described below:

Alternative A – Second Street Extension
Alternative A routes the roadway on Second Street then through the existing recreational fields and along Star Park before reconnecting with Ferndale Road in the vicinity of the Star Park parking lot. The major benefit is that it allows flexibility in the levee and trail design along the west bank of the Nooksack River, while the major impact is the bisection and possible conflicts with existing and proposed recreational facilities.

Alternative B – First Street Extension
Alternative B is similar to A, but the roadway is routed along First Street, then along the west parking area of the Pioneer Pavilion, then through the existing recreational fields and along Star Park before reconnecting with Ferndale Road in the vicinity of the Star Park parking lot. The major benefit, like A, is the flexibility in the levee and trail design, while the major impacts include Pioneer Pavilion parking, possible conflicts with existing and proposed recreational facilities, and routing vehicular traffic to the First and Main Street intersection where a traffic signal was recently removed.

Alternative C – One-Way
Alternative C utilizes a one-way concept where southbound traffic is routed from either First or Second Street (as described in Alternatives A and B) leaving northbound traffic to utilize the existing Ferndale Road alignment. The major benefit is added flexibility in the levee and trail design along the Nooksack River, while the major impacts affect existing and proposed recreational facilities and the introduction of a "second" roadway through the recreational complex.

Alternative D – Ferndale Road (Existing Alignment)
Alternative D utilizes the existing Ferndale Road with no major changes in roadway horizontal alignment. The major benefit is no impact to the recreational facilities, while the major impact is a resulting constraint on levee and trail design or the potential need to relocate the trail away from the Nooksack River if the geometric constraint is too severe.

Alternative E – Second Street Routed West
Alternative E routes the roadway on Second Street and then to the west around the Tosco / Phillips 66 complex before wrapping to the east to connect with Ferndale Road in the vicinity of the Star Park parking lot. The major benefit is added flexibility in the levee and trail design while also not bisecting the recreational facilities. Major impacts include the likely need to construct replacement parking for the Tosco / Phillips 66 complex along with impacts to known existing wetlands to the west.

Recommendations

The design team recommends that Alternatives A, D, and E be advanced to the Alternatives Analysis phase while Alternatives B and C be abandoned at this time. Alternatives A, D, and E while not without each of their own unique challenges, appear feasible and warrant further analysis.

The recommendation to abandon Alternative B is made for the following reasons:

- The traffic signal at the Main Street and First Street intersection was removed to alleviate traffic congestion on Main Street. Routing the Ferndale Road traffic through the First Street and Main Street intersection runs counter to that effort.
- The proximity of the roadway to the Pioneer Pavilion will eliminate existing parking. Options for replacement parking are limited and will result in further impact elsewhere.
- The alignment will likely result in impacts to recreational field lighting.
- The alignment will likely result in an impact to the proposed Star Park shelter or will be in proximity to it.
- The proximity of the alignment to recreational field A is undesirable and may result in an impact to the field.

The recommendation to abandon Alternative C is made for the following reasons:

- One-way streets do not currently exist in the City of Ferndale. Introduction of a small segment of one-way traffic within the transportation system may not operate as efficiently as conventional two-way systems.
- The concept will result in two separate roadway “constraints” in and through the recreational complex as opposed to a single roadway.
- Roadway elements such as lighting, storm drainage systems, and barrier curb are duplicated, resulting in a more costly roadway network when compared to a two-way street.
- The southbound First Street alignment will result in impacts to the Pioneer Pavilion parking as in Alternative B described above.
- The alignment will likely result in impacts to recreational field lighting.
- The alignment will likely result in an impact to the proposed Star Park shelter or will be in proximity to it.
- The proximity of the alignment to recreational field A is undesirable and may result in an impact to the field.

Next steps

The main objective of this memorandum is to narrow down the current field of five roadway alternatives to three, which can then be advanced to the alternative analysis stage. The secondary objective of this memorandum is to introduce the evaluation criteria to be utilized in the decision-making process to narrow down the three alternatives and select a preferred alternative.

Proposed Evaluation Criteria

The following is a proposed list of evaluation criteria for consideration by project stakeholders. The criteria are presented with a brief description and are intended to help select not only the preferred roadway alternative, but also alternatives associated with the levee itself and Ferndale Road south of the City limits. A weighting or ranking system has not been defined at this time and will be developed as a part of the alternatives analysis process.

- **Recreation**– Consider park connectivity, recreational opportunities created and/or impacted.
- **Traffic Flow** – Consider traffic impacts and opportunities.
- **Parking** – Consider parking impacts along with options for replacement parking if necessary.
- **Levee Integrity** – Consider the degree to which the desired level of robust flood protection can be provided.
- **Habitat Area** – Consider habitat opportunities and impacts including riparian areas and wetlands.
- **Permitting** – Consider the difficulty, cost, and timeframe associated with permitting a particular option.
- **Right-of-Way** – Consider the difficulty, cost, and timeframe associated with needed property rights acquisition, including the willingness of impacted property owners.
- **Maintenance and Operations** – Consider short and long-term maintenance and operations.
- **Cost** – Consider the capital cost of a particular option.

Alternative A – Second Street Extension

Benefits

- Allows design flexibility for the Levee and Riverwalk in the existing Ferndale Road footprint
- Ferndale Road becomes the Riverwalk / Trail
- The Riverwalk can be expanded in a similar design as the existing Riverwalk north of Cherry Street
- The Park is more connected to the Riverwalk
- Pioneer Park / Rec Fields B / Star Park / Senior Center / B&G club area / expanded Riverwalk can be planned and programmed as single opportunity zone
- Traffic loads on to Main Street further west

Impacts

- Recreation fields are bisected by road
- Impact to sports lighting at Recreation Field A
- Traffic routed adjacent to Star Park Playground
- Restricts and/or eliminates the development of a future skate and bike park near the end of Second Street

Alternative B - First Street Extension

Benefits

- Allows design flexibility for the Levee and Riverwalk in the existing Ferndale Road footprint
- Ferndale Road becomes the Riverwalk / Trail
- The Riverwalk can be expanded in a similar design as the existing Riverwalk north of Cherry Street
- The Park is more connected to the Riverwalk
- Pioneer Park / Rec Fields B / Star Park / Senior Center / B&G club area / expanded Riverwalk can be planned and programmed as single opportunity zone
- Recreation Fields A&B / Tosco / B&G Club are a second opportunity zone

Impacts

- Impact to sports lighting at Recreation Field A
- Increased traffic at Pioneer Pavilion Community Center (red roof)
- Potential need to offset parking loss at the Pioneer Pavilion
- Traffic routed adjacent to Star Park Playground
- Restricts and/or eliminates the development of a future shelter west of the Star Park Playground

Alternative C – One-Way (1st or 2nd with Ferndale Rd.)

Benefits

- Allows some design flexibility for the Levee and Riverwalk in the existing Ferndale Road footprint
- Pioneer Park / Star Park / Senior Center / expanded Riverwalk can be planned and programmed as single opportunity zone
- Recreation Fields A&B / Tosco / B&G Club are a second opportunity zone
- One-way traffic allows above zones to be more connected than two-way road
- Narrower road can be designed as multi-modal paths to better integrate with the river and the park

Impacts

- Impact to sports lighting at Recreation Field A
- Increased traffic at Pioneer Pavilion Community Center (red roof)
- Potential need to offset parking loss at the Pioneer Pavilion
- One-way roads do not currently exist in City of Ferndale

Alternative D – Ferndale Road (Existing Alignment)

Benefits

- No impact to sports fields or lighting
- Pioneer Park / Rec Fields A&B / Star Park / Senior Center / B&G club area / can be planned and programmed as single opportunity zone
- Less disruptive to current traffic patterns

Impacts

- Least flexibility to the Levee and the Riverwalk expansion footprint
- The two-way roadway presents a barrier between the river and the park
- Limited opportunity for habitat improvements

Alternative E - Second Street Routed West

Benefits

- Allows design flexibility for the Levee and Riverwalk in the existing Ferndale Road footprint
- Ferndale Road becomes the Riverwalk / Trail
- The Riverwalk can be expanded in a similar design as the existing Riverwalk north of Cherry Street
- The Park is more connected to the Riverwalk
- Pioneer Park / Rec Fields B / Star Park / Senior Center / B&G club area / expanded Riverwalk can be planned and programmed as single opportunity zone
- No impact to sports fields or lighting

Impacts

- Vehicle route is not direct
- Disconnects loop trail through mitigation area from rest of park
- Disrupts adjacent wetlands which requires further permitting

Appendix B: Geotechnical Data Report

Geotechnical Data Report

Ferndale Levee Improvements –
Alternatives Analysis and 30% Design
Ferndale, Washington

for
Reichhardt & Ebe Engineering, Inc.

April 7, 2021

GeoEngineers

554 West Bakerview Road
Bellingham, Washington 98226
360.647.1510

Geotechnical Data Report

Ferndale Levee Improvements – Alternatives Analysis and 30% Design Ferndale, Washington

File No. 0484-113-00

April 7, 2021

Prepared for:

Reichhardt & Ebe Engineering, Inc.
423 Front Street
Lynden, Washington 98264

Attention: Nathan Zylstra, PE

Prepared by:

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554 West Bakerview Road
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Senior Geotechnical Engineer

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Associate

AF2:AJH:SWC:leh

GeoEngineers

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APPENDICES

1.0 INTRODUCTION

This geotechnical data report presents the results of our geotechnical explorations completed for the project to date and a summary of existing soil and groundwater conditions for the proposed Whatcom County Ferndale Levee Improvements project in Ferndale, Washington. The project location is shown in the Vicinity Map, Figure 1. Existing site features are shown in the Site and Exploration Plans, Figures 2 and 2A through 2C.

At the time of this report the design for the proposed levee improvements is ongoing. The project will include reviewing and refining the conceptual design for Whatcom County River and Flood Division in conjunction with the City of Ferndale and the Public Utility District (PUD) and advancing it to a preliminary (30%) design level. As currently envisioned, the project will include upgrades to the existing Whatcom County Flood Control Zone District (FCZD) levee along approximately 1.04 miles of two levee segments referred to as the Ferndale Levee and the Water Treatment Plant Levee. We understand the levee improvements will provide greater flood protection and enhance riparian habitat. Both levees are active in the US Army Corps of Engineers (USACE) Public Law 84-99 Rehabilitation and Inspection Program (PL84-99). The conceptual design will include setting back the levee and reconstructing Ferndale Road on top of the proposed levee. Potential improvements and alternatives to be evaluated could also include relocating portions of Ferndale Road to allow increased room for levee improvement adjacent to Pioneer Park.

This report provides a summary of soil and groundwater conditions encountered in our recent explorations and includes previous explorations available at the site and nearby project sites. For this phase of the project, we have completed the following scope items:

- Completion of geotechnical explorations at the site including 11 borings (one completed as a piezometer);
- Completion of geotechnical laboratory testing on samples obtained from the explorations; and
- Preparing this geotechnical data report.

Once the project is further along in the design process, this geotechnical data will be incorporated into a geotechnical engineering report presenting conclusions and recommendations for design and construction of the proposed improvements.

2.0 SITE CONDITIONS

2.1. Surface Conditions

The project site is located along Ferndale Road, starting at Cherry Street and extending to the south, approximately 1 mile in Ferndale, Washington. The site is bounded by the Nooksack River to the east, city parks property and the existing City of Ferndale water and wastewater treatment plants to the west, and agricultural/residential properties to the southwest. Vegetation along the alignment consists of field grass, blackberries and medium to large diameter deciduous trees. Utilities consist of underground water, sewer (forcemain influent and discharge), overhead power and communication.

2.2. Geology

We reviewed a U.S. Geologic Survey (USGS) geologic map for the project area, “Geologic Map of The Bellingham 1:100,000 Quadrangle, Washington” by Lapen (2000) and the Washington Department of Natural Resources (DNR) Interactive Geologic Map (DNR 2016) for information about general geologic conditions at this site. The site lies within an area mapped as recent alluvium associated with the Nooksack River flood plain. Sumas Stade continental glacial outwash and Everson glaciomarine drift and are mapped in the site vicinity.

Quaternary alluvial deposits consist of stratified sand, gravel and silt deposited on the beaches, spits, and modern flood plains of the Nooksack River, and are often deposited in a relatively loose, unconsolidated manner. The continental glacial outwash unit typically consists of advance and recessional sand and gravel that were deposited by meltwater streams flowing from the glacier during the most recent glaciation. The melting water and sediment formed an outwash plain. Glaciomarine drift typically consists of unsorted, unstratified silt and clay with varying amounts of sand, gravel, cobbles and occasional boulders. Glaciomarine drift is derived from sediment melted out of floating glacial ice that was deposited on the sea floor. In upland areas, glaciomarine drift can have a stiff upper crust transitioning to medium stiff or soft with depth. Where glaciomarine drift is encountered below another geologic unit (such as alluvium or outwash) and in low-lying areas that are perennially wet, the clay is typically medium stiff to soft for the full depth of the unit.

2.3. Subsurface Explorations

Subsurface soil and groundwater conditions were evaluated by completing the following exploration program:

- Eleven (11) geotechnical borings, B-1-2021, B-3-2021, and B-5-2021 through B-13-2021, completed on February 8, 2021 through February 12, 2021 using a track-mounted drill rig subcontracted to GeoEngineers. The borings were completed to depths of 16½ to 61½ feet below the existing ground surface (bgs). The borings were completed as part of the 30% design planning phase.

The locations of the explorations are shown in Figures 2, and 2A through 2C. Details of the field exploration program, laboratory testing, and boring logs are presented in Appendix A, Field Explorations. Laboratory testing is summarized in Appendix B, Laboratory Testing. Previous explorations for the site vicinity are presented in Appendix C, Previous Explorations.

2.4. Previous Explorations

GeoEngineers reviewed available subsurface explorations from nearby projects along the alignment. We reviewed the following information:

- City of Ferndale Wastewater Treatment Plant Project (1996); Borings B-1 and B-4 through B-7.
- City of Ferndale Wastewater Facility Improvements (2016); Borings B-1 through B-6.
- City of Ferndale Water Treatment Plant Improvements (2019); Test pits TP-1 through TP-3, and CPT-1.

The locations of all the previous explorations are shown in Figure 2 and 2A-2C.

2.5. Subsurface Conditions

2.5.1. Soil Conditions

A general description of each of the soil units encountered at the project site is provided below. Surficial conditions consisted of approximately 4 inches of asphalt concrete in borings B-1-2021, B-3-2021, B-5-2021, B-7-2021, B-9-2021, and B-11-2021. Approximately 1 to 4 inches of crushed rock was encountered in borings B-6-2021, B-8-2021, B-10-2021 and B-12-2021. Approximately 5 inches of surficial sod was observed in boring B-13-2021.

- **Fill** – Fill soils were encountered in our new explorations underlying the asphalt or crushed concrete in borings B-3-2021, B-5-2021, B-6-2021, B-8-2021, and B-10-2021 through B-12-2021. The fill generally consisted of loose to medium dense silty fine to medium sand with variable gravel content. The fill layer was observed to extend to depths of 5 to 12 feet bgs where encountered. A majority of the fill soils had a composition similar in character to the underlying alluvium and were likely derived from local native soils during historical grading activities. Fill material was encountered in previous explorations extending to depths ranging from 1 to 9½ feet bgs.
- **Alluvium** – Native alluvium was encountered underlying the asphalt, crushed concrete surfacing and/or fill in all the 2021 borings as well as previous explorations. The alluvium consisted of very loose to medium dense, fine or fine to medium sand with variable silt content, very soft sandy silt, or medium stiff clayey silt with sand. Occasional organic material was observed in this unit. The alluvium extended to depths of 20 to 51 feet bgs. Shallower borings B-6-2021, B-8-2021, B-10-2021, B-12-2021 and B-13-2021 all terminated in this unit.

  The alluvium encountered in previous explorations generally extended to depths ranging from 35 to 48 feet bgs, with the shallower explorations also terminating in this unit.
- **Glaciomarine Drift** – Glaciomarine drift was encountered underlying the alluvium in borings B-1-2021, B-3-2021, B-5-2021, B-7-2021, B-9-2021, and B-11-2021. The glaciomarine drift generally consisted of very soft to stiff clay with variable silt and sand content. The glaciomarine drift unit extended to the depths explored between 51½ to 61½ feet bgs. Glaciomarine drift was also observed underlying the alluvium in B-5-2016 at a depth of approximately 35 to 52 feet bgs. The glaciomarine drift generally consisted of soft to stiff clay with occasional sand and gravel.

2.5.2. Groundwater Conditions

Saturated soil interpreted to be indicative of the groundwater table at the time of drilling was encountered in all recent borings at depths ranging from approximately 5 to 12½ feet bgs. The corresponding groundwater ranged between approximately Elevation 10 and 18½ feet (NAVD88). One groundwater monitoring piezometer was installed in the exploration at B-13-2021 and will be monitored periodically by County or Reichardt & Ebe personnel. Groundwater conditions should be expected to vary as a function of season, precipitation, and other factors including water levels in the Nooksack River.

3.0 LIMITATIONS

We have prepared this geotechnical data report for Reichhardt & Ebe Engineering, Inc., Whatcom County, and members of the design team for use in preliminary planning of the proposed Whatcom County Ferndale Levee Improvements project in Ferndale, Washington. This data will be incorporated into a geotechnical engineering design report at a later date that includes conclusions and recommendations and is not intended for design.

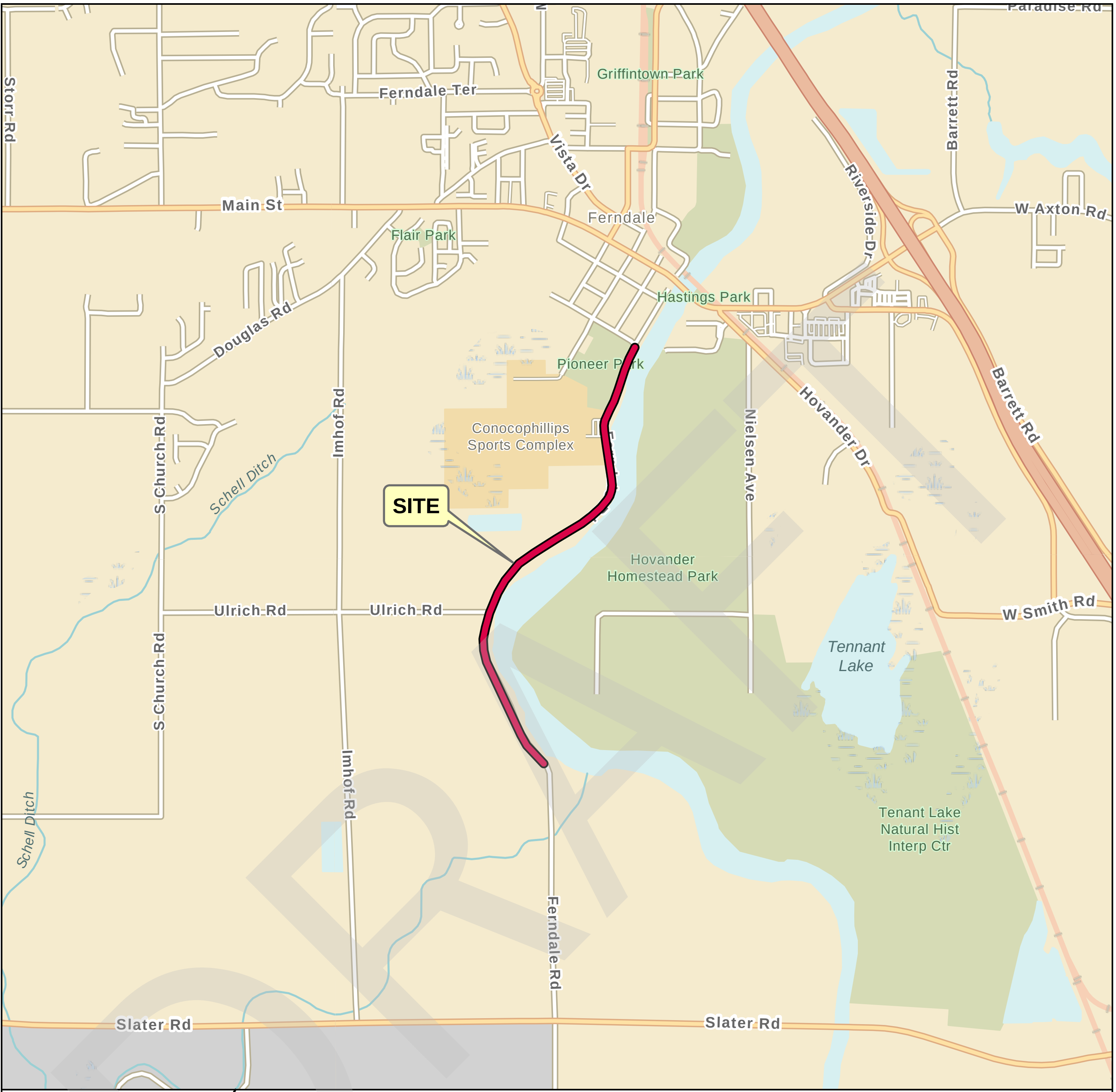
Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, express or implied, should be understood.

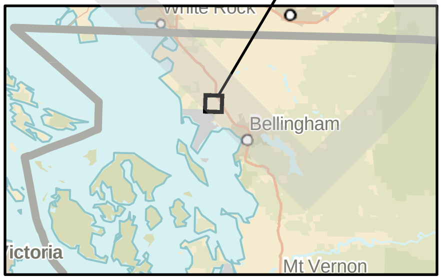
Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

4.0 REFERENCES

Lapen, T.J. 2000. "Geologic Map of the Bellingham 1:100,000 Quadrangle, Washington." Washington State Department of Natural Resources.

Washington State Department of Natural Resources Division of Geology and Earth Resources. Online Washington Interactive Geologic Map website http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/geology_portal.aspx.





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Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: ESRI

Projection: NAD 1983 UTM Zone 10N

Vicinity Map

Ferndale Levee Improvements
Ferndale, Washington

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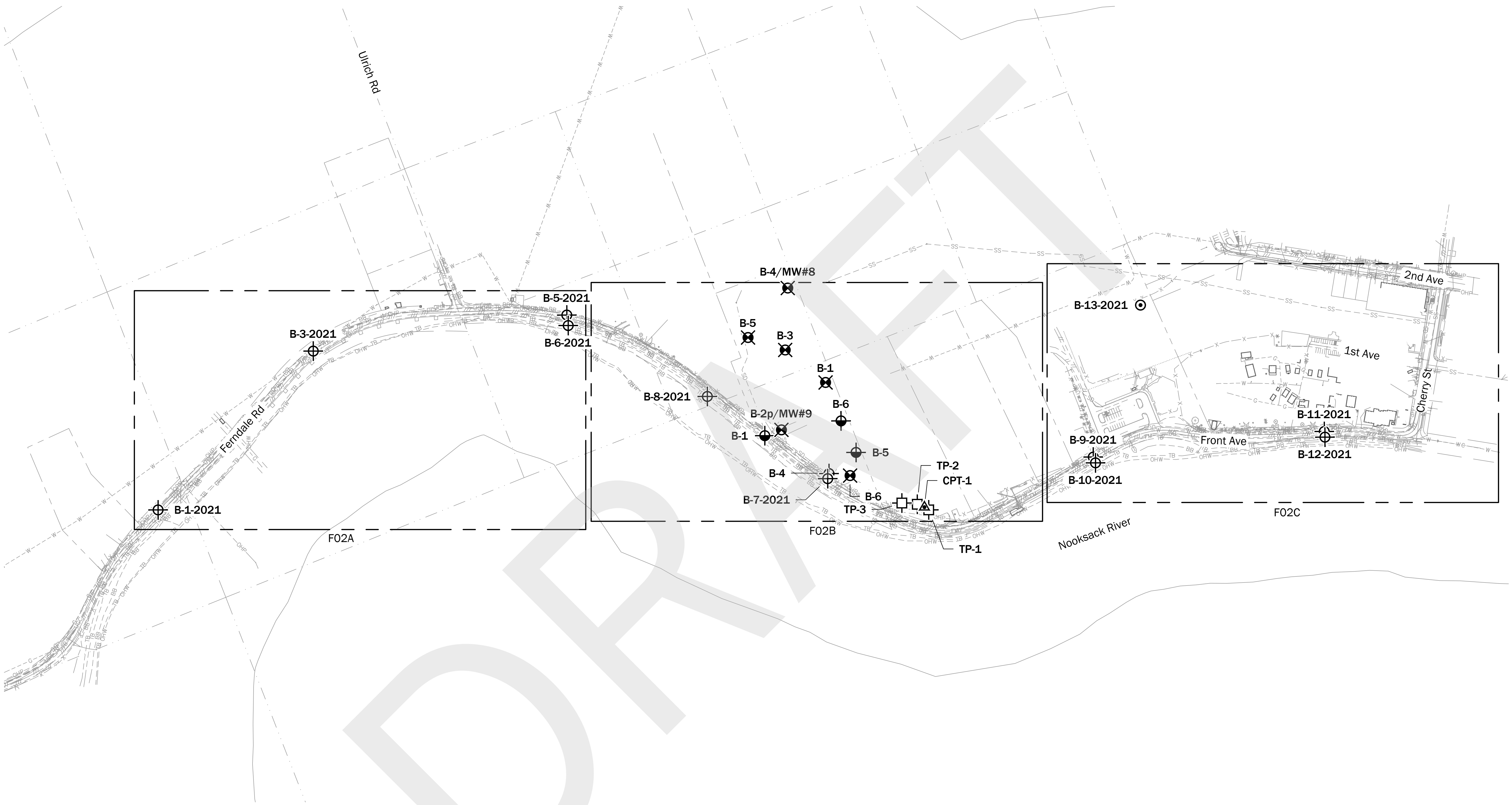
Figure 1



Legend

B-1-2021 ⊕ Boring by GeoEngineers, Inc., 2021
B-13-2021 ⊙ Piezometer by GeoEngineers, Inc., 2021
CPT-1 ▲ Cone Penetrometer Test by GeoEngineers, Inc., 2019
TP-1 ☐ Test Pit by GeoEngineers, Inc., 2019
B-1 ☒ Boring by GeoEngineers, 2016
B-5 ● Boring by GeoEngineers, 1996

Notes:
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Data Source: Background from Reichardt & Ebe Engineering dated 02/24/2021.

Projection: Washington State Plane, North Zone, NAD83, US Foot

W N S E

400 0 400
Feet

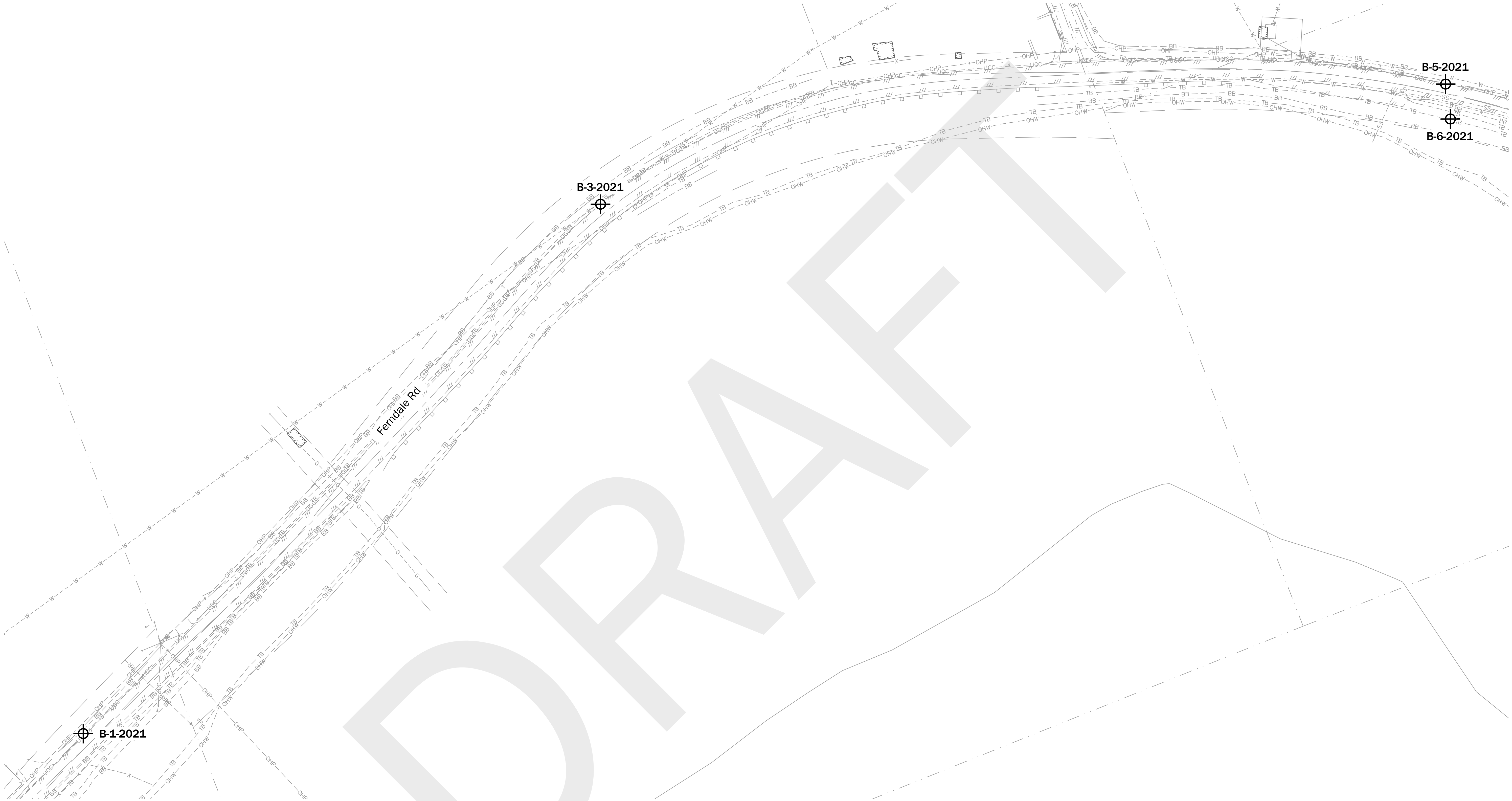
Site and Exploration Plan

Ferndale Levee Improvements
Ferndale, Washington

GeoEngineers

Figure 2

P:\0\0484113\CAD\00\Geotech Report\048411300_F02_Site Plan.dwg TAB:F02 - Site Plan Date Exported: 04/07/21 - 17:53 by gregister



Legend

B-1 ⌖ Boring by GeoEngineers, Inc., 2021

Notes:
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Data Source: Background from Reichardt & Ebe Engineering dated 02/24/2021.

Projection: Washington State Plane, North Zone, NAD83, US Foot

Site and Exploration Plan

Ferndale Levee Improvements
Ferndale, Washington

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Figure 2A

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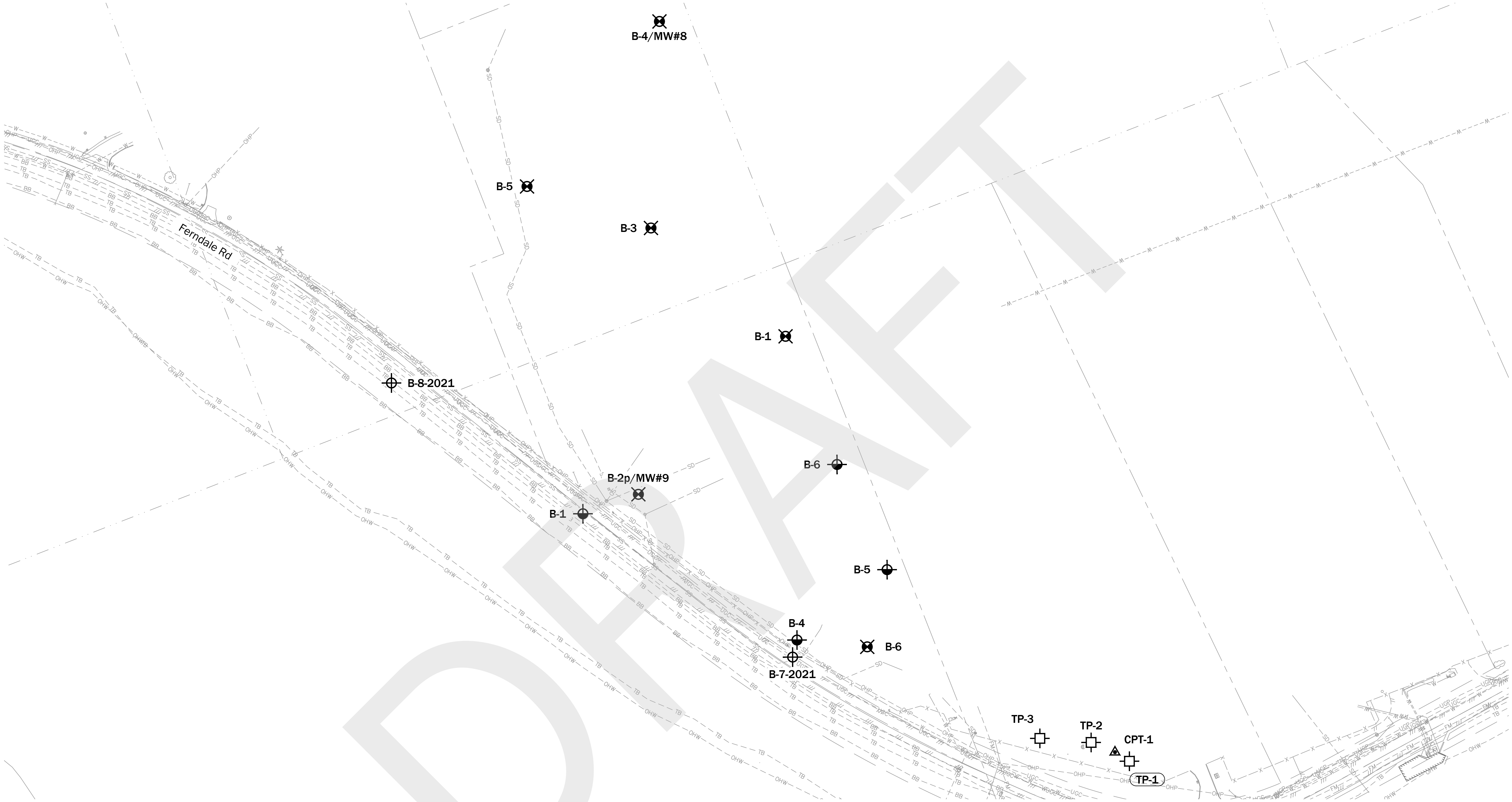

Legend

B-1-2021 ⊕ Boring by GeoEngineers, Inc., 2021

CPT-1 ▲ Cone Penetrometer Test by GeoEngineers, Inc., 2019

TP-1 ☐ Test Pit by GeoEngineers, Inc., 2019

B-1 ⊗ Boring by GeoEngineers, 2016

B-5 ● Boring by GeoEngineers, 1996

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Background from Reichardt & Ebe Engineering dated 02/24/2021.

Projection: Washington State Plane, North Zone, NAD83, US Foot

120 0 120
Feet

W N S E

Site and Exploration Plan

Ferndale Levee Improvements
Ferndale, Washington

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Figure 2B

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Legend

B-9	⌖	Boring by GeoEngineers, Inc., 2021
B-13-2021	◉	Piezometer by GeoEngineers, Inc., 2021

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Background from Reichardt & Ebe Engineering dated 02/24/2021.

Projection: Washington State Plane, North Zone, NAD83, US Foot

120 0 120
Feet

Site Exploration Plan

Ferndale Levee Improvements
Ferndale, Washington

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Figure 2C

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APPENDIX A

Field Explorations

APPENDIX A
FIELD EXPLORATIONS

Subsurface conditions at the site were explored by completing eleven (11) geotechnical borings, B-1-2021, B-3-2021, and B-5-2021 through B-13-2021, completed on February 8, 2021 through February 12, 2021 using a track-mounted drill rig subcontracted to GeoEngineers. Borings B-2-2021 and B-4-2021 were planned but not completed based on site access and existing levee geometry. The borings were completed to depths of 16½ to 61½ feet below the existing ground surface (bgs). The approximate locations of the explorations are shown in the Site and Exploration Plans, Figure 2, and 2A through 2C. The locations of the explorations shown in Figure 2 were measured using global positioning system (GPS), and should be considered accurate to the degree implied by the methods used.

A majority of the disturbed soil samples were obtained using Standard Penetration Test (SPT) methodology with the standard split-spoon sampler. The samples were obtained by driving the sampler 18 inches into the soil with a 140-pound automatic hammer free-falling 30 inches. Select samples were also obtained using a 3.0-inch outside diameter modified California sampler driven into the soil with a 140-pound hammer free-falling 30 inches. For both sampler types, the number of blows required for each 6 inches of penetration was recorded. The number of blows required to drive the sampler the last or middle 12 inches are recorded in the boring logs. This resistance, or N-value, provides a measure of the relative density of granular soils and the relative consistency of cohesive soils. The samples were placed in plastic bags to maintain the moisture content and transported back to our laboratory for analysis and testing.

The borings were continuously monitored by a geotechnical scientist from our firm who examined and classified the soils encountered, obtained representative soil samples, observed groundwater conditions and prepared a detailed log of each exploration. Soils encountered were classified visually in general accordance with ASTM D-2488-90, which is described in Figure A-1. An explanation of our boring log symbols is also shown in Figure A-1.

The logs of the borings are presented in Figures A-2 through A-12. The exploration logs are based on our interpretation of the field and laboratory data and indicate the various types of soils encountered. They also indicate the depths at which these soils or their characteristics change, although the change might actually be gradual. If the change occurred between samples in the borings, it was interpreted.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	▨	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
			▨	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▨	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	▨	SW	WELL-GRADED SANDS, GRAVELLY SANDS
			▨	SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▨	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▨	ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▨	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▨	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
			▨	OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS			▨	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTIONS
GRAPH	LETTER	
■	AC	Asphalt Concrete
▨	CC	Cement Concrete
▨	CR	Crushed Rock/ Quarry Spalls
▨	SOD	Sod/Forest Duff
▨	TS	Topsoil

Groundwater Contact

▼ **Measured groundwater level in exploration, well, or piezometer**

▼ **Measured free product in well or piezometer**

Graphic Log Contact

— **Distinct contact between soil strata**

╱ **Approximate contact between soil strata**

Material Description Contact

— **Contact between geologic units**

– – – **Contact between soil of the same geologic unit**

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point load test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

Sampler Symbol Descriptions

▯	2.4-inch I.D. split barrel
☒	Standard Penetration Test (SPT)
◩	Shelby tube
☰	Piston
◧	Direct-Push
▯	Bulk or grab
▥	Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

Key to Exploration Logs

GeoEngineers

Figure A-1

Rev 09/2020

Drilled	Start 2/10/2021	End 2/10/2021	Total Depth (ft) 51.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.
Drilling Method	Mud Rotary				
Surface Elevation (ft) 25 Vertical Datum NAVD88	Hammer Data Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment Diedrich D-50 track			
Easting (X) 1215497 Northing (Y) 672396	System Datum WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed			

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	Approximately 4 inches of asphalt concrete pavement			
								SM	Brown silty fine to medium sand (loose, moist) (alluvium)			
			11	6		1 MC				20		
20	5		10	8		2 MC				26		
			7	3		3 %F			Becomes very loose, wet	31	25	Groundwater observed at approximately 7 feet below ground surface during drilling
15	10		10	4		4 %F			Becomes loose	30	31	
			9	9		5						California sampler Approximate SPT N-value is 4
10	15		10	10		6			Becomes medium dense			
5	20		9	12		7						California sampler Approximate SPT N-value is 5
0	25		0	7		8			Becomes loose			No recovery
-5	30		13	12		9 MC		CL	Gray clay (medium stiff, wet) (glaciomarine drift)	37		California sampler Approximate SPT N-value is 5
-10	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-1-2021

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Elevation (feet)	Depth (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	35	☒	18	0		10 MC	▨	CL	Gray clay (very soft, wet)			
-15	40	☒	18	0		11 AL	▨			54		AL (PI = 27; LL = 49)
-20	45	☒	18	0		12 MC	▨			43		
		■	0			13	▨					Shelby-tube, no recovery
-25	50	☒	18	0		14 MC	▨			39		

Log of Boring B-1-2021 (continued)

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Drilled	Start 2/10/2021	End 2/10/2021	Total Depth (ft) 61.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.
Drilling Method	Mud Rotary				
Surface Elevation (ft) Vertical Datum	24 NAVD88	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-50 track
Easting (X) Northing (Y)	1215109 673429	System Datum	WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	Approximately 4 inches of asphalt concrete pavement			
								SM	Brown silty fine to medium sand with occasional gravel (medium dense, wet) (fill)			
		☒	12	22		1 MC				19		
20												
	5	☒	0	6		2		SM	Brown silty fine to medium sand with gravel (loose, wet) (alluvium)			Groundwater observed at approximately 5 feet below ground surface during drilling
		▥	12	5		3 MC			Becomes very loose	17		California sampler Approximate SPT N-value is 2
15												
	10	☒	6	4		4						
		▥	18	6		5 SA		ML/SM	Brown sandy silt to silty fine sand (soft/loose, wet)	29	51	California sampler Approximate SPT N-value is 3
10												
	15	☒	9	4		6						
5												
	20	▥	11	11		7			Becomes soft to medium stiff/loose			California sampler Approximate SPT N-value is 5
0												
	25	☒	8	8		8						No recovery
								SP-SM	Gray fine to medium sand with silt (loose, wet)			
-5												
	30	▥	12	19		9 %F				24	5	California sampler Approximate SPT N-value is 8
-10												
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-3-2021

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Elevation (feet)	Depth (feet)	FIELD DATA Interval	 Recovered (in)	 Blows/foot	 Collected Sample	 Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	☒	6	12		10	⁘					
-15							⁘					
	40	▯	12	5		11 MC	▨	CL	Gray clay with trace sand with decomposed piece of wood (very soft, wet) (glaciomarine drift)	44		California sampler Approximate SPT N-value is 2
-20							▨					
	45	☒	12	28		12 SA	⁘	SW-SM	Gray fine to coarse sand with silt (medium dense, wet)	17	10	
-25							⁘					
	50	☒	10	49		13	⁘		Becomes very dense with occasional gravel			
-30							⁘					
	55	☒	18	5		14 MC	▨	CL-ML	Gray clayey silt with sand and organic matter (medium stiff, wet)	22		
-35							▨					
	60	☒	18	12		15 MC	▨	CL	Gray silty clay with organic matter (stiff, wet)	25		

Log of Boring B-3-2021 (continued)

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-3
Sheet 2 of 2

Drilled	Start 2/12/2021	End 2/12/2021	Total Depth (ft) 51.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary
Surface Elevation (ft) 23 Vertical Datum NAVD88			Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D-50 track
Easting (X) 1215487 Northing (Y) 674310			System Datum WA State Plane North NAD83 (feet)		See "Remarks" section for groundwater observed
Notes:					

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						AC	Approximately 4 inches of asphalt concrete pavement			
							SM	Brown silty fine to medium sand with occasional gravel (loose, moist) (fill)			
20		☒	10	6		1					
	5	☒	5	2		2	SP-SM	Brown fine to medium sand with silt (very loose, wet) (alluvium)			Groundwater observed at approximately 5 feet below ground surface during drilling
15		▥	19	9		3 %F			21	11	California sampler Approximately SPT N-value is 4
	10	☒	4	2		4					
10		▥	12	5		5 %F			34	10	California sampler Approximate SPT N-value is 2
	15	☒	5	4		6					
5											
							SM	Gray silty fine to medium sand (very loose, wet)			
	20	▥	4	7		7 %F			36	16	California sampler Approximate SPT N-value is 3
0											
	25	☒	10	4		8					
-5											
	30	▥	5	5		9		With decomposed piece of wood			California sampler Approximate SPT N-value is 2
-10											
	35										

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-5-2021

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-4
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	35	☒	9	15		10 MC	▨	CL	Gray clay with silt (stiff, wet) (glaciomarine drift)	25		
-15							▨					
	40	▯	18	14		11 AL	▨		Becomes medium stiff	25		California sampler Approximate SPT N-value is 6 AL (PI = 23; LL = 44)
-20							▨					
	45	■	0			12	▨					Shelby-tube, no recovery
		☒	18	5		13 MC	▨			24		
-25							▨					
	50	☒	18	5		14 MC	▨			26		

Log of Boring B-5-2021 (continued)

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Drilled	Start 2/12/2021	End 2/12/2021	Total Depth (ft) 16.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary

Surface Elevation (ft) Vertical Datum	23 NAVD88	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-50 track
Easting (X) Northing (Y)	1215487 674310	System Datum	WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

		FIELD DATA										
Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							CC	Approximately 1 to 4 inches of crushed rock			
								SM	Brown fine to medium silty sand with gravel (medium dense, moist) (fill)			
20		☒	9	12		1 MC				10		
	5	☒	0	17		2						No recovery
15		☒	7	7		3 MC				54		Groundwater observed at approximately 7½ feet below ground surface during drilling
								SM	Brown-gray silty sand with occasional gravel (loose, wet)			
	10	☒	0	5		4						No recovery
								ML	Gray silt with sand (very soft, wet) (alluvium)			
10		▯	13	2		5 %F				35	70	California sampler Approximate SPT N-value is 1
	15	☒	18	0		6 MC				54		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

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Log of Boring B-6-2021

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-5
Sheet 1 of 1

Drilled	Start 2/9/2021	End 2/9/2021	Total Depth (ft) 51.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary

Surface Elevation (ft) Vertical Datum	24 NAVD88	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-50 track
Easting (X) Northing (Y)	1216018 674690	System Datum	WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	Approximately 4 inches of asphalt concrete rock			
								SM	Brown silty fine to medium sand (loose, moist) (possible fill/alluvium)			
			7	5		1 MC				21		
20												
	5		8	4		2 %F				26	32	
			5	4		3 %F			Becomes wet	31	36	Groundwater observed at approximately 7 feet below ground surface during drilling
15												
	10		6	3		4 MC			Becomes very loose	38		
								SP-SM	Brown fine to medium sand with silt (loose, wet) (alluvium)			
			18	21		5 %F				29	12	California sampler Approximate SPT N-value is 8
10												
	15		7	8		6						
5												
								SP-SM	Gray fine to medium sand with silt and occasional gravel (medium dense, wet)			
	20		7	10		7						
0												
	25		6	15		8						
-5												
	30		0	*50/6"		9			No recovery			California sampler Approximate SPT N-value is 20/6" Drilled through wood *Blow count overstated
-10												
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-7-2021

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Elevation (feet)	Depth (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	35	☒	0	5		10A						
						10B MC		CL	Gray silty clay (medium stiff, wet) (glaciomarine drift)	24		
-15												
	40	■	24			11						Shelby-tube
		☒	18	7		12 MC				27		
-20												
	45	☒	18	5		13 MC				24		
-25												
	50	☒	4	5		14						

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Log of Boring B-7-2021 (continued)

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Drilled	Start 2/11/2021	End 2/11/2021	Total Depth (ft) 16.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.	Drilling Method Hollow-stem Auger
Surface Elevation (ft) 24 Vertical Datum NAVD88			Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D-50 track
Easting (X) 1216018 Northing (Y) 674690			System Datum WA State Plane North NAD83 (feet)		See "Remarks" section for groundwater observed

Notes:

		FIELD DATA										
Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							CC	Approximately 1 to 4 inches of crushed rock			
								SM	Brown silty fine to medium sand with crushed rock (medium dense, moist) (fill)			
		☒	12	25		1 MC				9		
20												
	5	☒	6	16		2 MC				10		
		☒	6	5		3 MC			Becomes loose	17		
15												
	10	☒	9	5		4 %F		SM	Brown silty fine sand (loose, wet) (alluvium)	27	50	Groundwater observed at approximately 10 feet below ground surface during drilling
		☒	14	7		5 %F				32	45	
10												
	15	☒	10	11		6			Becomes medium dense			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-8-2021

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-7
Sheet 1 of 1

Drilled	Start 2/8/2021	End 2/8/2021	Total Depth (ft) 61.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.
Drilling Method	Mud Rotary				
Surface Elevation (ft)	25	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-50 track
Vertical Datum	NAVD88				
Easting (X)	1216748	System	WA State Plane North	See "Remarks" section for groundwater observed	
Northing (Y)	676070	Datum	NAD83 (feet)		

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	Approximately 4 inches of asphalt concrete rock			
								SM	Brown silty fine to medium sand with occasional gravel (loose, moist) (alluvium)			
		☒	5	10		1 MC				17		
20	5	☒	6	4		2 MC				21		
		☒	10	4		3 MC				25		
15	10	☒	0	7		4 MC				19		Groundwater observed at approximately 10 feet below ground surface during drilling
								SP-SM	Brown fine to medium sand with silt (loose, wet)			
		☒	0	7		5 %F				25	6	
10	15	☒	0	10		6						
5	20	☒	0	7		7 %F				26	7	
0	25	☒	5	6		8						
-5	30	☒	6	8		9		SP-SM	Gray fine to medium sand with silt and gravel (loose, wet)			Lost drilling mud
-10	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-9-2021

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-8
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	35	☒	5	12		10			Becomes medium dense			
-15	40	☒	5	7		11			Becomes loose			
									Becomes very loose			
-20	45	▥	11	5		12						Approximate SPT N-value is 2
-25	50	☒	16	8		13A						
						13B		CL	Gray silty clay (medium stiff, wet) (glaciomarine drift)			
-30	55	☒	12	4		14 AL				24		AL (PI = 18; LL = 37)
-35	60	☒	0	13		15			Becomes stiff			No recovery

Log of Boring B-9-2021 (continued)

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Drilled	Start 2/11/2021	End 2/11/2021	Total Depth (ft) 16.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.	Drilling Method Hollow-stem Auger

Surface Elevation (ft) 25 Vertical Datum NAVD88	Hammer Data Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment Diedrich D-50 track
Easting (X) 1216748 Northing (Y) 676070	System Datum WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							CC	Approximately 1 to 4 inches of crushed rock			
								SM	Brown silty fine to medium sand (medium dense, moist) (fill)			
		☒	5	*36		1 MC				8		*Blow count overstated
20	5	☒	4	12		2			With occasional gravel			
		☒	3	17		3						
15	10	▥	4	6		4 %F		SM	Brown silty fine to medium sand (loose, wet) (alluvium)	19	29	Groundwater observed at approximately 10 feet below ground surface during drilling
		☒	11	6		5 %F				12	16	
10	15	☒	9	7		6 MC				16		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

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Log of Boring B-10-2021

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-9
Sheet 1 of 1

Drilled	Start 2/8/2021 End 2/8/2021	Total Depth (ft) 51.5	Logged By JES Checked By AJH	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary
Surface Elevation (ft) 22 Vertical Datum NAVD88		Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D-50 track	
Easting (X) 1217056 Northing (Y) 676947		System Datum WA State Plane North NAD83 (feet)		See "Remarks" section for groundwater observed	
Notes:					

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						AC	Approximately 4 inches of asphalt concrete pavement			
							SM	Brown silty sand (loose, moist to wet) (fill)			
20											
		☒	6	5		1 / MC			24		
	5	☒	8	5		2 / MC	SM	Brown silty fine to medium sand (loose, wet) (alluvium)	27		Groundwater observed at approximately 5 feet below ground surface during drilling
15											
		☒	7	3		3 / %F		Becomes very loose	29	17	
	10	☒	8	3		4 / %F			36	23	
10											
		☒	9	2		5 / MC			42		
	15	☒	10	2		6 / MC			50		
5											
	20	☒	11	8		7 / MC	CL	Brown clay with occasional decomposed organic matter (medium stiff to stiff, wet)	32		
0											
	25	☒	18	15		8 / AL			23		AL (PI = 14; LL = 34)
-5											
	30	☒	18	4		9 / MC		Becomes medium stiff	24		
-10											
	35										

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-11-2021

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-10
Sheet 1 of 2

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	☒	18	2		10 MC	▨		Becomes soft	24		
-15							▨					
	40	☒	18	5		11 MC	▨		Becomes medium stiff	22		
-20							▨					
	45	☒	18	1		12 MC	▨		Becomes very soft	19		
-25							▨					
	50	☒	18	16		13	▨		Becomes stiff			

Log of Boring B-11-2021 (continued)

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Figure A-10
Sheet 2 of 2

Drilled	Start 2/11/2021	End 2/11/2021	Total Depth (ft) 16.5	Logged By JES Checked By AJH
Driller	Holocene Drilling, Inc.	Drilling Method	Hollow-stem Auger	
Surface Elevation (ft) Vertical Datum	22 NAVD88	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	
Drilling Equipment	Diedrich D-50 track			
Easting (X) Northing (Y)	1217056 676947	System Datum	WA State Plane North NAD83 (feet)	
See "Remarks" section for groundwater observed				
Notes:				

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							CC	Approximately 1 to 4 inches of crushed concrete			
								SM	Brown silty fine to medium sand (very loose, moist) (fill)			
20												
		☒	0	0		1			No recovery			
	5	☒	7	3		2 MC				15		
15												
		☒	12	5		3 MC			Becomes loose	20		
	10	☒	11	5		4 %F				14	15	
10								SM	Dark gray silty fine to medium sand (very loose, wet) (alluvium)			
		☒	16	2		5 %F				29	31	Groundwater observed at approximately 12½ feet below ground surface during drilling
	15	☒	15	2		6 %F				36	37	

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring B-12-2021

GeoEngineers

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

Drilled	Start 2/11/2021	End 2/11/2021	Total Depth (ft)	21.5
Logged By	JES	Checked By	AJH	
Driller	Holocene Drilling, Inc.	Drilling Method	Hollow-stem Auger	

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-50 track
Surface Elevation (ft) Vertical Datum	25 NAVD88	Top of Casing Elevation (ft)	
Easting (X) Northing (Y)	1216259 676449	Horizontal Datum	WA State Plane North NAD83 (feet)

DOE Well I.D.: BMR 964
A 2-in well was installed on 2/11/2021 to a depth of 21.5 ft.

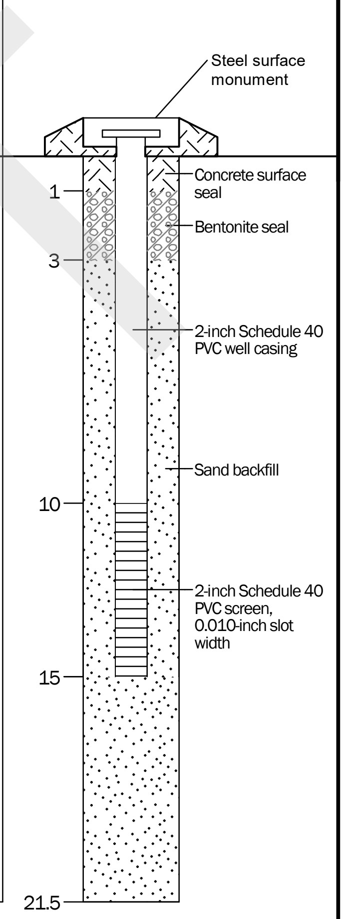
Groundwater

Date Measured	Depth to Water (ft)	Elevation (ft)
2/10/2021	12.50	12.50

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0								SOD	Approximately 5 inches of sod		
									CL-ML	Brown/gray clayey silt with sand (medium stiff, moist) (alluvium)		
		☒	16	6		1 MC					29	
20	5	☒	10	8		2 MC			SM	Brown silty fine to medium sand (loose, moist)	27	
		☒	15	0		3 MC			CL	Dark gray silty clay (very soft, moist)	43	
15	10	☒	10	2		4 MC				With decomposed pieces of wood	36	
							▼					
		☒	2	0		5			SP-SM	Gray fine to medium sand with silt (very loose, wet)		
10	15	▥	9	4		6 SA				(California sampler Approximate SPT N-value is 2)	29	6
5	20	☒	9	*28		7				(*Blow count overstated)		

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Aerial Imagery.

Log of Boring with Monitoring Well B-13-2021

GEOENGINEERS

Project: Ferndale Levee Improvements
Project Location: Ferndale, Washington
Project Number: 0484-113-00

APPENDIX B

Laboratory Testing

APPENDIX B
LABORATORY TESTING

Laboratory Test Results

Soil samples obtained from the explorations were transported to our laboratory and examined to confirm or modify field classifications, as well as to evaluate index properties of the soil samples. Representative samples were selected for laboratory testing consisting of the determination of the moisture content, percent fines/grain size analysis, and Atterberg limits. The tests were performed in general accordance with test methods of ASTM International (ASTM) or other applicable procedures.

Moisture Content Testing

The natural moisture contents of selected soil samples obtained from the exploratory borings were determined in general accordance with ASTM D 2216 test procedures. The results from the moisture content determinations are displayed shown on the exploration logs in Appendix A in the column labeled "Moisture Content %" adjacent to the corresponding samples.

Percent Passing U.S. No. 200 Sieve

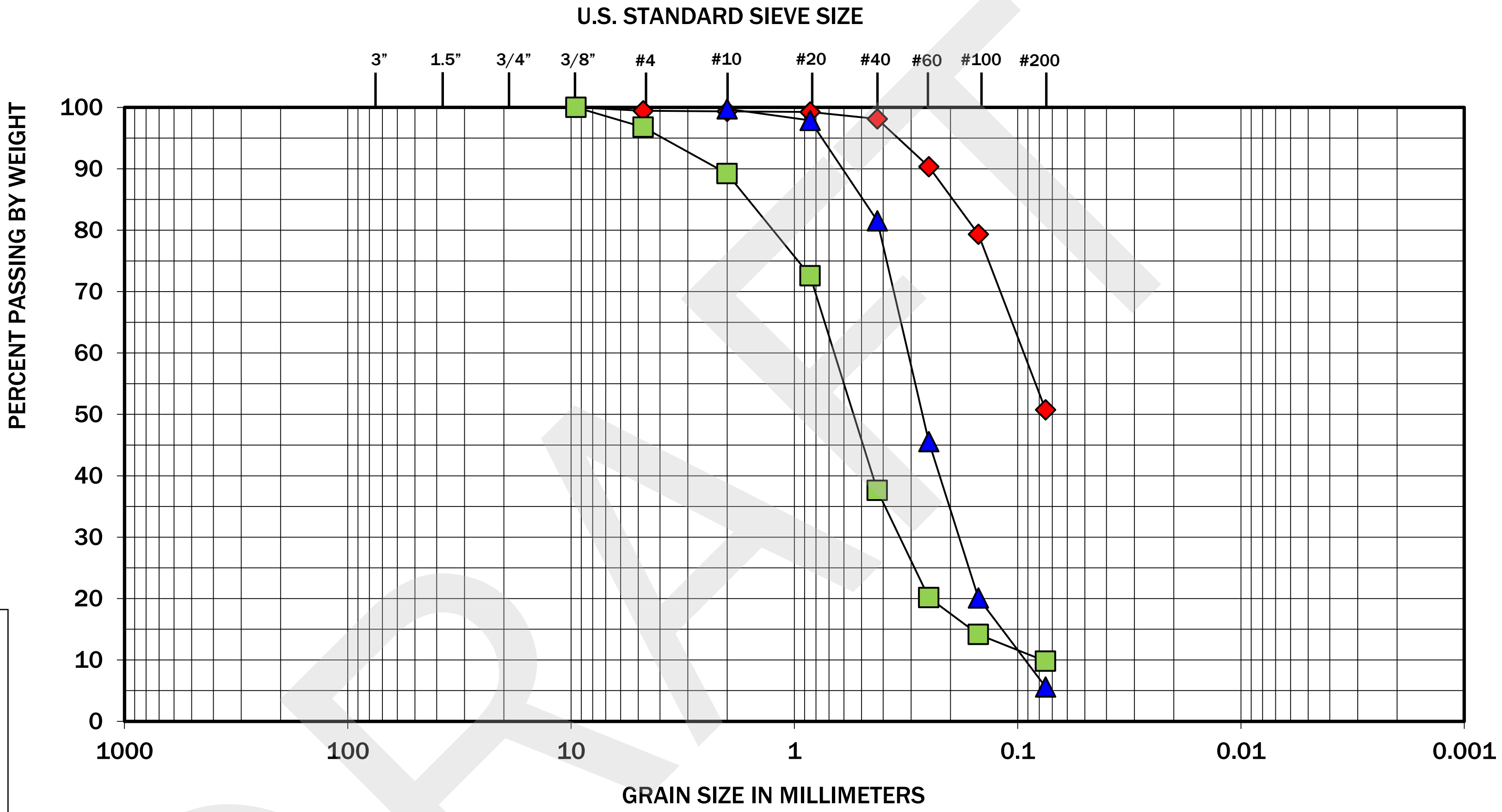
Selected samples were "washed" through the U.S. No. 200 mesh sieve to determine the relative percentage of coarse- and fine-grained particles in the soil. The percent passing value represents the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted in general accordance with ASTM D 1140. The results from the percent fines determinations are displayed in the column labeled "Fines Content (%)" adjacent to the corresponding samples on the summary exploration logs.

Sieve Analyses

Sieve analyses were performed on selected samples in general accordance with ASTM D 422 to determine the sample grain size distribution. The wet sieve analysis method was used to determine the percentage of soil greater than the U.S. No. 200 mesh sieve. The results of the sieve analyses were plotted, classified in general accordance with the Unified Soil Classification System (USCS), and are presented in Figure B-1.

Atterberg Limits Testing

Atterberg limits tests were performed on selected fine-grained soil samples. The tests were used to classify the soils as well as to evaluate index properties. The liquid limit and the plastic limit were estimated through a procedure performed in general accordance with ASTM D 4318. The results of the Atterberg limits tests are summarized in Figure B-2.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆	B-3-2021	12.5	29	Sandy silt (ML)
🟩	B-3-2021	45	17	Well-graded fine to coarse sand with silt (SW-SM)
▲	B-13-2021	15	29	Poorly-graded fine to medium sand with silt (SP-SM)

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

The grain size analysis results were obtained in general accordance with ASTM D 6913. GeoEngineers 17425 NE Union Hill Road Ste 250, Redmond, WA 98052

Sieve Analysis Results

Ferndale Levee Improvements
Ferndale, Washington

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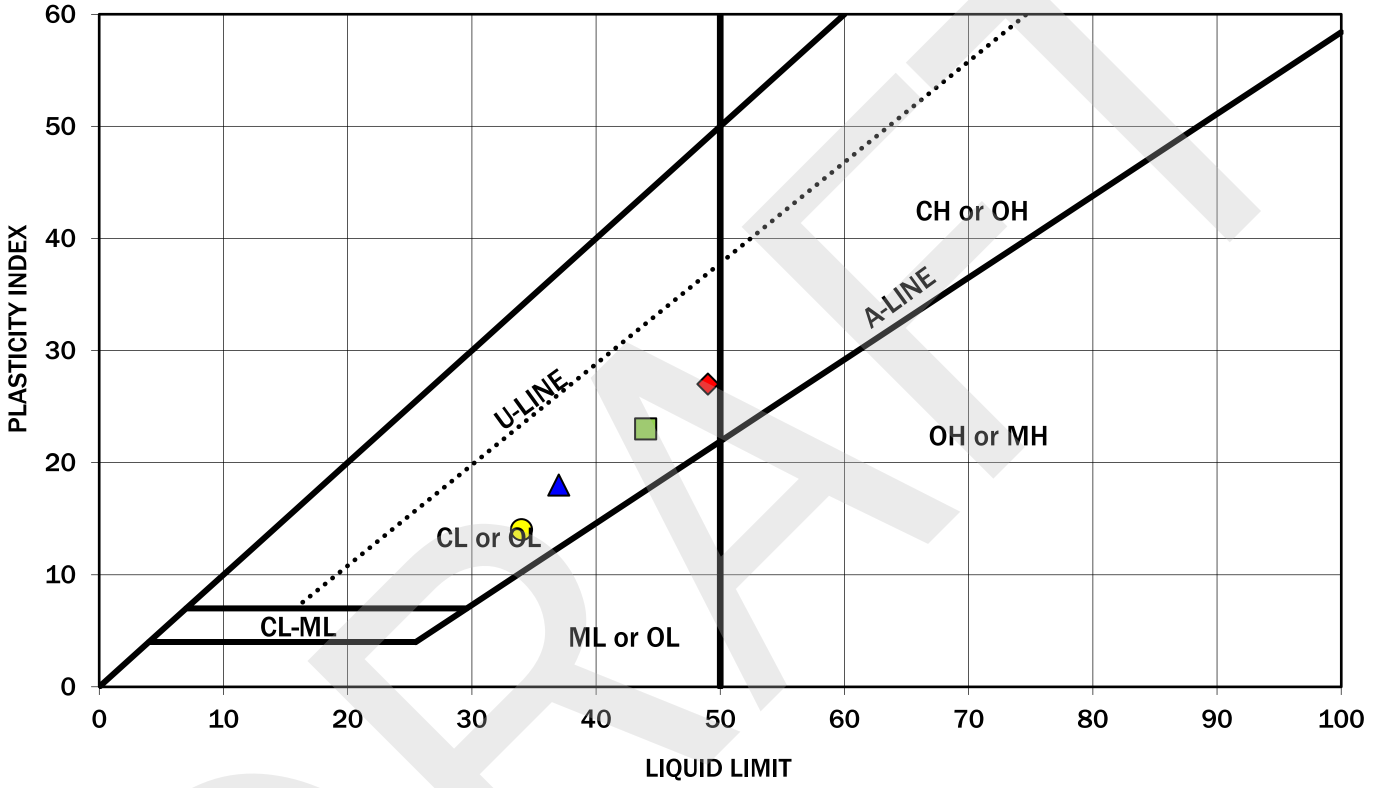
Figure B-1

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-1-2021	40	54	49	27	Gray clay (CL)
🟩	B-5-2021	40	25	44	23	Gray clay (CL)
▲	B-9-2021	55	24	37	18	Gray clay (CL)
🟡	B-11-2021	25	23	34	14	Gray clay (CL)

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes. The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318. GeoEngineers 17425 NE Union Hill Road Ste 250, Redmond, WA 98052

Atterberg Limits Test Results

Ferndale Levee Improvements
Ferndale, Washington

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Figure B-2

APPENDIX C

Previous Explorations

APPENDIX C
PREVIOUS SITE EXPLORATIONS

Selected logs from GeoEngineers' previous studies completed in the project vicinity are included in this appendix:

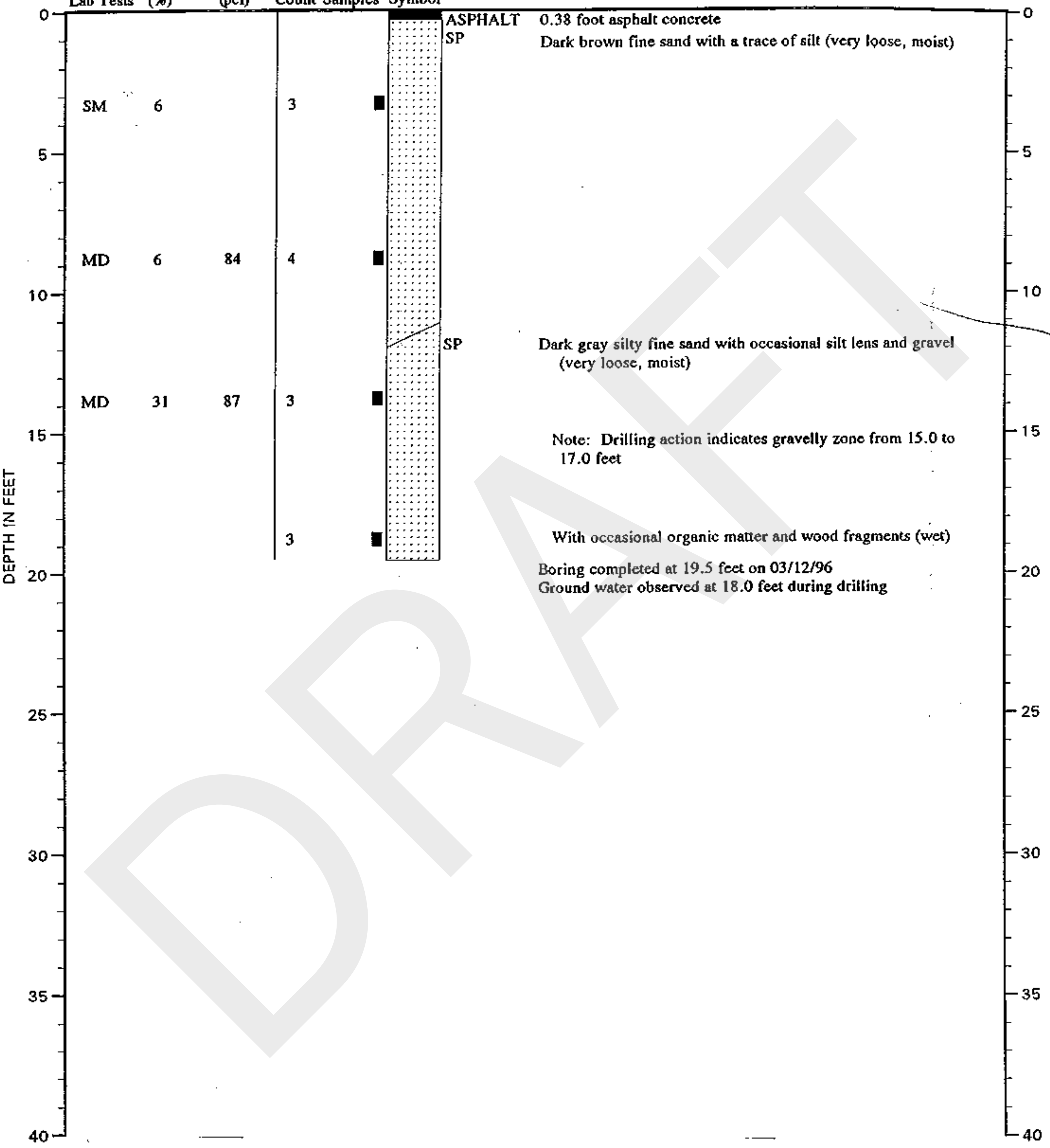
- City of Ferndale Wastewater Treatment Plant Project (1996); Borings B-1 and B-4 through B-7.
- City of Ferndale Wastewater Facility Improvements (2016); Borings B-1 through B-6.
- City of Ferndale Water Treatment Plant Improvements (2019); Test pits TP-1 through TP-3, and CPT-1.

BORING B-1

TEST DATA

DESCRIPTION

Surface Elevation (ft.): 24.0



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					ASPHALT	0.38 foot asphalt concrete
					SP	Dark brown fine sand with a trace of silt (very loose, moist)
SM	6		3	■		
MD	6	84	4	■		
					SP	Dark gray silty fine sand with occasional silt lens and gravel (very loose, moist)
MD	31	87	3	■		
						Note: Drilling action indicates gravelly zone from 15.0 to 17.0 feet
			3	■		With occasional organic matter and wood fragments (wet)

Boring completed at 19.5 feet on 03/12/96
Ground water observed at 18.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

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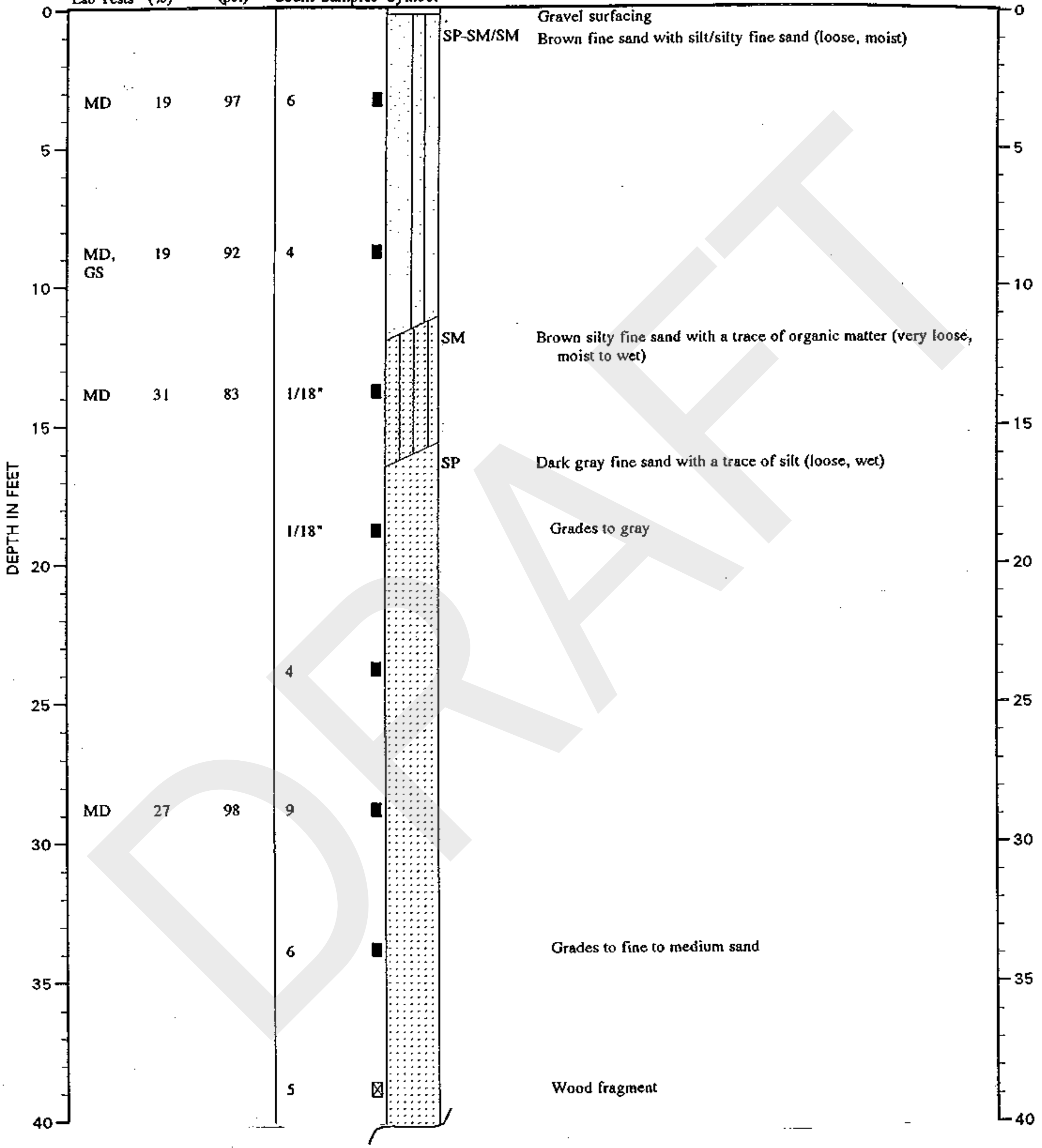
LOG OF BORING

FIGURE A-3

TEST DATA

BORING B-4

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples
MD	19	97	6	■
MD, GS	19	92	4	■
MD	31	83	1/18"	■
			1/18"	■
			4	■
MD	27	98	9	■
			6	■
			5	☒



DESCRIPTION

Surface Elevation (ft.): 25.8

Gravel surfacing

SP-SM/SM Brown fine sand with silt/silty fine sand (loose, moist)

SM Brown silty fine sand with a trace of organic matter (very loose, moist to wet)

SP Dark gray fine sand with a trace of silt (loose, wet)

Grades to gray

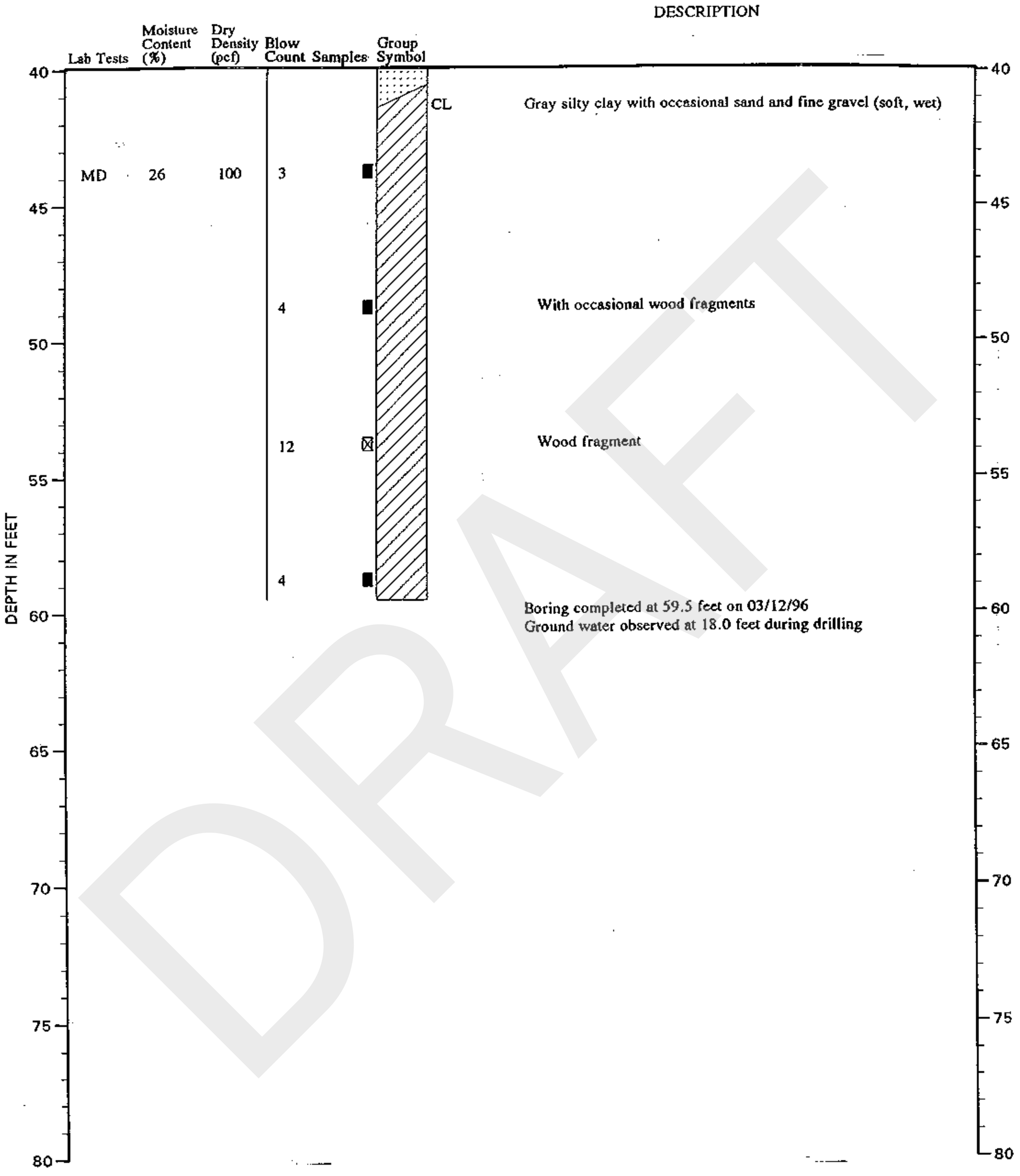
Grades to fine to medium sand

Wood fragment

Note: See Figure A-2 for explanation of symbols

TEST DATA

BORING B-4
(Continued)



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					CL	Gray silty clay with occasional sand and fine gravel (soft, wet)
MD	26	100	3	■		
			4	■		With occasional wood fragments
			12	☒		Wood fragment
			4	■		

Boring completed at 59.5 feet on 03/12/96
Ground water observed at 18.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

3358-003-73-5130 :GRS:JRG:CMS 4/9/96

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LOG OF BORING

FIGURE A-6

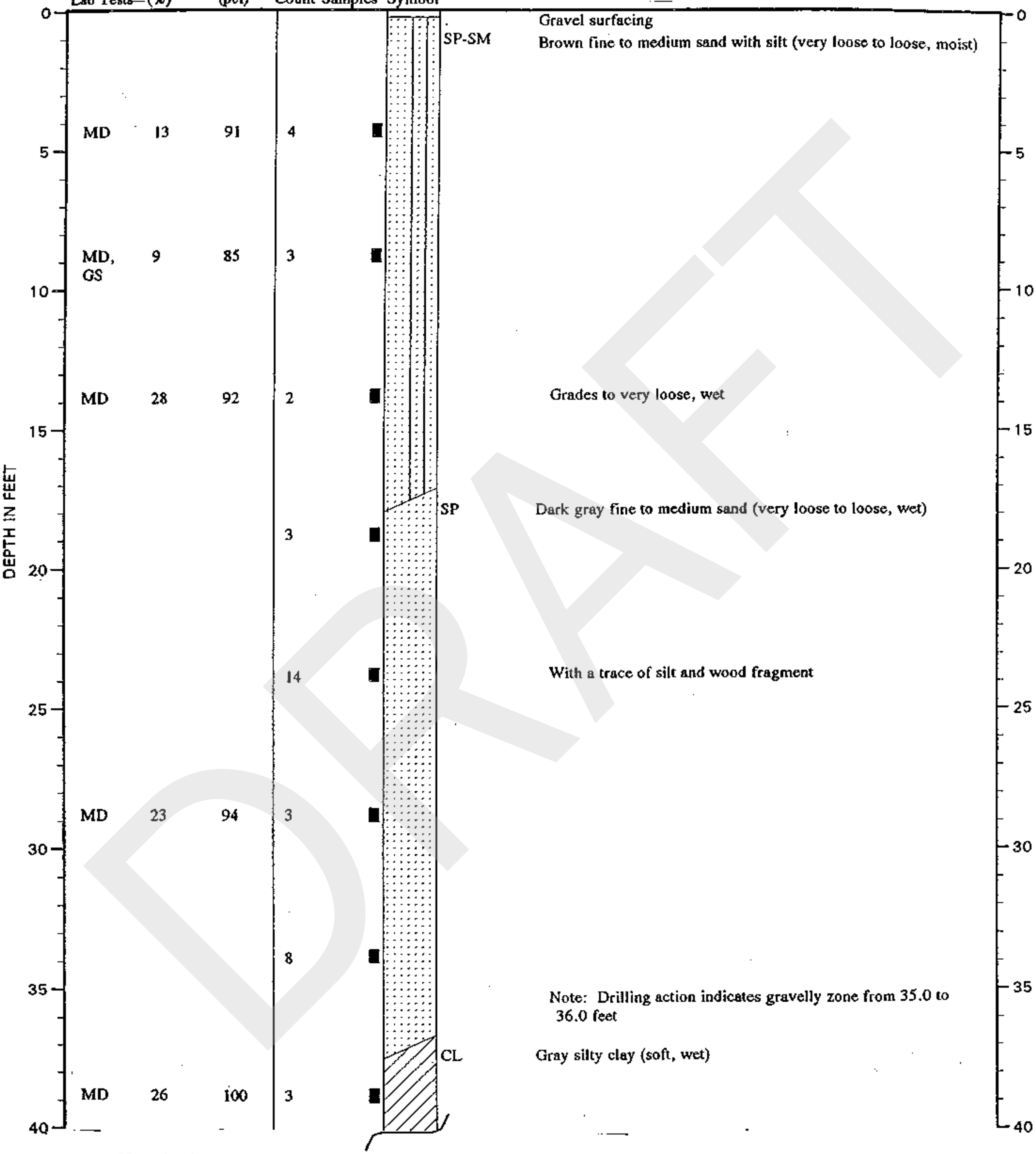
TEST DATA

BORING B-5

DESCRIPTION

Surface Elevation (ft.): 26.1

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
						Gravel surfacing
					SP-SM	Brown fine to medium sand with silt (very loose to loose, moist)
MD	13	91	4	■		
MD, GS	9	85	3	■		
MD	28	92	2	■		Grades to very loose, wet
					SP	Dark gray fine to medium sand (very loose to loose, wet)
			3	■		
			14	■		With a trace of silt and wood fragment
MD	23	94	3	■		
			8	■		
						Note: Drilling action indicates gravelly zone from 35.0 to 36.0 feet
					CL	Gray silty clay (soft, wet)
MD	26	100	3	■		



Note: See Figure A-2 for explanation of symbols

3358-003-73-5130 ;GRS:JRG:CMS 4/9/96

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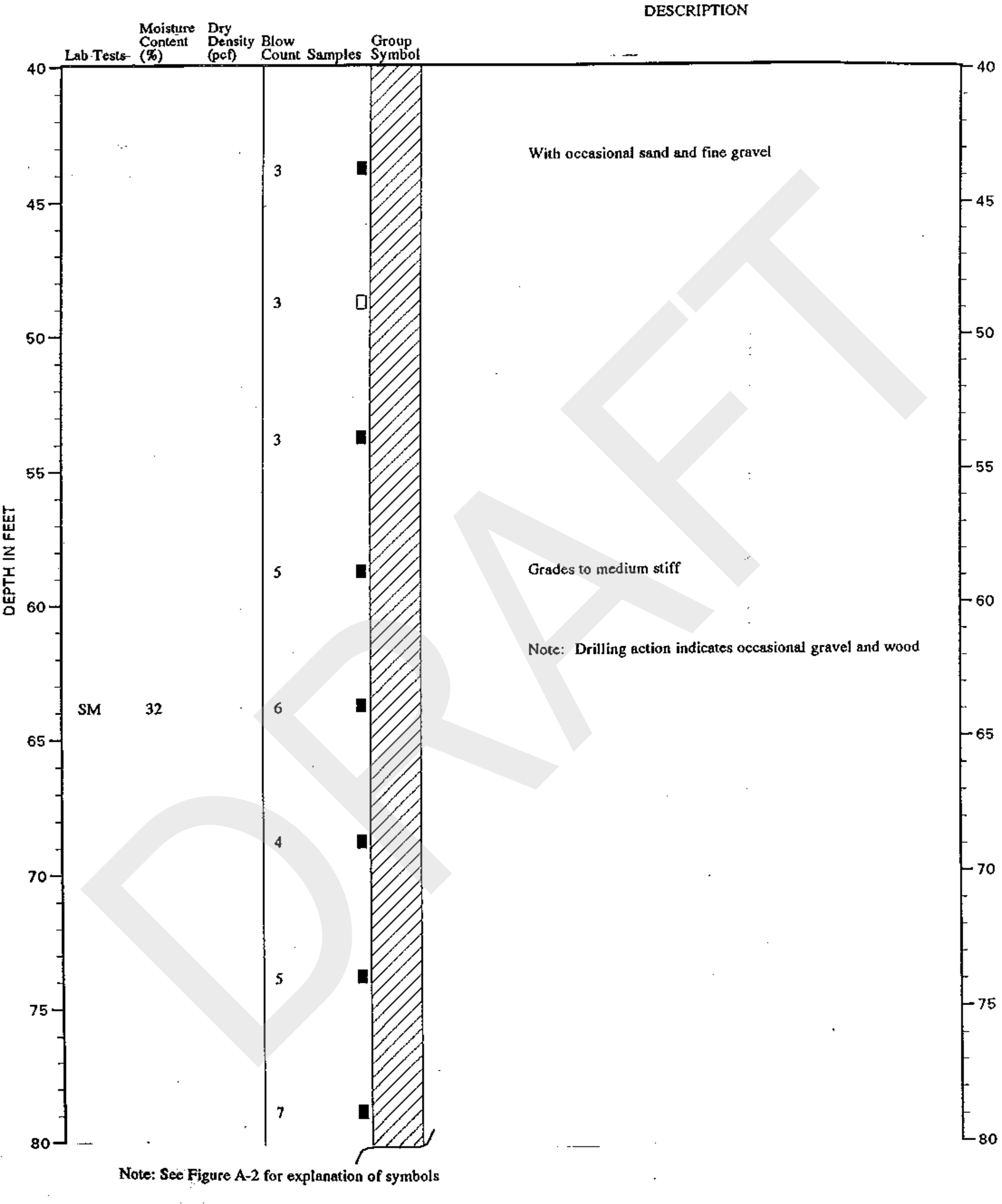
LOG OF BORING

FIGURE A-7

TEST DATA

BORING B-5
(Continued)



With occasional sand and fine gravel

Grades to medium stiff

Note: Drilling action indicates occasional gravel and wood

Note: See Figure A-2 for explanation of symbols

:GRS:JRG:CMS 4/9/96

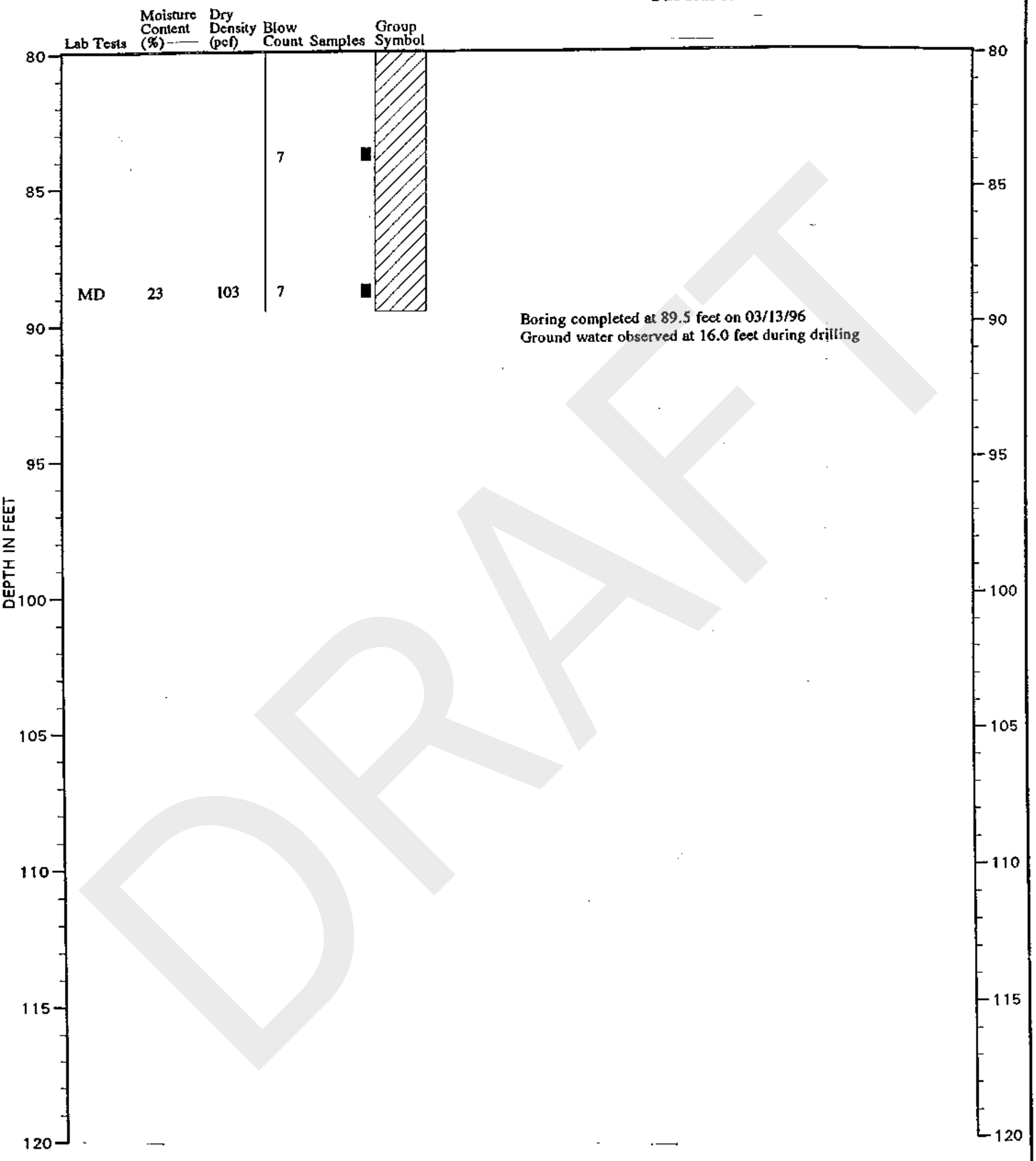
3358-003-73-5130

Geo Engineers

LOG OF BORING

FIGURE A-7

BORING B-5
(Continued)



Boring completed at 89.5 feet on 03/13/96
Ground water observed at 16.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

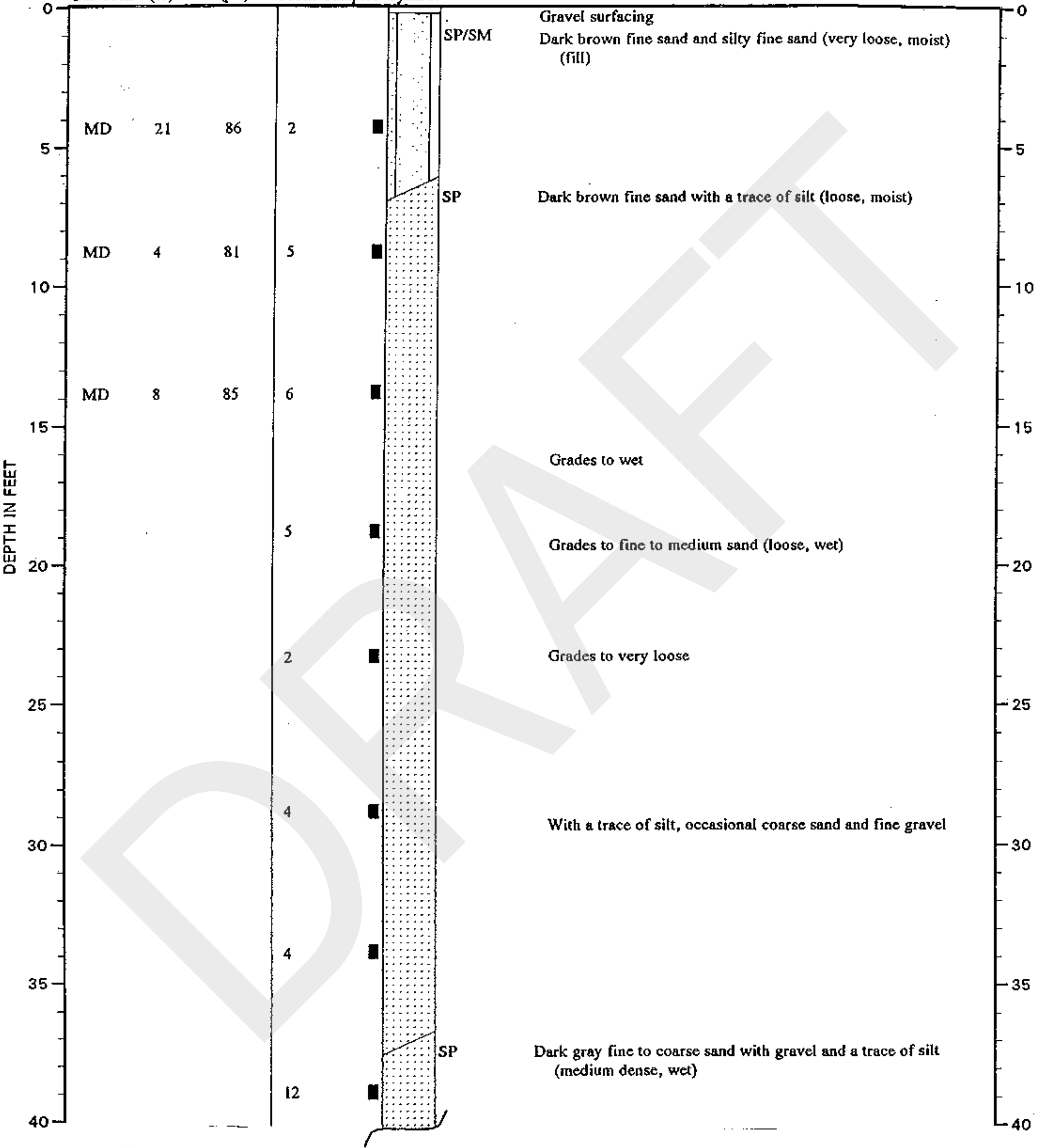
3358-003-73-5130 :GRS:JRG:CMS 4/9/96

TEST DATA

BORING B-6

DESCRIPTION

Surface Elevation (ft.): 25.7



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count
MD	21	86	2
MD	4	81	5
MD	8	85	6
			5
			2
			4
			4
			12

Gravel surfacing

SP/SM Dark brown fine sand and silty fine sand (very loose, moist) (fill)

SP Dark brown fine sand with a trace of silt (loose, moist)

Grades to wet

Grades to fine to medium sand (loose, wet)

Grades to very loose

With a trace of silt, occasional coarse sand and fine gravel

SP Dark gray fine to coarse sand with gravel and a trace of silt (medium dense, wet)

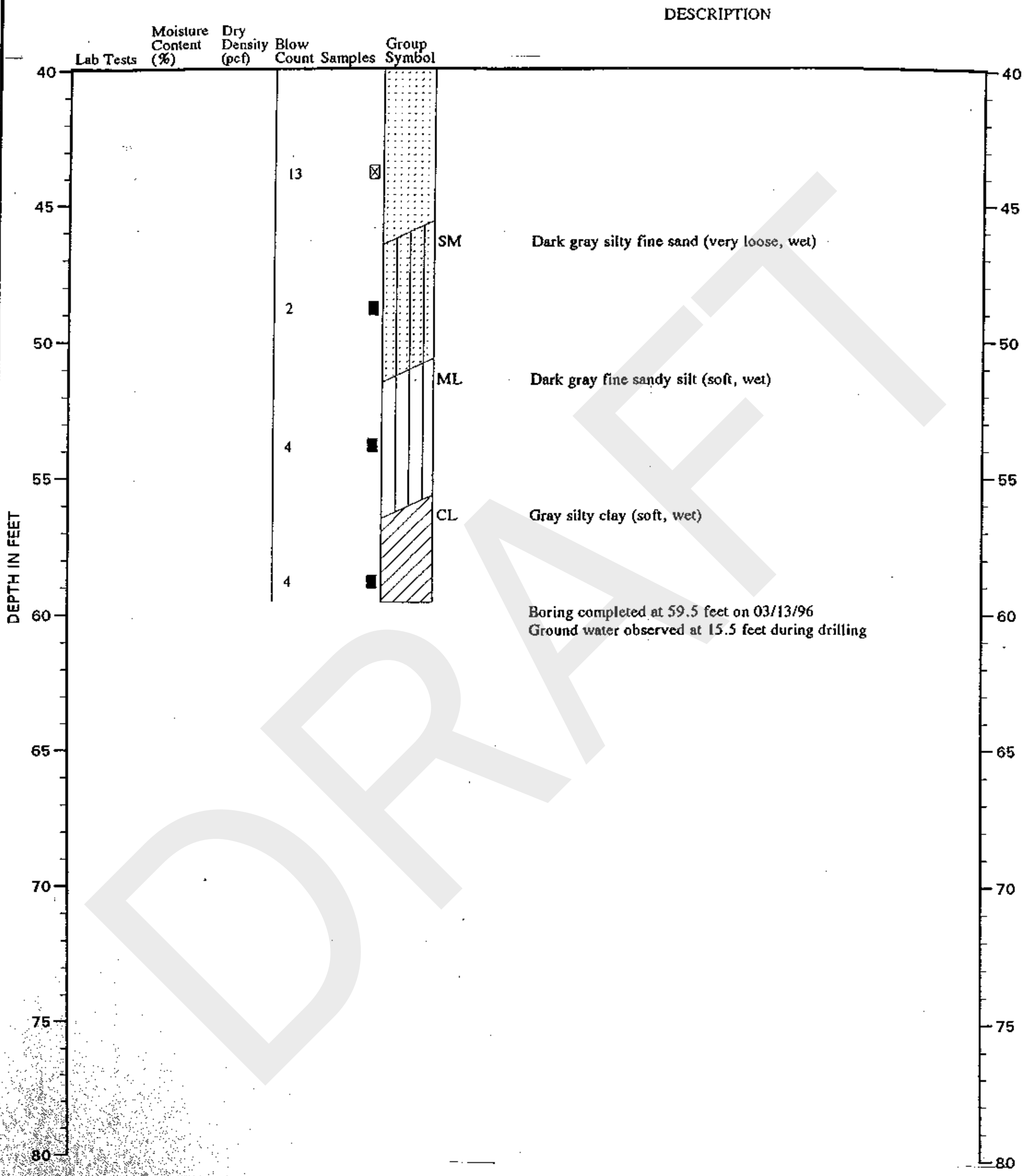
Note: See Figure A-2 for explanation of symbols

LOG OF BORING

FIGURE A-8

TEST DATA

BORING B-6
(Continued)



Dark gray silty fine sand (very loose, wet)

Dark gray fine sandy silt (soft, wet)

Gray silty clay (soft, wet)

Boring completed at 59.5 feet on 03/13/96
Ground water observed at 15.5 feet during drilling

Note: See Figure A-2 for explanation of symbols

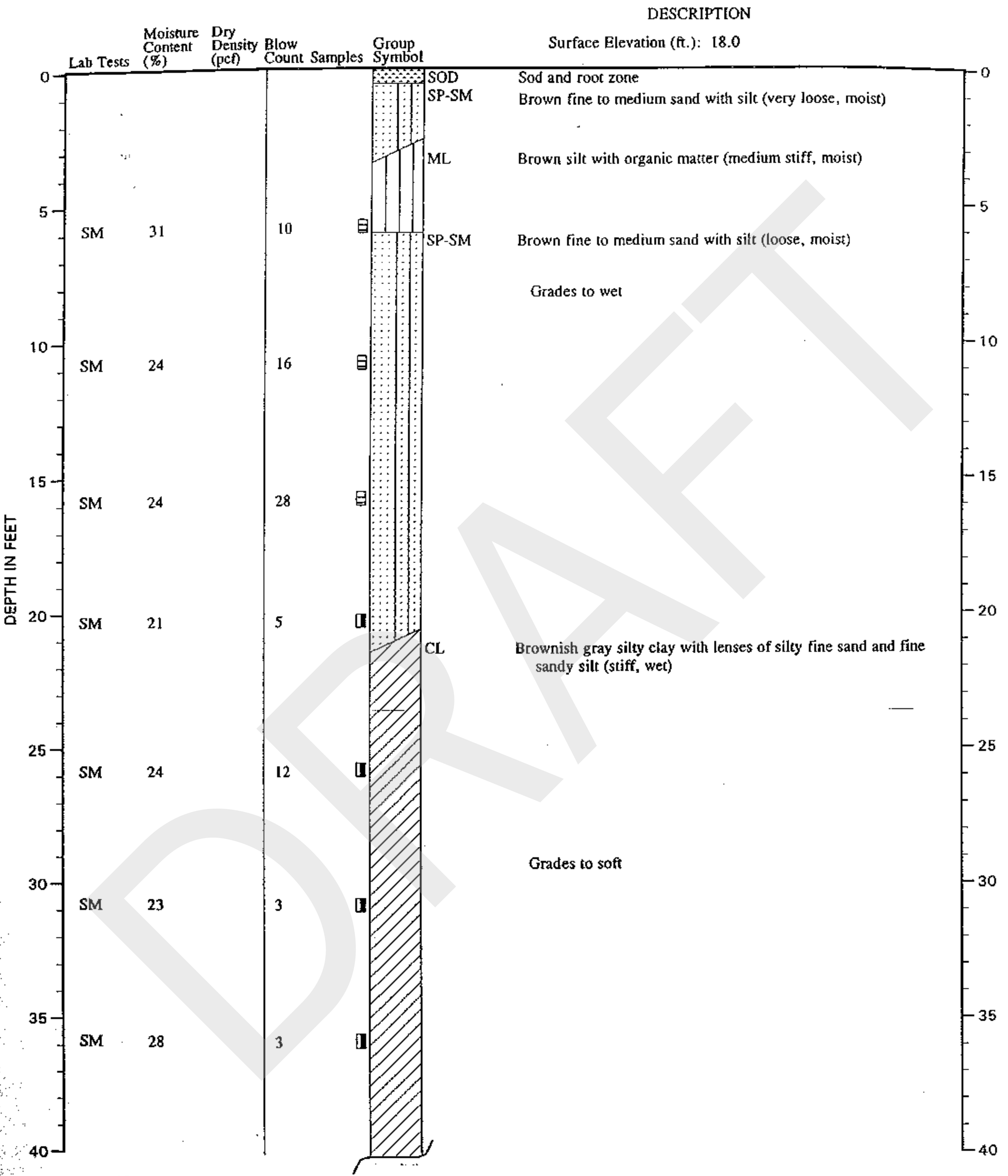
3358-003-73-5130 :GRS:JRG:CMS 4/9/96

BORING B-7

TEST DATA

DESCRIPTION

Surface Elevation (ft.): 18.0



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					SOD	Sod and root zone
					SP-SM	Brown fine to medium sand with silt (very loose, moist)
					ML	Brown silt with organic matter (medium stiff, moist)
SM	31		10		SP-SM	Brown fine to medium sand with silt (loose, moist)
						Grades to wet
SM	24		16			
SM	24		28			
SM	21		5			
					CL	Brownish gray silty clay with lenses of silty fine sand and fine sandy silt (stiff, wet)
SM	24		12			
						Grades to soft
SM	23		3			
SM	28		3			

Note: See Figure A-2 for explanation of symbols

GeoEngineers

LOG OF BORING

FIGURE A-9

BORING B-7
(Continued)

TEST DATA

DEPTH IN FEET	Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	DESCRIPTION
40				3	▯	▨	
45	SM	30		5	▯		Grades with sand and occasional gravel
50	SM	24		4	▯		
55	SM	28		13	▯		
60	SM	23		25	▯		
65	SM	32		17	▯		

Boring completed at 66.5 feet on 11/19/96
Ground water seepage observed at 8.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

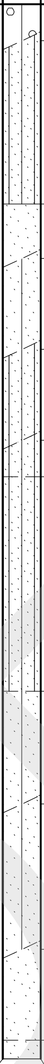
GeoEngineers

LOG OF BORING

FIGURE A-9

Drilled	Start 12/19/2016	End 12/19/2016	Total Depth (ft) 29	Logged By AF2 Checked By SWC	Driller Environmental Drilling, Inc.
Drilling Method	Hollow-stem Auger				
Surface Elevation (ft)	26	Hammer Data	Automatic 140 (lbs) / 30 (in) Drop	Drilling Equipment	B-61 Truck-mounted
Vertical Datum	NAVD88				
Easting (X)	1216052.6	System	WA State Plane North	Groundwater observed at 12½ feet at time of exploration	
Northing (Y)	675130.78	Datum	NAD83 (feet)		

Notes:



Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							GP-GM	Brown fine to coarse gravel with silt and sand (medium dense, moist) (pit run/road base)			
25		☒	6			1 MC				7		
								SM	Brown silty fine sand (medium dense, moist) (fill)			
		■	12	10		2 SA				17	43	
	5	■	12	5		3 MC			Grades to fine to coarse sand with occasional gravel	11		
20								SP	Brown-gray fine to medium sand with trace silt (loose, moist) (alluvium)			
		■	8	12		4 SA		SP-SM	Brown-gray fine to medium sand with silt (medium dense, moist)	9	14	
	10	■	18	3		5		SM/ML	Brown with slight iron staining silty fine sand with faint laminations interbedded with sandy silt and fine to medium sand layers (very loose/soft, moist)			
15												
		■	18	4		6A 6B MC		SM/ML	Brown with iron staining silty fine sand to sandy silt (loose/medium stiff, wet)			
								SM	Brown with slight iron staining silty fine to medium sand with discontinuous lenses of silty fine sand (loose, wet)	22		
	15											
10												
		■	18	2		7A						
						7B		SP-SM	Gray fine to medium sand with silt and wood piece (fresh) (loose, wet)			
	20											
5												
		■	18	12		8		SP-SM	Gray fine to coarse sand with silt and occasional gravel (medium dense, wet)			
	25											
0								SP	Gray fine to medium sand (medium dense to dense, wet)			
		■	18	33		9A %F				28	1	
						9B		SP	Gray fine to coarse with gravel (dense, wet)			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo, Vertical approximated based on Topographic Survey

Log of Boring B-1-2016

GEOENGINEERS

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Figure A-2
Sheet 1 of 1

Drilled	Start 12/21/2016	End 12/21/2016	Total Depth (ft) 24	Logged By MWR Checked By SWC	Driller Environmental Drilling, Inc.	Drilling Method Hollow-stem Auger

Hammer Data	Automatic 140 (lbs) / 30 (in) Drop	Drilling Equipment	B-61 Truck-mounted
Surface Elevation (ft) Vertical Datum	25 NAVD88	Top of Casing Elevation (ft)	
Easting (X) Northing (Y)	1216163.08 674887.86	Horizontal Datum	WA State Plane North NAD83 (feet)

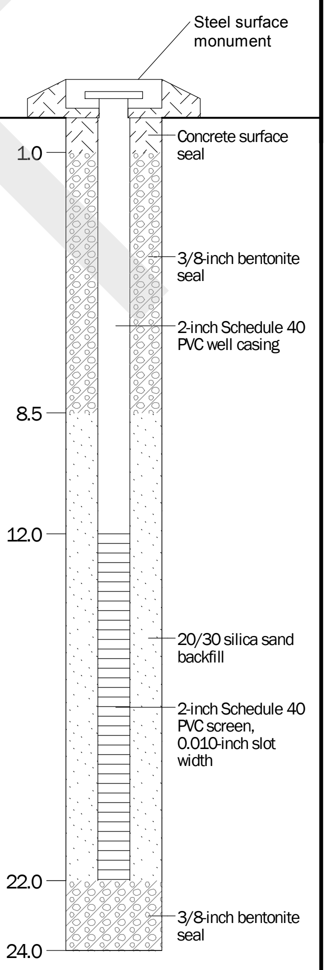
DOE Well I.D.: BIZ 328
A 2 (in) well was installed on 12/19/2016 to a depth of 24 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0		3			1			GP-GM	Brown fine to coarse gravel with silt and sand (medium dense, moist) (fill)		
			13	25		2 MC				Grades to gray-brown	6	
20	5		10	22		3 MC			SP-SM	Brown fine to medium sand with silt and gravel (medium dense, moist) Decreased gravel content from 5½ to 5¾ feet	9	
			12	8		4 MC			SP	Brown fine to medium sand with 1-inch silt lens (loose, moist) (alluvium)	6	
15	10		15	7		5A MC 5B			SM	Brown silty fine sand (loose, moist)	22	
									SP	Brown fine to medium sand (loose, moist)		
			15	5		6 %F			SM	Brown silty fine to medium sand (loose, moist to wet)	24	21
10	15											
									SP	Brown fine to medium sand with trace silt (medium dense, wet)		
			18	12		7				2-inch wood lens at 18¼ feet		
5	20											
			18	13		8				Grades to coarse sand with occasional wood (fresh)		
										(3 feet of heave in auger at 24 feet)		

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo, Vertical approximated based on Topographic Survey

Log of Boring B-2P-2016

GeoEngineers

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Figure A-3
Sheet 1 of 1

Drilled	Start 12/19/2016	End 12/19/2016	Total Depth (ft) 68.75	Logged By AF2 Checked By SWC	Driller	Environmental Drilling, Inc.	Drilling Method: Hollow-stem Auger
Surface Elevation (ft) Vertical Datum	26 NAVD88		Hammer Data	Automatic 140 (lbs) / 30 (in) Drop	Drilling Equipment	B-61 Truck-mounted	
Easting (X) Northing (Y)	1215865.15 675028.49		System Datum	WA State Plane North NAD83 (feet)	Groundwater observed at 13½ feet at time of exploration		
Notes:							

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
25	0						SP-SM	Brown fine to coarse sand with silt and gravel (dense, moist) (pit run/fill)			
			16	12		1 MC	SM	Brown with slight iron staining silty fine sand with occasional gravel, discontinuous silt lenses and organic matter (charcoal bits) (medium dense, moist) (fill)	44		Rough drilling at 1½ feet
20	5		18	4		2 SA	SM	Brown silty fine sand with fine to medium sand lenses (loose, moist) (alluvium)	12	31	
			18	3		3 MC		Grades to with faint iron staining and occasional organic matter, becomes very loose	31		
15	10		12	5		4 MC	SP-SM	Brown fine to medium sand with silt (loose, moist)	10		
			18	6		5	SM/ML	Brown interbedded silty fine to medium sand and sandy silt (loose/medium stiff, moist) Becomes wet			
10	15										
			18	4		6	WOOD	12-inch thick wood layer (4 inches partially decomposed, 8 inches of fresh wood)			
							CL/SC	Gray sandy clay to clayey fine to medium sand (medium stiff/loose, wet)			
5	20										
			12	50/6"*		7	SP-SM	Gray fine to medium sand with silt and brown silt lenses (medium dense, wet) 8-inch thick wood layer at 23 feet			*Blow count overstated, on wood
0	25						SP	Gray fine to coarse sand with gravel, trace silt, and occasional wood (fresh) (loose, wet)			
			18	6		8 SA			19	3	
-5	30						GP	Gray fine gravel with sand (medium dense, wet)			
			2	18		9					Poor recovery 2 feet of heave in auger
	35										

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo, Vertical approximated based on Topographic Survey

Bellingham: Date:2/3/17 Path:W:\PROJECTS\3\3358017\GINT\335801701.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-3-2016

GeoEngineers

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Figure A-4
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
-10	35							SP/GP	Gray fine to coarse sand with gravel to sandy gravel (dense, wet) (glacial outwash)			
			6	31		10						2 feet of heave in auger
-15	40											
			12	39		11						3 feet of heave in auger
-20	45											Driller noted gravel layer at 45 feet
								SP-SM	Gray fine to medium sand with silt and occasional gravel (dense, wet)			
			17	64/11"		12A 12B MC						
								ML	Gray clayey silt with occasional gravel (hard, moist) (glacially consolidated deposits)	17		
-25	50											
								SP-SM	Gray fine to medium sand with silt (very dense, wet)			
			15	93/11"		13 SA				22	8	
-30	55											
			18	64		14 MC			Sand grades finer	20		2 feet of heave in auger
-35	60											
								SM	Gray silty fine sand (very dense, wet)			
			18	73		15						9 feet of heave in auger
-40	65											
			12	93/9"		16						

Log of Boring B-3-2016 (continued)

GeoEngineers

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Drilled	Start 12/20/2016 · End 12/20/2016
Total Depth (ft)	59
Logged By	AF2
Checked By	SWC
Driller	Environmental Drilling, Inc.
Drilling Method	Hollow-stem Auger
Hammer Data	Automatic 140 (lbs) / 30 (in) Drop
Drilling Equipment	B-61 Truck-mounted
Surface Elevation (ft)	28
Vertical Datum	NAVD88
Top of Casing Elevation (ft)	
Easting (X)	1215633.53
Northing (Y)	675136.15
Horizontal Datum	WA State Plane North NAD83 (feet)

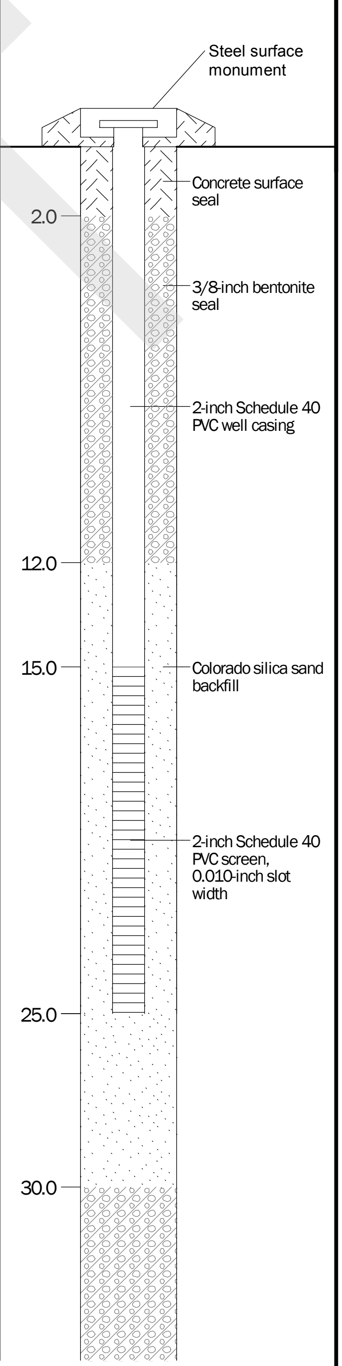
A 2 (in) well was installed on 12/20/2016 to a depth of 25 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0								GP	2 to 3 inches of gravel		
			6			1			GM	Brown silty gravel with sand and quarry spalls (medium dense, moist) (fill)		
25			6	18		2 MC					9	
									SM	Gray silty fine sand with occasional gravel (medium dense, moist)		
	5		18	24		3 SA					13	33
20			18	17		4 MC					14	
	10		18	6		5 %F			SP-SM	Gray fine sand with silt (loose, moist) (alluvium)	10	13
15			18	2		6A SA 6B				Grades to gray-brown	15	9
									ML	Gray-brown sandy silt (soft, moist)		
	15											
									SM	Gray silty sand with occasional wood (fresh) (very loose, wet)		
10			18	1		7 %F					30	28
	20											
									SM	Gray silty fine to medium sand (loose, wet)		
5			18	6		8						
	25											
									ML	Gray sandy silt with clay, fine to medium sand lenses, silty clay lenses and laminations (medium stiff, wet)		
0			18	7		3						
	30											
									CL	Gray to brown silty clay with organic matter (charcoal, partially decomposed wood) (stiff, wet) (TV = 1.6, PP = 0.5)		
-5			18	11		10 MC					47	
	35											

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo, Vertical approximated based on Topographic Survey

Log of Boring B-4P-2016

GEOENGINEERS

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Figure A-5
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	WELL LOG
	35								SP	Gray fine to medium sand with trace silt (very dense, moist) (glacially consolidated deposits)			
-10		■	12	51		11				(2 feet of heave in auger)			
	40												
									GP-GM	Gray fine gravel with silt and sand (very dense, wet)			
-15		■	18	68		12							
	45								SP-SM	Gray fine to medium sand with silt and gravel layers (very dense, wet)			3/8-inch bentonite seal
-20		■	18	93/9"		13							
	50												
									CL	Gray clay with sand and occasional gravel (hard, wet)			
-25		■	8	32		14 AL				AL (LL = 41; PI = 25) (TV = 4.0) (Rough, gravelly drilling from 54 to 57 feet)	20		
	55												
-30		■	16	45		15A				Increased gravel content			
						15B			SM	Gray silty fine sand (dense, wet)			59.0

Log of Boring B-4P-2016 (continued)

GeoEngineers

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Drilled	Start 12/20/2016 End 12/20/2016	Total Depth (ft) 68.75	Logged By AF2 Checked By SWC	Driller Environmental Drilling, Inc.	Drilling Method Hollow-stem Auger
Surface Elevation (ft) 27 Vertical Datum NAVD88		Hammer Data Automatic 140 (lbs) / 30 (in) Drop		Drilling Equipment B-61 Truck-mounted	
Easting (X) 1215758.99 Northing (Y) 674906.71		System Datum WA State Plane North NAD83 (feet)		Groundwater observed at 12½ feet at time of exploration	
Notes:					

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0		6			1		GP-GM	Brown fine to coarse gravel (quarry spalls) with silt and sand (dense, moist) (fill)			
25								SM	Brown silty fine sand (medium dense, moist)			
			18	16		2 MC				18		
	5		18	8		3 MC		SM/ML	Gray silty fine sand with sandy silt lenses (loose/medium stiff to stiff, moist)	22		
20			18	14		4A MC				18		
						4B		SM	Brown silty fine sand with faint laminations (loose, moist) (alluvium)			
	10		8	4		5 MC				22		
15									Becomes fine to medium			
			18	1		6		ML	Brown with iron staining sandy silt with clay (very soft, wet)			
	15											
10								CL	Gray with slight iron staining clay with silt (very soft, wet)			
			18	8		7A 7B 7C		ML	Gray-brown with iron staining sandy silt (medium stiff, wet)			
	20							SP	Brown with iron staining fine to medium sand with trace silt (loose, wet)			
5								SP-SM	Gray fine to medium sand with silt (loose, wet)			
			12	7		8 %F				27	6	
	25											
0								SM	Gray silty fine to medium sand (very loose, wet)			
			18	1		9		WOOD	9-inch thick wood layer			
								SM	Gray silty fine to medium sand (very loose, wet)			
	30											
-5								SP-SM	Gray fine to medium sand with silt (loose, wet)			
			18	7		10A						
	35					10B		CL/SC	Gray sandy clay to clayey sand (medium stiff/loose, wet)			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo, Vertical approximated based on Topographic Survey

Log of Boring B-5-2016

GEOENGINEERS

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Elevation (feet)	Depth (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	35							CL	Brown silty clay with occasional sand (stiff, moist) (glaciomarine drift)			Driller noted stiffer drilling at 35 feet
-10												
			18	12		11 AL				24		AL (LL = 46; PI = 28) TV = 6.1, PP = 2.75
	40											
								CL	Gray clay with sand and occasional gravel (medium stiff to stiff, wet)			
-15												
			18	8		12 MC				26		TV = 4.8
	45											
								CL	Gray clay with sand and occasional gravel (soft, wet)			
-20												
			18	2		13 AL				22		AL (LL = 34; PI = 19) TV = 2.6
	50		24	P		14						
-25												
			18	6		15			Gravel in bottom of sampler tube			TV = 2.5
	55											
-30												
			12	50/6"		16 MC		ML/SM	Gray sandy silt to silty fine sand (hard/very dense, moist) (glacially consolidated deposits)	18		
	60											
-35												
			18	63		17						
	65											
-40								ML	Gray sandy silt (hard, moist)			
			10	50/4"		18 MC				12		

Log of Boring B-5-2016 (continued)

GEOENGINEERS

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Figure A-6
Sheet 2 of 2

Bellingham: Date:2/3/17 Path:W:\PROJECTS\3\3358017\GINT\335801701.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Drilled	Start 12/21/2016	End 12/21/2016	Total Depth (ft) 16.5	Logged By MWR Checked By SWC	Driller Environmental Drilling, Inc.
Drilling Method	Hollow-stem Auger				

Surface Elevation (ft) Vertical Datum	26 NAVD88	Hammer Data	Automatic 140 (lbs) / 30 (in) Drop	Drilling Equipment	B-61 Truck-mounted
Easting (X) Northing (Y)	1216445.65 675076.79	System Datum	WA State Plane North NAD83 (feet)	Groundwater observed at 15 feet at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
25	0	☒	3			1		GP	Gray-brown fine gravel with sand and trace silt (medium dense, moist) (fill)			
		■	10	27		2 MC		SP	Brown fine to medium sand with gravel (medium dense, moist) (pit run/fill)	10		Rough drilling from 2 to 2½ feet
20	5	■	11	21		3A 3B		SP-SM	Gray fine to medium sand with silt (medium dense, moist) (fill) ¼-inch organic matter lens			
		■	18	9		4A MC 4B MC		SM	Gray silty fine to medium sand with occasional gravel and organic matter (loose, moist)	19		
								SM	2-inch wood fragment and organic matter lens at 7½ feet	16		
15	10	■	15	6		5 MC		SP-SM	Brown with iron staining silty fine to medium sand (loose, moist) (alluvium)	13		
									Brown fine to medium sand with silt and 2- to 4-inch silty sand to sand lenses (loose, moist)			
10	15	■	9	4		6		SP	Brown with iron staining fine to medium sand (very loose to loose, wet)			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo, Vertical approximated based on Topographic Survey

Log of Boring B-6-2016

GEOENGINEERS

Project: Ferndale Wastewater Facility Improvements
Project Location: Ferndale, Washington
Project Number: 3358-017-01

Date Excavated	10/22/2019	Total Depth (ft)	10.5	Logged By	AF2	Excavator	See "Remarks" section for groundwater observed
				Checked By	MWR	Equipment Kubota KX080-3 Mini-Excavator	See "Remarks" section for caving observed

Surface Elevation (ft)	23	Easting (X)	1216701	Coordinate System	WA State Plane North
Vertical Datum	NAVD88	Northing (Y)	675322	Horizontal Datum	NAD83 (feet)

Elevation (feet)	Depth (feet)	SAMPLE Testing Sample	 Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
					SOD	2 to 3 inches sod			
					SM	Brown silty fine sand with trace rootlets (loose, moist) (fill)			
22	1		1						Moderate caving observed 0 to 10 feet
					SP-SM	Gray to brown fine sand with silt (loose, moist)			
21	2		2						
20	3		3						
					SP-SM	Gray fine sand with silt (loose, moist)			
19	4		4 SA				4	8	
18	5								
					SM	Gray-brown silty fine sand (loose, moist) (alluvium)			
17	6		5						
16	7					Faint iron staining			
15	8		6 SA				20	29	
14	9								
			7		SP	Gray fine to medium sand with trace silt (loose to medium dense, moist to wet)			
13	10		8						Rapid groundwater seepage observed at approximately 10 feet Severe caving observed below 10 feet
						Grades wet and fine to coarse sand with occasional gravel			

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
Coordinates Data Source: Horizontal approximated based on Topographic Survey. Vertical approximated based on Topographic Survey.

Log of Test Pit TP-1

GeoEngineers

Project: Ferndale Water Treatment Plant Improvements
Project Location: Ferndale, Washington
Project Number: 3358-021-00

Figure A-2
Sheet 1 of 1

Date Excavated	10/22/2019	Total Depth (ft)	10.25	Logged By AF2 Checked By MWR	Excavator Equipment Kubota KX080-3 Mini-Excavator
See "Remarks" section for groundwater observed					
See "Remarks" section for caving observed					

Surface Elevation (ft) Vertical Datum	23 NAVD88	Easting (X) Northing (Y)	1216661 675287	Coordinate System Horizontal Datum	WA State Plane North NAD83 (feet)

Elevation (feet)	Depth (feet)	SAMPLE Testing Sample	 Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
					SOD	3 inches sod			
			1		SM	Brown silty fine sand with organic matter (small pieces of wood, rootlets) (loose to moist) (topsoil)			
22	1								
			2		SM	Brown silty fine sand with gravel and trace rootlets (loose to medium dense, moist) (fill)			
21	2		3		SP-SM	Gray-brown fine to medium sand with silt and organic matter (loose, moist)			
			4		SM	Brown silty fine sand with trace rootlets (loose to medium dense, moist)			
20	3								
			5		SP-SM	Brown fine sand with silt (loose to medium dense, moist)			
19	4								
18	5								Severe caving observed below 5 feet
17	6				SM	Brown silty fine sand with occasional twigs, faint iron staining (loose, moist) (alluvium)			
			6						
16	7								
15	8								
			7						
14	9		8			Grades with lenses of gray fine to medium sand			
					SP	Gray-brown fine to medium sand with trace silt (loose to medium dense, wet)			Slow groundwater seepage observed at 9½ feet
13	10								

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
Coordinates Data Source: Horizontal approximated based on Topographic Survey. Vertical approximated based on Topographic Survey.

Log of Test Pit TP-2

GEOENGINEERS

Project: Ferndale Water Treatment Plant Improvements
Project Location: Ferndale, Washington
Project Number: 3358-021-00

Figure A-3
Sheet 1 of 1

Date Excavated	10/22/2019	Total Depth (ft)	10.75	Logged By	AF2
				Checked By	MWR
Excavator Equipment	Kubota KX080-3 Mini-Excavator	See "Remarks" section for groundwater observed		See "Remarks" section for caving observed	
Surface Elevation (ft)	23	Easting (X)	1216632	Coordinate System	WA State Plane North
Vertical Datum	NAVD88	Northing (Y)	675230	Horizontal Datum	NAD83 (feet)

Elevation (feet)	Depth (feet)	SAMPLE Testing Sample	SAMPLE Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
					SOD	6 inches sod			
					SM	Brown silty fine sand with occasional gravel and rootlets (loose, moist) (fill)			
22	1		1						
21	2		2						
20	3								
			3						
19	4								
					SP-SM	Brown fine sand with silt (loose, moist)			
18	5		4 SA				5	12	
17	6								
16	7				SM	Brown silty fine sand with faint iron staining and occasional twigs (loose, moist) (alluvium)			Moderate caving from 7 to 10 feet
15	8		5						
14	9								
			6						
13	10				SP	Gray-brown fine to medium sand (loose to medium dense, wet)			Severe caving observed below 10 feet Rapid groundwater seepage observed at 10½ feet

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
Coordinates Data Source: Horizontal approximated based on Topographic Survey. Vertical approximated based on Topographic Survey.

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Log of Test Pit TP-3

GEOENGINEERS

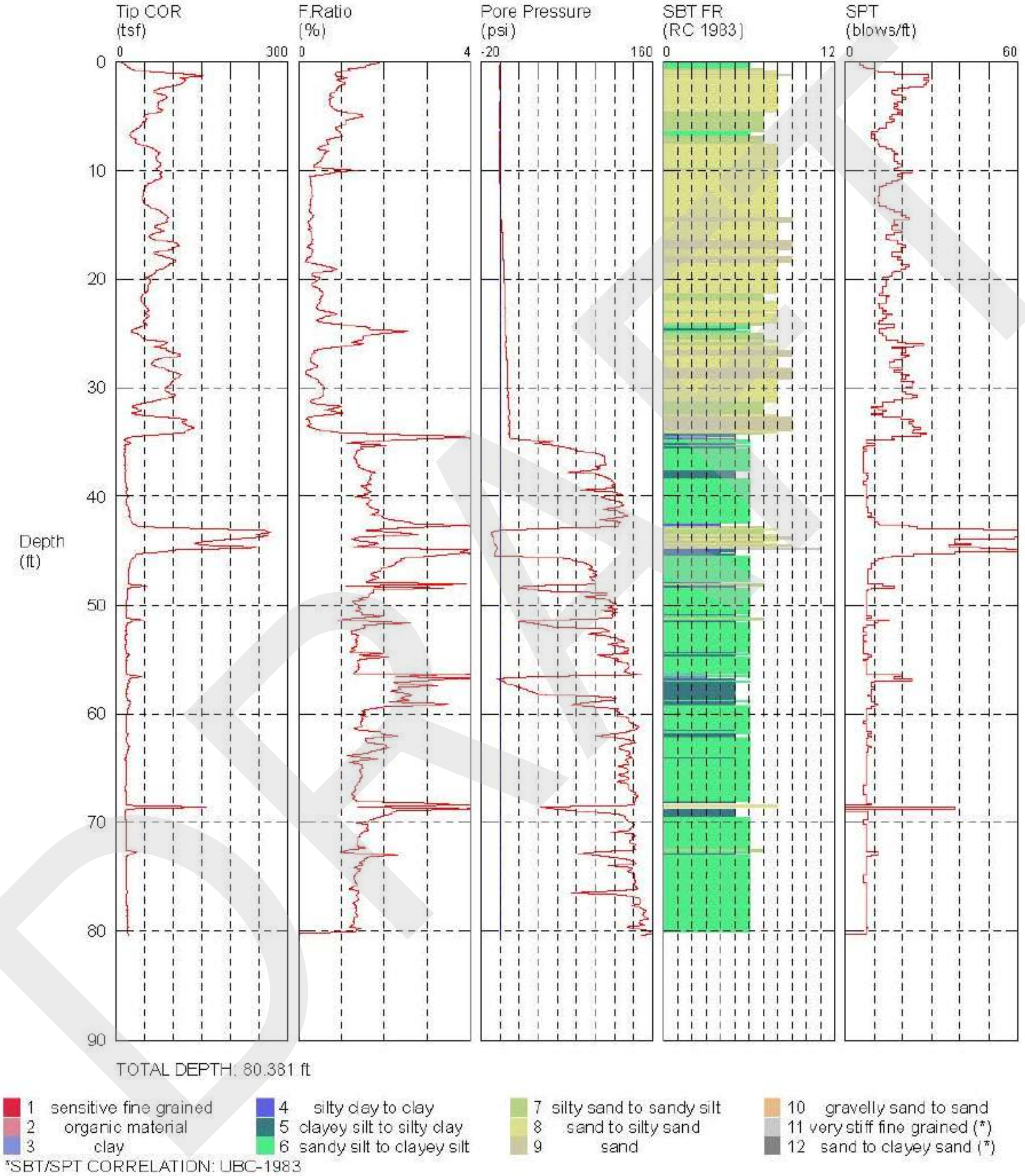
Project: Ferndale Water Treatment Plant Improvements
Project Location: Ferndale, Washington
Project Number: 3358-021-00

Figure A-4
Sheet 1 of 1

CPT - 01

CPT CONTRACTOR: In Situ Engineering
CUSTOMER: GeoEngineers INC
LOCATION: Ferndale
JOB NUMBER: 3358-021-00
COMMENT: Ferndale Water Treatment Plant

OPERATOR: Okbay
CONE ID: DDG1394
TEST DATE: 10/22/2019 9:08:56 AM
PREDRILL: N/A
BACKFILL: 20% Bentonite Grout + Bentonite Chips
SURFACE PATCH: N/A



Log of Cone Penetration Test

Ferndale Water Treatment Plan Improvements
Ferndale, Washington

Figure A-5

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: In Situ Engineering

3358-021-00 Date Exported: 01/10/2020

APPENDIX D

Report Limitations and Guidelines for Use

APPENDIX D
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Report Use and Reliance

This report has been prepared for Reichhardt & Ebe Engineering, Inc., Whatcom County, and their authorized agents, and for the project specifically identified in the report. The information contained herein is not applicable to other sites or projects. GeoEngineers structures its services to meet the specific needs of its clients. No party other than Reichhardt & Ebe Engineering, Inc., Whatcom County, and their authorized agents may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our signed agreement dated September 17, 2020 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or Projects other than those identified in this report.

If changes to the Project or property occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations in the context of such changes. Based on that review, we can provide written modifications or confirmation, as appropriate.

Information Provided by Others

GeoEngineers has relied upon certain data or information provided or compiled by others in the performance of our services. Although we use sources that we reasonably believe to be trustworthy, GeoEngineers cannot warrant or guarantee the accuracy or completeness of information provided or compiled by others.

Conditions Can Change

This report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Professional Judgment

It is important to recognize that the geoscience practices (geotechnical engineering, geology, and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to its services, GeoEngineers includes these explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know how these "Report Limitations and Guidelines for Use" apply to your Project or site.

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[1] Developed based on material provided by GBA, GeoProfessional Business Association; www.geoprofessional.org.

Appendix C: Hydrology, Hydraulics, and Geomorphology Report

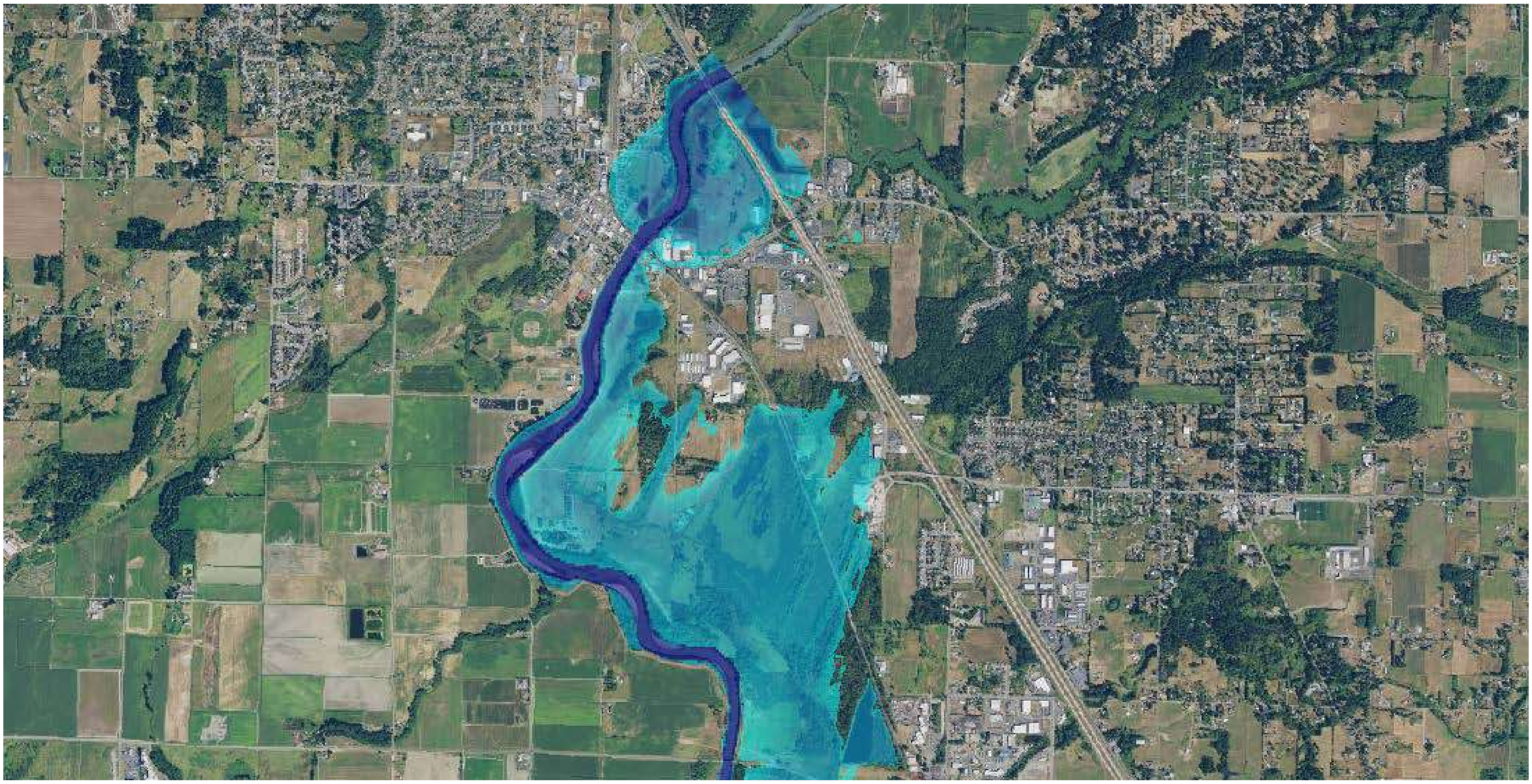

Photo source : Ferndale Levee Improvement HEC-RAS 2D Model

Ferndale Levee Improvement Project
Hydrology, Hydraulics, and Geomorphology
Existing Conditions Report

Prepared by:

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NHC Project Contact:
Vaughn Collins, P.E.
Principal

September 24, 2021
Final Report, Rev. R2

NHC Reference 2005590

Prepared for:

Reichhardt & Ebe Engineering Inc.
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On behalf of:

Whatcom County Flood Control Zone District
Public Works Department
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Bellingham, WA 98225

Document Tracking

Date	Revision No.	Reviewer	Issued for
6/30/2021	R0	Vaughn Collins	Reichhardt and Ebe
7/23/2021	R1	Jaron Brown	Reichhardt and Ebe
9/24/2021	R2	Jaron Brown	Reichhardt and Ebe

Report prepared by:

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21019178

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Bathymetry, Hydraulic Modeling, Scour

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Geomorphologist
Geomorphology

Mariza Costa-Cabral, PhD.
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Report reviewed by:

Jaron Brown, P.E.
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Vaughn Collins, P.E.
Hydraulic Engineer
Principal

DISCLAIMER

This document has been prepared by **Northwest Hydraulic Consultants Inc.** in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of Reichhardt & Ebe Engineering Inc. and their authorized representatives for specific application to the Ferndale Levee Improvement Project in Ferndale, Washington. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization from **Northwest Hydraulic Consultants Inc**. No other warranty, expressed or implied, is made.

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TABLE OF CONTENTS

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1 INTRODUCTION

The Ferndale Levee Improvement Project is intended to improve the Ferndale and Ferndale Water Treatment Plant Levees (USACE, 2020) near Ferndale, WA to provide greater flood protection and enhance riparian and aquatic habitat. The current levee does not provide adequate flood protection to critical infrastructure such as water and wastewater treatment plants, roads, residences, and farmland (USACE, 2020). To support the Levee Improvement project, Northwest Hydraulic Consultants (NHC) is scoped to provide services including inspection of existing conditions along the levee toe, bathymetric survey of the project site, hydraulic modeling of existing and alternative conditions, levee scour and erosion assessment, fluvial geomorphic assessment, and design support. The levee toe inspection and summary of bathymetric survey work are reported in the *Levee Toe Inspection and Bathymetric Survey Memorandum* (NHC, 2020). This report includes documentation of hydrologic and hydraulic analysis, geomorphological assessment, and scour and erosion assessment.

2 BACKGROUND

The Ferndale and Ferndale Water Treatment Plant Levees are located near Ferndale, WA along Upper Reach 1 of the main stem Nooksack River (Figure 2.1). They are the two most upstream of five right bank levee segments (Rainbow Slough, Rayhorst, Sigardson, Ferndale Water Treatment Plant, and Ferndale Levees) in the Ferndale Levee system.

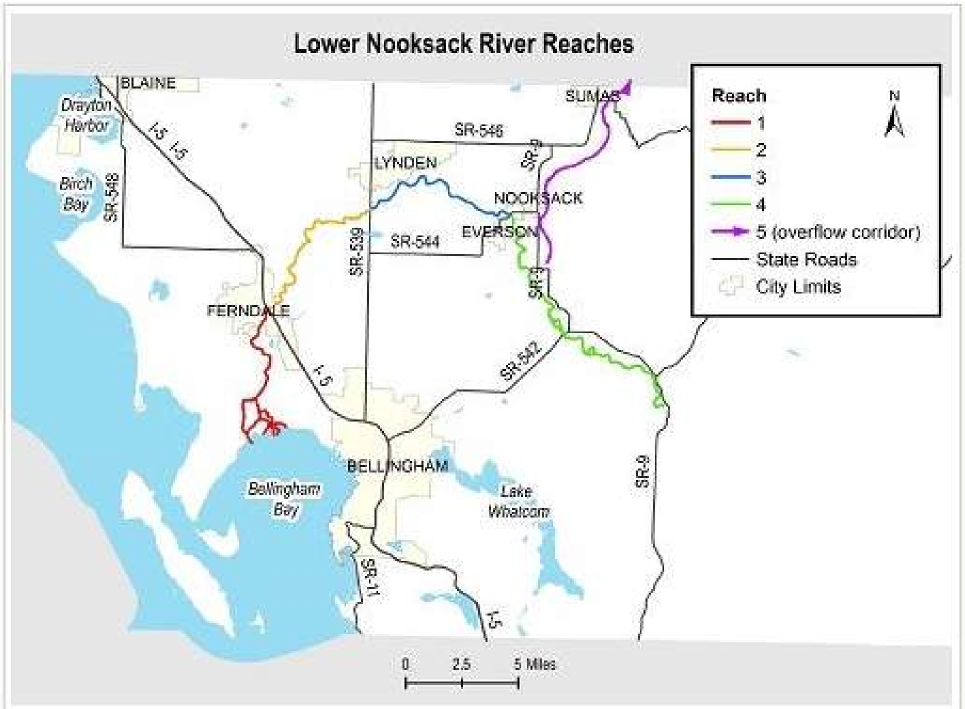

Figure 2.1 Main stem Nooksack River reaches

The levees were constructed in the 1930s by the Works Progress Administration (USACE, 2020) and have overtopped, breached and/or experienced scour damage from flood events. Most recently the November 2017 and 2018 floods damaged the Ferndale levee near Star Park (USACE, 2020). The levee sustained scour along 125 feet of the riverward levee slope and toe, including loss of riprap, and was repaired in 2019. The Ferndale Levee was also damaged during the January 2009 event (roughly a 25- to 30- year event near Ferndale) including loss of toe material and seepage of floodwater and back-slope deterioration, requiring repairs (USACE, 2010). The Ferndale WTP levee was breached in the 1951 event (Whatcom County, 1999). In 2017 United States Army Corps Engineers (USACE) assessed the risk posed by the levee (updated in 2019), as follows:

> *"If inundation were to occur, approximately $24 million in property damages would accrue with 314 structures affected. Loss of life is expected to be low, but may be reduced further by developing a system specific flood response plan and engaging the stakeholders in the leveed area more directly. Reducing flood damages to buildings and infrastructure may be decreased by proactive efforts to improve the resiliency of these assets"* (USACE, 2020).

The USACE assessed the recurrence event for overtopping to be 1 in 5 years and 1 in 100 years for the Ferndale and Ferndale WTP levee, respectively. The inspection rating for the Ferndale levee is currently Minimally Acceptable, primarily due to erosion risk. The Ferndale WTP levee is rated as Unacceptable, due to erosion risk and overtopping risk.

3 HYDROLOGY

3.1 Existing Condition Hydrology

Hydrology for Reach 1 of the Nooksack River is influenced by the hydrodynamics in the upstream reaches. Because flows above a certain threshold are diverted through Reach 5 into Canada, the existing condition hydrology requires routing of flows through the entire system. Therefore, outputs of the Reach 1-5 Nooksack HEC-RAS 2D (Hydrologic Engineering Center's River Analysis System) model in development for the Floodplain Integrated Planning (FLIP) process were used to determine existing condition and future climate scenario hydrology. Results from the Reach 1-5 model were extracted at the I-5 bridge and input into the Ferndale HEC-RAS 2D model, which extends from the I-5 bridge to Slater Rd.

The 2-, 5-, 10-, 25-, and 50-year flows from the Lower Nooksack River Geomorphic Assessment (AGI, 2019) were compared to recurrence interval flows identified by Linsley, Kraeger Associates (LKA, 2005) in Table 3.1. The differences in the recurrence interval flows indicates AGI (2019) predicts lower peak flows by approximately 7.3% on average.

Table 3.1 Flood frequency analysis from LKA (2005) at Ferndale.

Source	LKA (2005)	AGI (2019)	
Return Period (years)	**Peak Flow at Ferndale (ft^3/s)**	**Peak Flow at Upper Reach 1 (ft^3/s)**	**% Difference**
1.01	13,817		
1.25	19,631		
2	24,918	22,752	-8.69
5	32,609	31,506	-3.38
10	39,599	39,419	-0.45
25	52,222	45,547	-12.78
50	56,723	51,428	-9.33
100	60,502	54,799	-9.43
200	64,457		
500	69,998		

The 100-year flow is determined by the FEQ 100-year hydrograph, which was initially developed by Linsley, Kraeger Associates, Ltd. (2005) based on a scaling of the November 1990 flood event. The FEQ 100-year hydrograph at Cedarville was routed through the Reach 1-5 2D HEC-RAS model to determine the 100-year hydrograph at Ferndale for this study. It is important to note that changes to the Reach 1-5 2D HEC-RAS model have significant impacts on the hydrograph peak and shape at Ferndale, and that further revisions to the Reach 1-5 2D HEC-RAS model may result in changes to the hydrograph. However, as discussed in Section 3.3, the resulting impact to water surface elevation (WSEL) is generally not significant.

3.2 Climate Change Hydrology

The Nooksack River Floodplain Integrated Planning (FLIP) Steering Committee sought guidance from Dr. Guillaume Mauger of the University of Washington's Climate Impacts Group (CIG) on recommended numerical factors for which to multiply historical flood hydrographs to represent the end of century time horizon, 2070-2099. At the FLIP meeting of March 12, 2021, Dr. Mauger recommended multiplying factors 1.3 and 1.7, to be applied at Cedarville gauge. These values are derived from results for the Ferndale stream gauge from the hydrologic modeling performed by CIG using projections of future climate (see Table 3.2 and Table 3.3). The hydrologic modeling study was described in Hamlet and et al. (2013). The climate projections used in the hydrologic modeling were those associated with the 2007 report by the Intergovernmental Panel on Climate Change (IPCC). Two scenarios of future global emissions of greenhouse gases were used in the hydrologic modeling study: B1 and A1B.

Limitations of the hydrologic modeling were included in the minutes from the March 12, 2021 FLIP meeting with Dr. Mauger. The minutes point out that the climate projections used were not the most recent ones but those associated with the 2007 report by the Intergovernmental Panel on Climate Change (IPCC) and they are based on an older approach for downscaling global climate model projections. The minutes also state that while the projections do well in representing anticipated snowpack decreases, they underrepresent the increases in expected precipitation intensities. Furthermore, the CIG hydrologic modeling does not account for the diversion of flow out of the Nooksack basin at the Everson overflow. Although CIG hydrologic simulations using more recent climate predictions are available, Dr. Mauger does not recommend using those datasets due to bias associated with overestimation of snowpack. The more recent climate predictions also fail to provide accurate estimates of changes in precipitation extremes. One focus of the CIG's current work is to improve such estimates.

While the climate projections recommended by Dr. Mauger for this study are not the most recent, it is noted in the same meeting minutes that there is an approximate correspondence between the two scenarios of future global greenhouse gas emissions used in the study – B1, A1B – and the representative concentration pathways used in more recent IPCC reports – RCP 4.5, RCP 6.0, respectively. Scenario A1B, said to be roughly similar to RCP 6.0 was recommended by Dr. Mauger for this study. For the future time horizon, Dr. Mauger recommended the decade of the 2080s, which is represented by the hydrologic projections for the 30-year period 2070-2099.

Table 3.2 100-year peak daily flow projected for 2070-2099 by different GCMs for emissions scenario A1B, from the Hamlet study[1]. The average percent change for all GCMs is 30%, the minimum percent change is 8% (for ccsm3) and the highest is 67% (for miroc_3.2).

Scenario	100-yr flow [cfs]	Change (%)
historic	43,829	-
ccsm3	47,551	8%
cgcm3.1	60,429	38%
cnrm-cm3	56,428	29%
echam5	53,681	22%
echo_g	50,268	15%
hadcm	49,653	13%
hadgem1	63,845	46%
ipsl_cm4	57,740	32%
miroc_3.2	73,031	67%
pcm1	57,931	32%

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[1] Data downloaded from http://warm.atmos.washington.edu/2860/products/sites/r7climate/subbasin_summaries/6022/floodstats_daily_A1B_2070-2099.dat

Table 3.3 Table presented at the FLIP meeting of 03-12-2021 (redrawn), showing projected changes in peak flow quantile. The average, minimum and maximum percent changes in peak flows indicated by the simulation results (based on different global climate model runs) in CIG's hydrologic study are listed. The multiplying factors 1.3 and 1.7 recommended by Dr. Mauger correspond approximately to the average and maximum projected changes, respectively, for scenario A1B and the 100-year return period (see Table 3.2).

	Return Interval	Greenhouse Gas Scenario	AVG (%)	MIN (%)	MAX (%)
Water Year, 2080s	2-yr	B1	32	11	69
	2-yr	A1B	37	14	79
	5-yr	B1	29	9	59
	5-yr	A1B	34	11	74
	10-yr	B1	27	7	56
	10-yr	A1B	32	11	72
	25-yr	B1	27	4	52
	25-yr	A1B	31	12	70
	100-yr	B1	26	0	49
	100-yr	A1B	30	8	67

3.3 Design Flows

Based on the results and associated uncertainty in climate change hydrology and through discussions with Whatcom County, FLIPSC, UWCIG and the USGS, the mean and maximum predicted percent of flow increase were used, resulting in scaling factors of 1.3 and 1.7, respectively. The scaling factors were applied in the Reach 1-5 HEC-RAS 2D model at the Cedarville gage inflow location. The flow was then routed through the model and extracted at Ferndale (Figure 3.1). It is important to note that the 100-year flow routed through the HEC-RAS 2D model and the FEQ model result in a different peak flow at Ferndale. This difference is likely due to a number of factors, including inherent differences between 1D and 2D modeling and updates to the underlying terrain data. Despite this, the 100-year water surface elevation does not differ significantly compared to prior FEQ modeling (See Section 4.2.4). Routing the climate change hydrograph is important because the portion of flow that is diverted through the Sumas Overflow into Canada increases with increasing flow. For the 100-year flow, approximately 14% is diverted through the Sumas Overflow, however for the 1.7*100-year flow, approximately 55% of flow is diverted. In other words, most of the additional flow added at Cedarville is diverted through the Sumas Overflow, reducing the impact at Ferndale. The resulting change in peak flow at Ferndale for the 1.3 and 1.7 scaling factors is 4% and 25% respectively. Because the conveyance conditions at the Sumas Overflow impact the project substantially and have shown to be dynamic over time, a scenario was also run which blocks any flow leaving through the Sumas Overflow. This condition represents a worst case 100-year flow scenario and results in a 36% increase in peak flow.

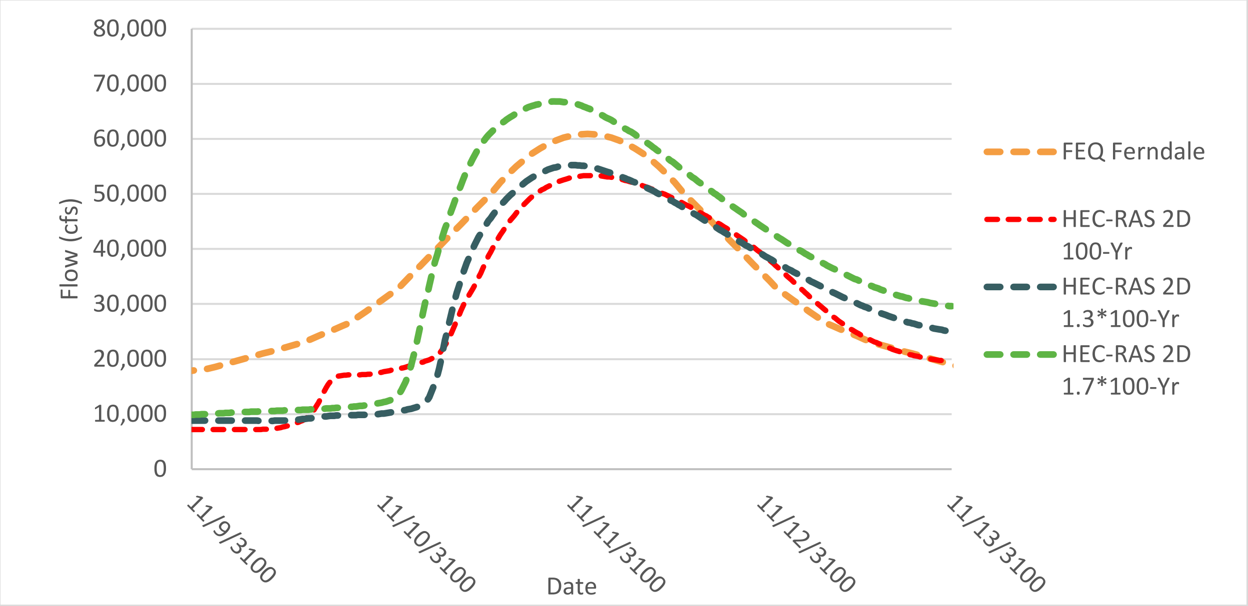


Figure 3.1 Design Flows at Ferndale

4 HYDRAULIC MODELING

4.1 Model Development

The Ferndale 2D HEC-RAS model is a more refined, clipped version of the Nooksack Reach 1-5 HEC-RAS 2D model. HEC-RAS 2D Version 6.0 (USACE, 2021) was used for this project due to its ability to represent the Main Street, Burlington railroad, and I-5 bridges upstream of the project reach.

4.1.1 Survey and Terrain Creation

NHC visited the project site to perform bathymetric survey and to assess the toe condition of the Ferndale and Ferndale Water Treatment Plant levee segments (USACE, 2020) on October 9th, 2020 (NHC, 2020). The flow during the time of survey based on Nooksack River at Ferndale (USGS Gage 12213100) was 1,300 cfs. Bathymetric survey and toe inspection were performed using a jet boat to access the river side of the levee, extent of the survey is shown in Figure 4.1. NHC visited the project site again on March 10th, 2021, to gather survey of channel bars supplement the bathymetric survey and inform the geomorphic analysis. The bar survey was completed using RTK GPS rod survey as well as bathymetric survey from jet boat. The flow during the time of survey based on Nooksack River at Ferndale (USGS Gage 12213100) was 2,250 cfs. Topographic survey was provided by Reichhardt & Ebe Engineering, Inc. (R&E) for the levee and landward side of the levee. Bathymetry, survey, and LiDAR data was combined to create the composite terrain for existing condition. Bathymetry and survey data were extracted at the same cell resolution as the 2015 LiDAR (3 ft x 3 ft).

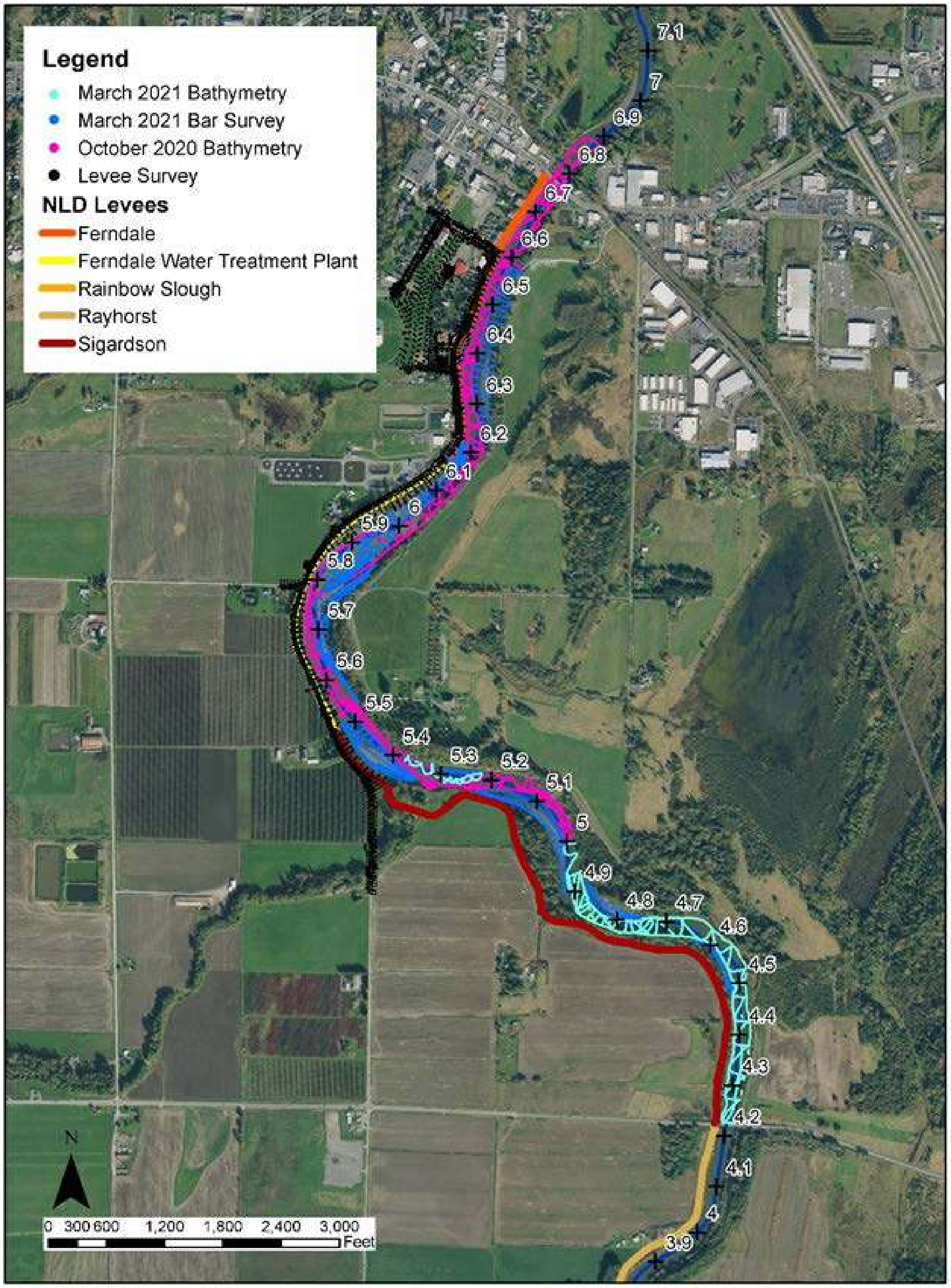


Figure 4.1 Vicinity map, including survey extents

4.1.2 Hydraulic Model

The Ferndale HEC-RAS 2D hydraulic model was extracted from the Reach 1-5 Nooksack River HEC-RAS 2D model to allow for more detailed modeling along the levee. The model solves the 2D unsteady flow equations using an implicit finite volume algorithm and returns depth-averaged hydraulic properties such as depth, velocity, and shear stress (Table 4.2). The hydraulic model mesh was densified in the main channel and aligned with the primary direction of flow to account for velocity gradient along the levee. The mesh size increases for overbank and floodplain areas, except at grade control features such as roadways. Breaklines were used to align mesh cells to the primary flow direction, as well as to enforce features with high ground, such as levees and roadways. The model extends from just upstream of I-5 to just downstream of Slater Rd., approximately 3.5 miles. One upstream boundary condition is used to define the inflow for the main channel and overbank. Four normal depth boundary conditions were used at the downstream end to define the downstream main channel, downstream left floodplain, downstream right floodplain, and Lummi River. The hydraulic model boundary conditions were tested for a projected sea level rise of 1.9 feet, which represents the 50% likelihood of exceedance for the year 2100 under low- and high-emission scenarios (Whatcom County, 2020). This amount of sea level rise does not propagate to the downstream end of the modeled reach. Hydraulic roughness zones were adjusted from the Reach 1-5 model based on updated aerial imagery and survey; hydraulic roughness values are shown in Table 4.21.

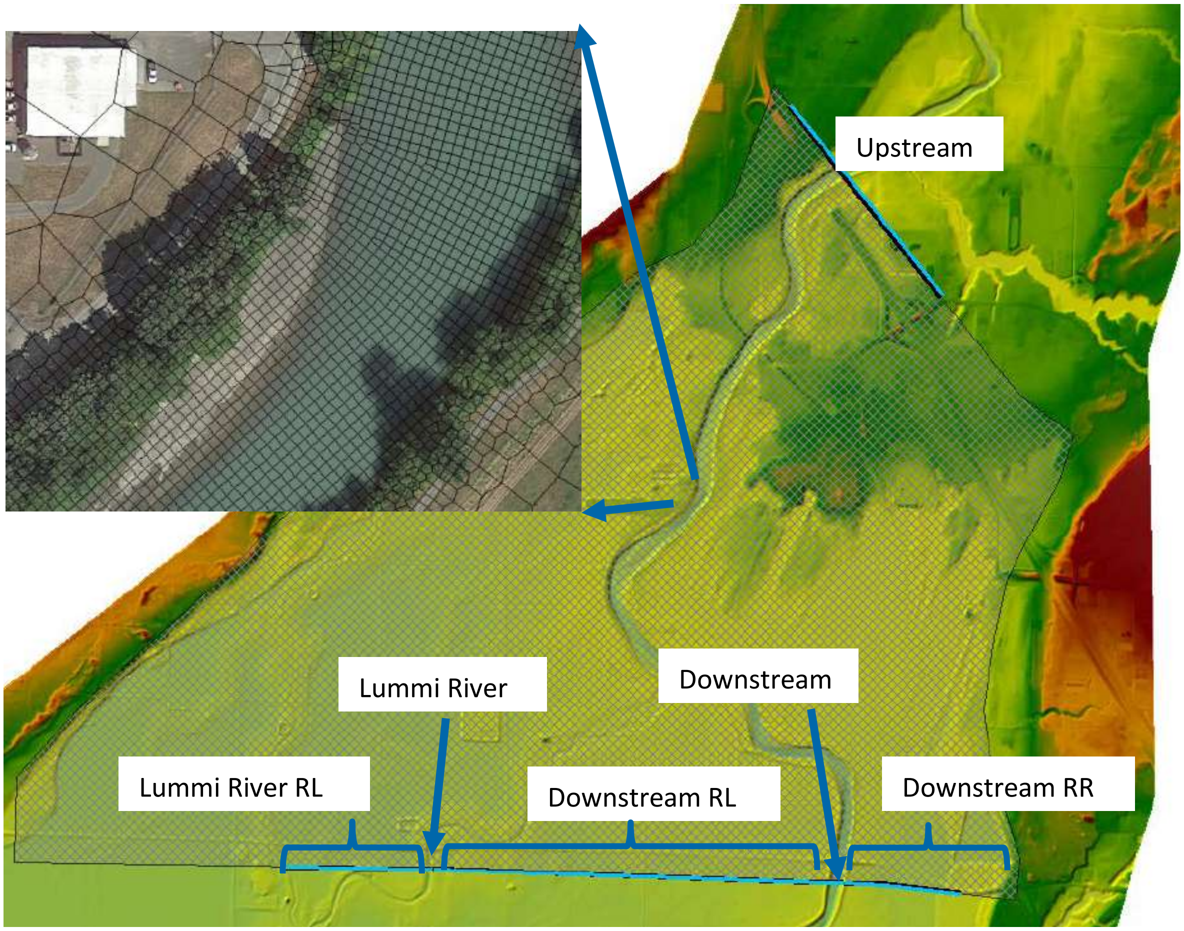


Figure 4.2 Model perimeter and boundary condition lines and example of mesh orientation (inset)

Table 4.1 Manning’s n Roughness Values

Land Cover Type	Manning’s n Roughness Value
Ag Pond	0.28
Barren	0.023
Channel	0.03
Cultivated	0.045
Delta	0.023
Distributary	0.028
Emergent Wetland	0.055
Emerging Floodplain	0.04
Herbaceous Wetland	0.052
High Density Developed	0.07
Industrial	0.05
Low Density Developed	0.04
Med Density Developed	0.06
Mixed Cultivated	0.05
Mixed Forest	0.06
Mixed Forest Residential	0.025
Open Developed	0.02
Open Water	0.012
Pavement	0.023
Riparian Forest	0.18
Tributary	0.04
Wetland	0.095
Woody Wetland	0.18

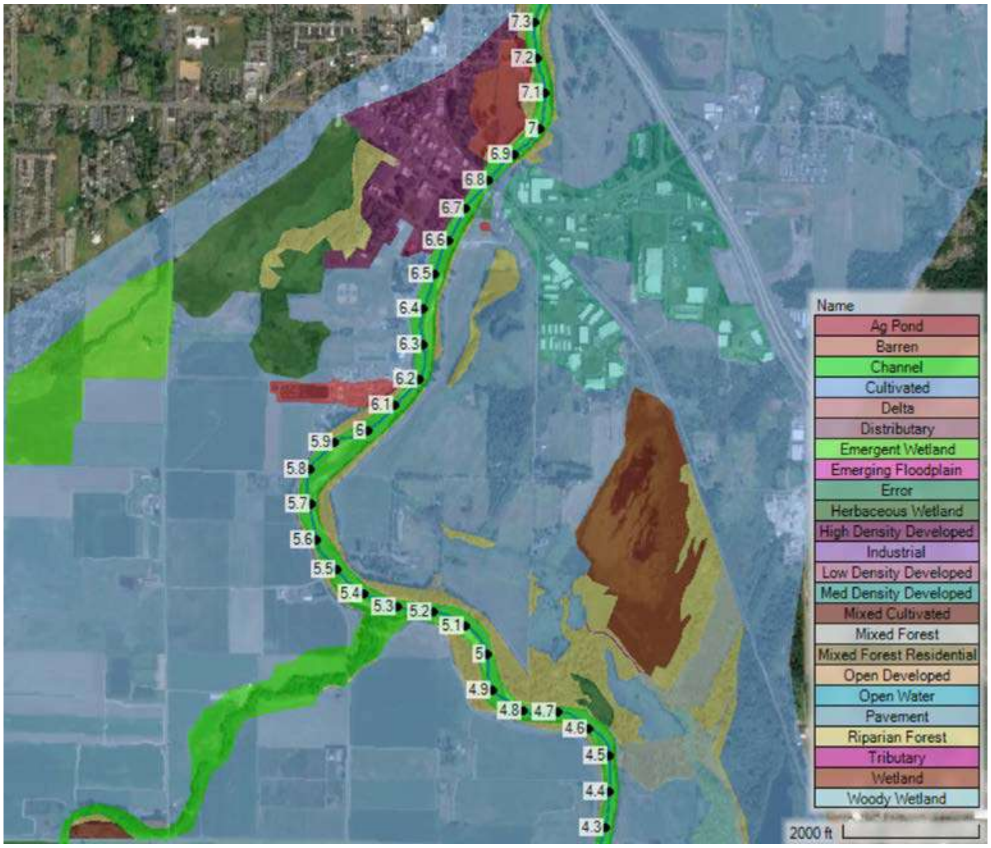


Figure 4.3 Manning’s n Roughness value spatial distribution

Roughness values for the main channel are the result of calibration (See Section 4.2) for low recurrence interval events. Roughness values for more frequent events may have higher roughness values, which could be more accurately determined with additional High-Water Mark (HWM) data. Roughness values were calibrated in conjunction with turbulence parameters.

Table 4.2 Hydraulic Model Parameters

Model Parameter	Value
Solution Equation	Shallow Water Equation - Eulerian-Lagrangian
Main Channel Cell Size (ft)	20
Transverse Turbulence	0.1
Longitudinal Turbulence	0.3
Time Step (s)	3

Three bridges were added to the Ferndale HEC-RAS 2D model: I-5 just northwest of Ferndale, the Ferndale Main St bridge, and the railroad bridge just upstream of Main St. The Ferndale Bridge Rehabilitation project plans (R&E, 2004) and topographic survey information provided by R&E were used to determine bridge geometry for Ferndale Main St bridge. The railroad bridge geometry is estimated from imagery, with survey verification of the low and high chord and river right pier geometry. The I-5 bridge is based on as-built plans provided by Whatcom County, with low chord and deck elevation based on lowest location above the main channel (located at pier no. 8).

Table 4.3 Bridge Geometry Summary

Model Parameter	Low Chord Elev.	Deck Elev. [ft. NAVD88]	Data Source
I-5 Bridge	43.90	46.85	As-Builts
Railroad Bridge	40.00	44.60	Survey/Imagery
Main St Bridge	35.48	38.44	Survey/Plans

Figure 4.4 Ferndale Main Street Bridge

Figure 4.5 Ferndale railroad bridge

4.2 Model Calibration

The Ferndale Levee model was calibrated to four observed events - February 2020, January 2009, November 2004, and November 1990 - as well as compared to the FEQ 100-year event. Inflow conditions for the observed events utilized published flow values at USGS Gage 1213100, and a terrain surface representing conditions closest in time to the event was used (Table 4.4). Inflows for the FEQ 100-year comparison are based on the hydrograph output from FEQ at Ferndale. HWM data was provided by Whatcom County. In general, the hydraulic model simulation predicted slightly lower WSELs than observed for the January 2009 event and slightly higher WSELs for the November 2004 event.

Considering all high water mark comparisons, the model results simulate on average 0.08 feet above the observed values, indicating a low model bias for WSEL predictions.

Table 4.4 Calibration Event Summary

Event	Peak Flow at Ferndale [cfs]	Terrain	Calibration Focus
February 2020	36,600	2013-2015 Updated 2021	Updated topography R1-5 inflow
January 2009	51,700	2006	River left overtopping
November 2004	42,300	2006	Main Channel downstream of project
100-Year	60,900	2013-2015 Updated 2021	Comparison with FEMA FEQ model

4.2.1 February 2020 Event

The February 2020 event did not have HWMs within the project reach. Therefore, the gage stage and flow are the only calibration metrics. The observed peak stage for this event is 29.49 feet and the simulated peak stage is 29.59 feet, 0.1 feet higher than observed. The hydrograph shape is relatively similar, with some differences seen in the rate of recession and the initial starting WSEL. Even though there are relatively few data point to compare, the gage comparison results indicate that the updated terrain represents existing conditions well.

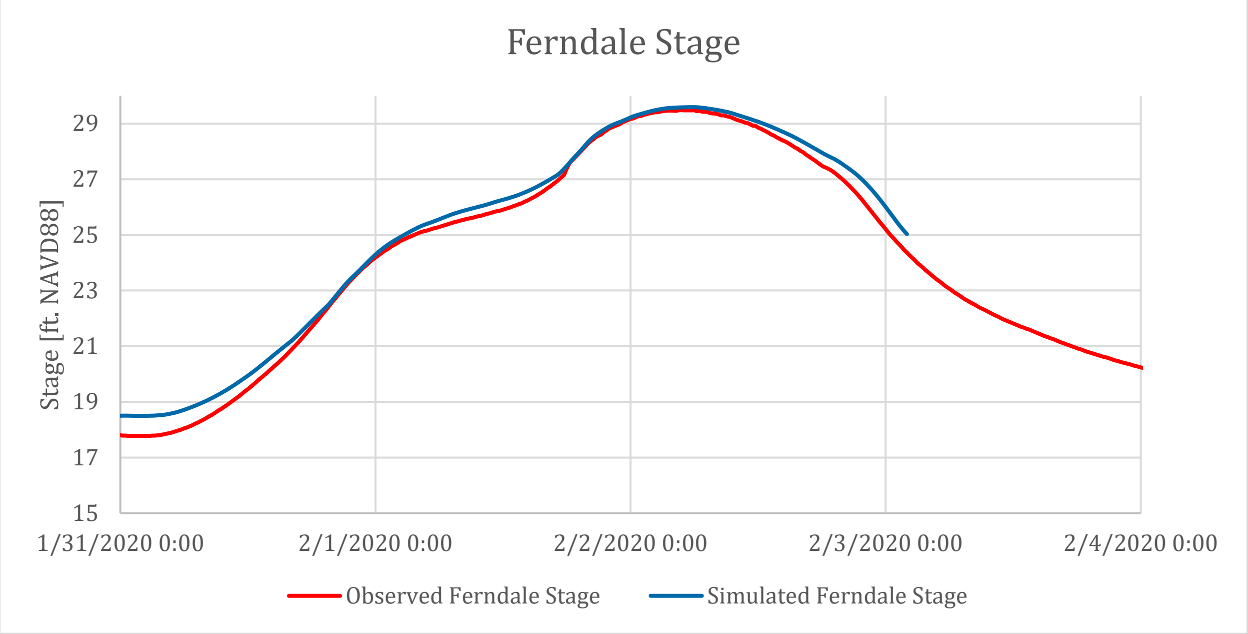


Figure 4.6 Comparison of observed and simulated stage at the Ferndale Gage (USGS 12213100) during the February 2020 event

4.2.2 January 2009 Event

The January 2009 event included 8 HWMs in addition to the USGS Ferndale gage. The majority of the HWMs are located in the river left floodplain (Table 4.5,Figure 4.8, points jnt 13, jnt29-33). The average difference between simulated and observed WSEL is -0.23 feet (excluding jnt13, which appears to be an anomaly). These results indicate that the model, using the 2006 terrain, is slightly underestimating the WSEL for the January 2009 event.

Table 4.5 High water marks for the January 2009 event, including comparison to simulated results

ID	Observed HWM Elevation [ft. NAVD88]	Simulated WSEL [ft. NAVD88]	Difference [ft.]
jnt13*	29.9	27.11	-2.7
jnt14	28.6	28.80	0.2
jnt21	27.7	27.44	-0.2
jnt29	27.2	26.99	-0.2
jnt30	27.4	27.02	-0.4
jnt31	27.4	27.02	-0.4
jnt32	25.9	25.45	-0.4
jnt33	25.3	25.35	0.1
Ferndale Gage	31.34	30.96	-0.38
Mean Error			**-0.23**
Mean Absolute Error			**0.29**
RMSE			**0.31**

***Excluded from statistical calculation due to anomalous observed elevation**

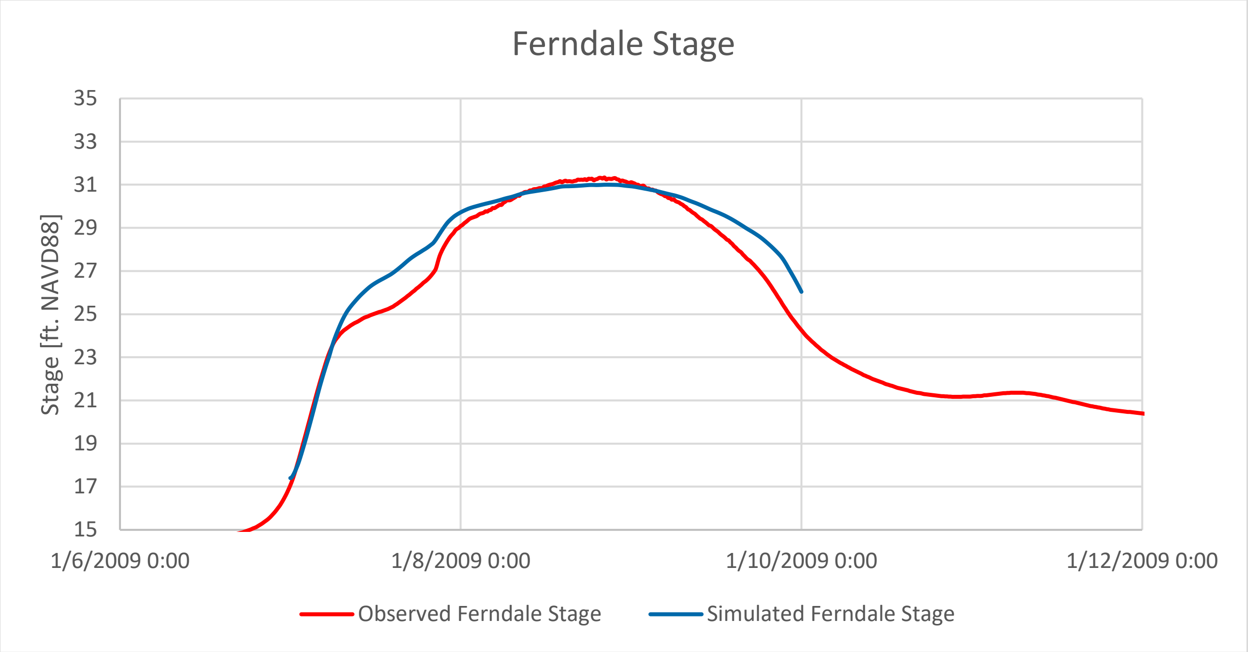


Figure 4.7 **Comparison of observed and simulated stage at the Ferndale Gage (USGS 12213100) during the January 2009 event**

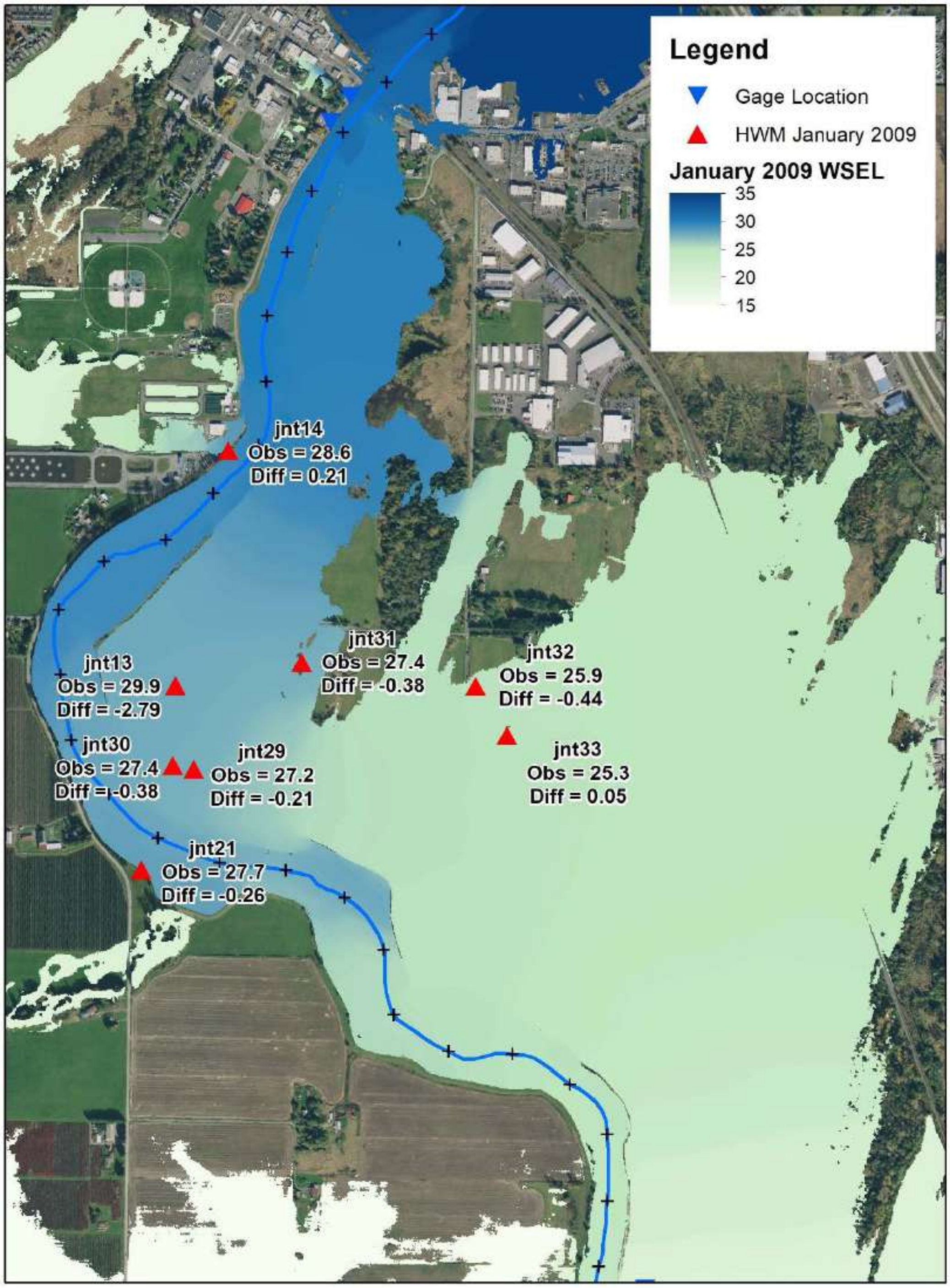


Figure 4.8 Observed HWMs from the January 2009 event, including observed elevations and difference between simulated and observed WSEL.

4.2.3 November 2004 Event

The November 2004 event includes 11 HWMs and one peak WSEL at the gage, however no USGS time series stages were published for this event. The HWMs are typically located along the river left bank. HWM 1-11B is suspect as it is directly adjacent to HWM 1-11A but the elevations are significantly different. Excluding 1-11B, the average error is 0.20 feet.

Table 4.6 High water marks for the November 2004 event, including comparison to simulated results

ID	Observed HWM Elevation [ft. NAVD88]	Simulated WSEL [ft. NAVD88]	Difference [ft.]
1-10	25.24	25.41	0.17
1-9	26.40	26.19	-0.21
1-8	24.81	25.13	0.32
1-7	25.50	25.85	0.35
1-6	26.62	26.53	-0.09
1-13	19.45	19.67	0.22
1-5	26.74	26.63	-0.11
1-3	26.96	26.93	-0.03
1-17A_B_C	22.94	23.89	0.95
1-11A	24.80	25.21	0.41
1-11B*	23.38	25.21	1.83
Mean Error			0.20
Mean Absolute Error			0.29
RMSE			0.38

***Excluded from statistical calculation due to anomalous observed elevation**

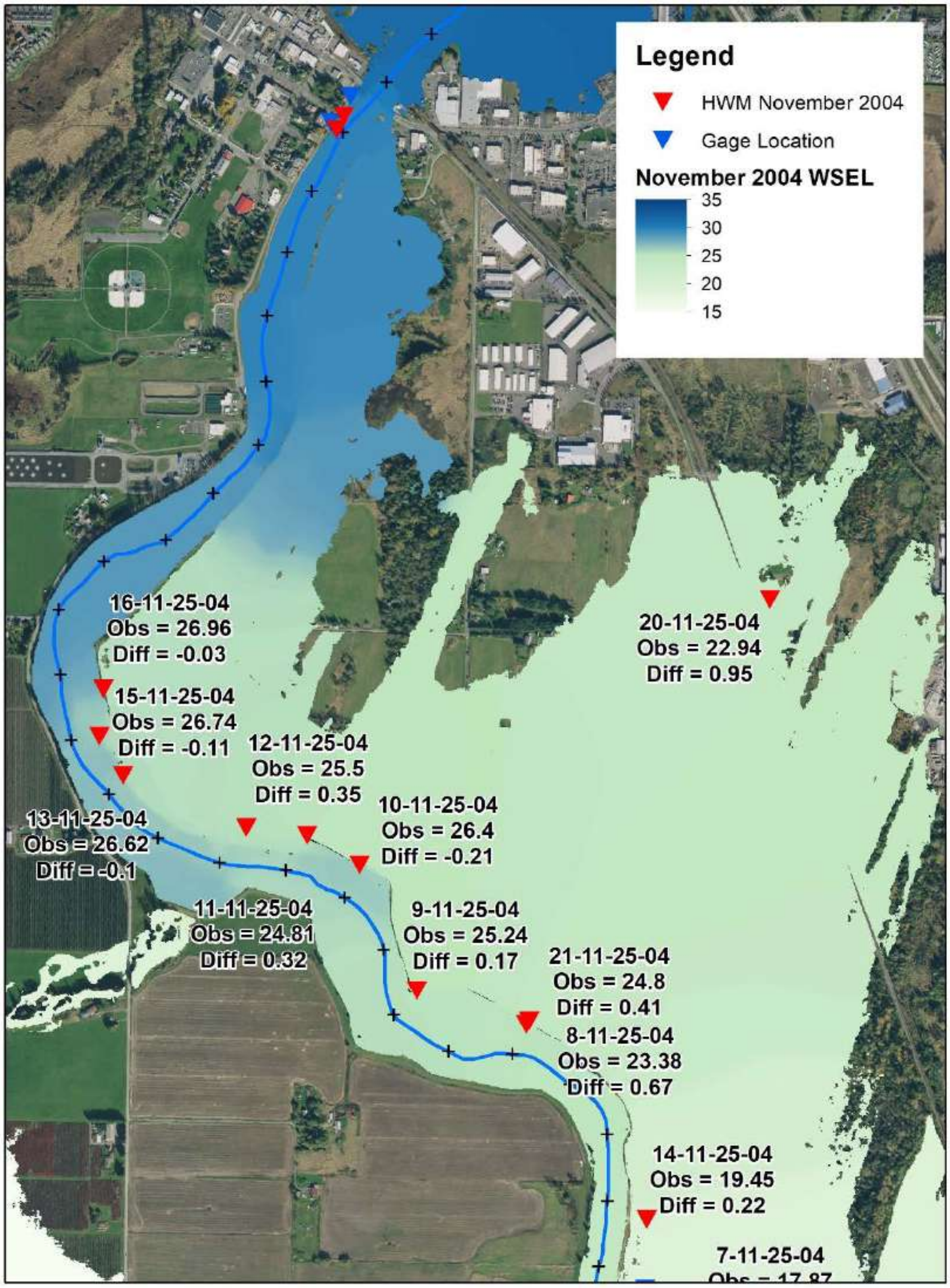


Figure 4.9 Observed HWMs from the November 2004 event, including observed elevations and difference between simulated and observed WSEL.

4.2.4 FEQ 100-year Event

Comparison of simulated results from the Ferndale Levee HEC-RAS 2D model to the FEQ 100-year WSEL at the channel thalweg is shown in Table 4.7. The average difference between FEQ and HEC-RAS WSELs within the project reach is -0.05 feet, with a maximum difference of -0.37 feet. Differences upstream of the project reach are likely due to the difference in computation method and topography at the Main St and railroad bridges.

Table 4.7 Comparison of simulated results from the Ferndale Levee HEC-RAS 2D model to the FEQ 100-year WSEL, cross sections within the project reach are bolded.

XSID	FEQ Station	FEQ WSEL [ft. NAVD88]	HEC-RAS 100-yr WSEL [ft. NAVD88]	Difference [ft.]
RAXSAZ	3.63	26.17	25.71	0.46
RAXSAA	3.76	26.82	26.87	-0.05
RAXSBK	3.82	26.99	26.97	0.03
RAXSAB	**3.96**	**27.31**	**27.36**	**-0.05**
RAXSAC	**4.04**	**27.86**	**27.80**	**0.06**
RAXSAD	**4.14**	**28.30**	**28.32**	**-0.03**
RAXSAE	**4.18**	**29.15**	**29.32**	**-0.17**
RAXSAF	**4.28**	**29.43**	**29.36**	**0.07**
RAXSAG	**4.46**	**29.83**	**30.02**	**-0.19**
RAXSGE	**4.48**	**29.82**	**30.15**	**-0.32**
RAXSGF	**4.48**	**29.85**	**30.20**	**-0.35**
RAXSGG	**4.48**	**29.92**	**30.24**	**-0.32**
RAXSGH	**4.51**	**29.96**	**30.33**	**-0.37**
RAXSGI	**4.53**	**30.38**	**30.32**	**0.06**
RAXSGK	**4.53**	**30.36**	**30.33**	**0.03**
RAXSGL	**4.58**	**30.40**	**30.42**	**-0.02**
RAXSGM	**4.62**	**30.68**	**30.58**	**0.09**
RAXSGN	**4.66**	**30.98**	**30.77**	**0.20**
RAXSAH	**4.70**	**30.84**	**30.87**	**-0.03**
RAXSAI	**4.79**	**31.20**	**31.14**	**0.06**
RAXSAJ	**4.82**	**31.21**	**31.29**	**-0.08**
RAXSAK	**4.86**	**31.27**	**31.37**	**-0.11**
RAXSAL	**4.90**	**31.38**	**31.44**	**-0.06**
RAXSAM	**4.95**	**31.99**	**31.69**	**0.29**
RAXSAN	**4.98**	**32.14**	**31.97**	**0.17**
RAXSAR	5.03	34.74	33.81	0.94
RAXSAS	5.07	34.98	34.03	0.95
RAXSAT	5.10	35.20	34.70	0.50
RAXSCZ	5.18	35.45	35.18	0.27
RAXSAU	5.26	35.62	35.56	0.06

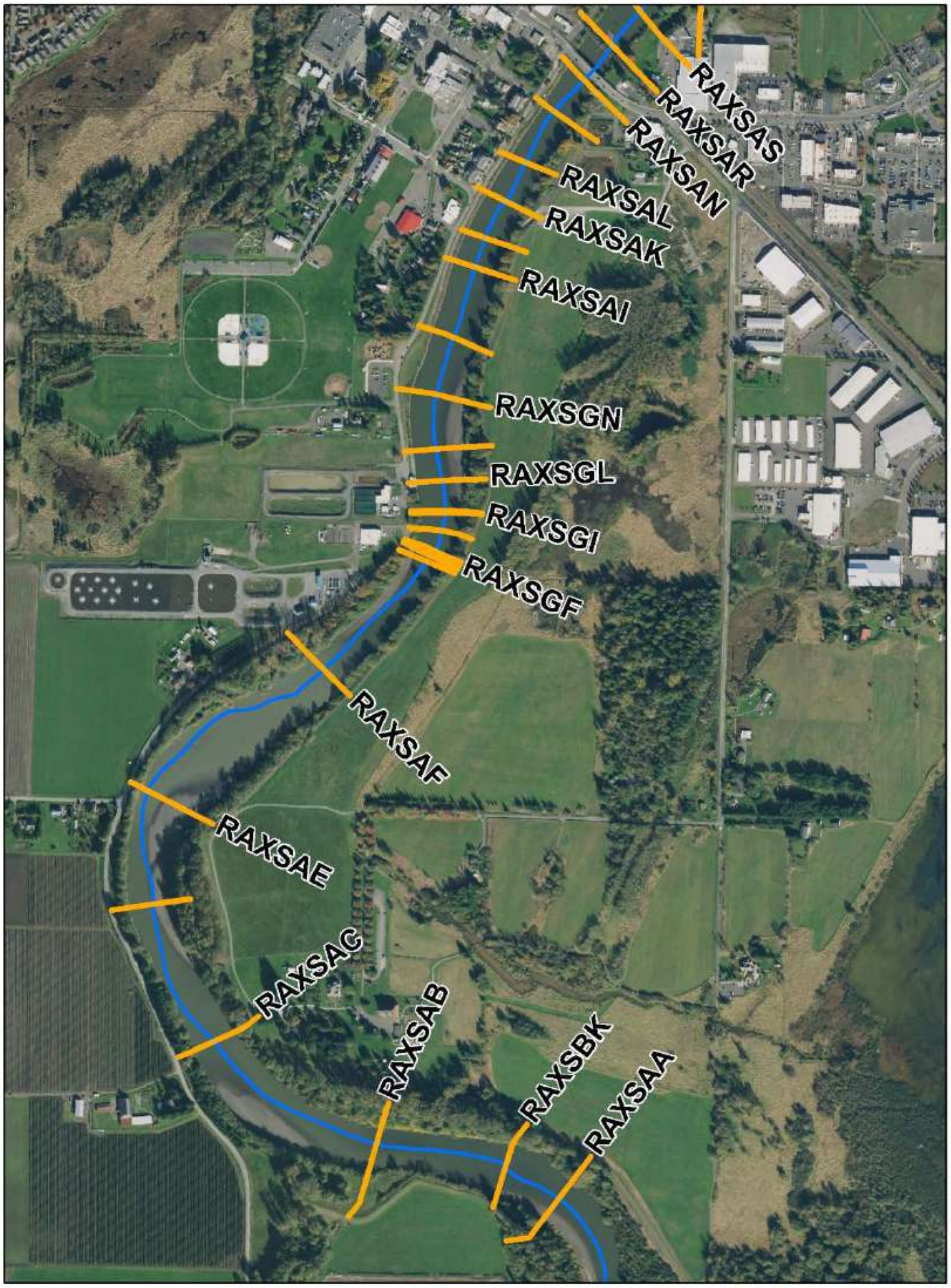


Figure 4.10 FEQ Nooksack Main Stem Cross Sections

4.2.5 Calibration Summary

Overall, the Ferndale HEC-RAS 2D model calibrated well to a total of 20 HWMs from three large floods spanning 16 years. Simulation errors were generally less than 0.3 feet. Water surface profiles in the project reach generally matched those of the calibrated 1D FEQ model. There are differences between the FEQ model and HEC-RAS 2D model around the bridges upstream of the project area, but there is a lack of HWMs in this area. It is recommended that future HWM collection include the reach between the I-5 bridge and the Main Street Bridge.

4.3 Existing Levee Protection

The Ferndale and Ferndale WTP levees protect the right bank of the Nooksack River between Ferndale and the Lummi River. According to the Corps of Engineers, the Ferndale WTP levee and Ferndale levee overtop with a frequency of 1 in 5 years and 1 in 100 years, respectively (USACE, 2020). HEC-RAS 2D modeling of the recurrence interval events indicates that the Ferndale levee at RM 6.9 near Main Street and RM 6.25 near the PUD No. 1 intake begin to overtop at the 25-year event (Figure 4.11 and Figure 4.12), which is consistent with records of imminent overtopping without mitigating efforts during the 1990 event (Whatcom County, 1999) and with observed conditions during the 2009 event. HEC-RAS 2D modeling shows overtopping near RM 6.0 occurs at flows near the 50-year event and larger. Overbank flow typically accesses the river left floodplain at flows greater than the 2-year event. The discrepancy between overtopping recurrence interval from the HEC-RAS results and the USACE *Levee System Summary* could be caused by local bed changes, levee crest elevation modifications, and/or flood volume and peak differences.

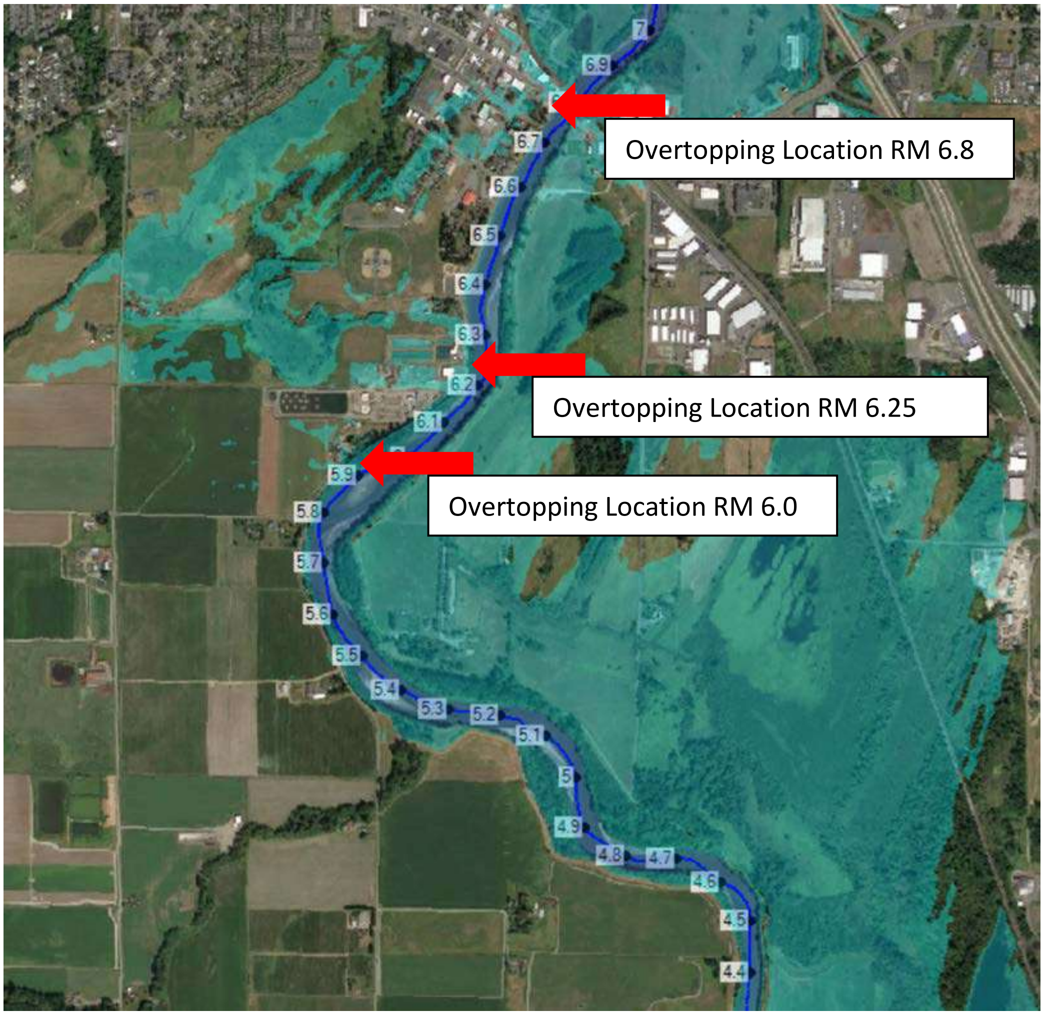


Figure 4.11 Overview of initial levee overtopping locations

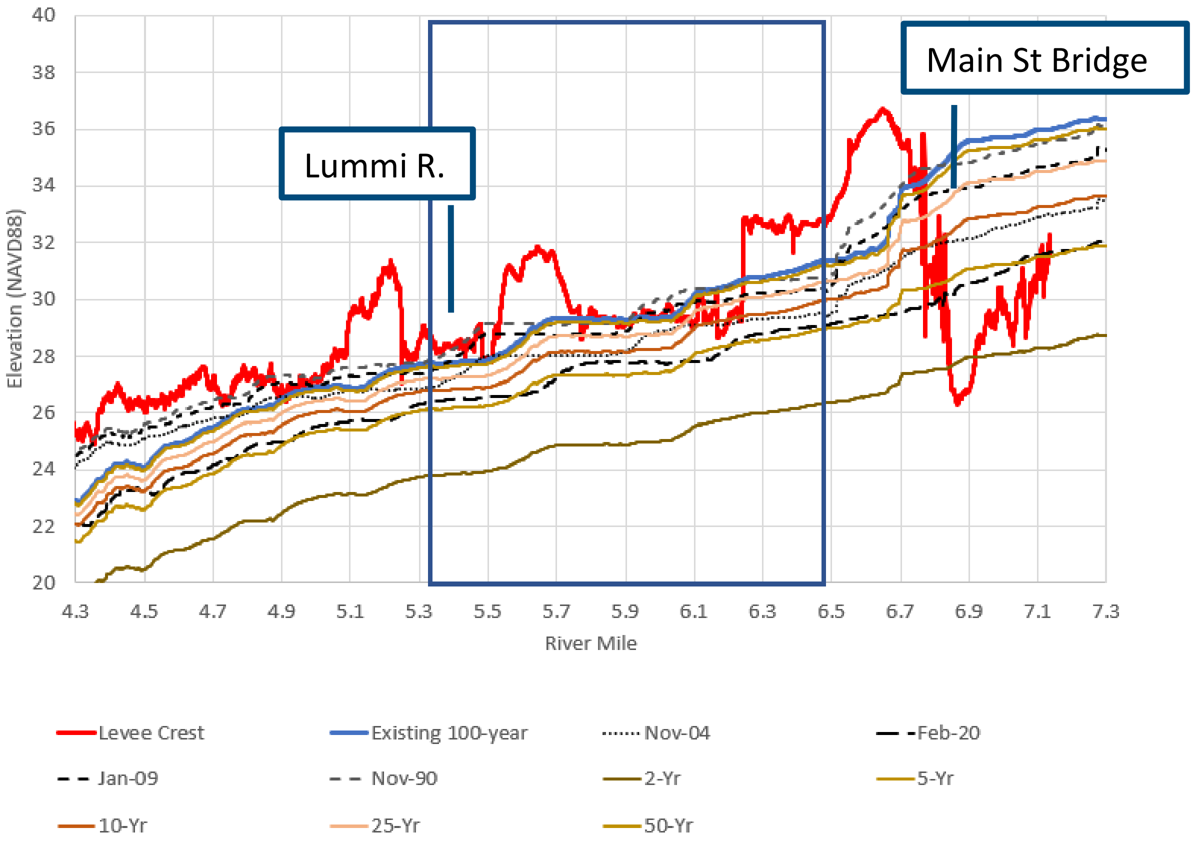


Figure 4.12 **Profile of recurrence interval events, calibration events, and levee crest elevation. Blue box indicates project reach. Note November 1990, November 2004, and January 2006 do not use existing condition topography. Note that thalweg WSELs are displayed: run-up, superelevation, and location conditions may cause variations in WSEL along the levee face.**

4.4 Levee Crest Design Elevation Recommendation

The Ferndale 2D HEC-RAS model was used to simulate the design flows through the project reach to inform the levee crest design elevation. The 100-year, 1.3*100-year, 1.7*100-year, and no Sumas Overflow conditions were modeled, as well as the 100-year, 1.3*100-year, and 1.7*100-year with 2.6 feet of aggradation in the main channel (see Section 5 for more detail). While formal FEMA levee accreditation is not part of this project, the levee design is generally following the same standards, including for freeboard above existing conditions 100-year water surface elevations. As climate change starts to affect future water surface elevations, the freeboard is expected to fall below FEMA standards in the future. The text below summarizes the base design considerations for FEMA levees (44 CFR 65.10(b)(1)(i) FEMA, 2020).

“Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-

half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required."

Three feet of freeboard on the existing simulated 100-year water surface elevation contains all the other simulated conditions within the project reach (Figure 4.13). The capacity for flow to overtop and spill into the river left floodplain is likely the reason for low model sensitivity to flow, since the overbank can accommodate additional inflows without substantially increasing the WSEL adjacent to the levee. These results indicate a high level of robustness to a levee designed to an existing conditions 100-year + 3 feet freeboard standard even under increased peak flows, bed aggradation, or reduced overflow at Sumas.

However, 3 feet of freeboard does not contain all simulated alternatives upstream of the Main St and railroad bridges (Figure 4.13 and Figure 4.14). Additional levee improvements should be considered under the railroad bridge in order to provide a consistent level of protection for the Ferndale levee system. Currently this area is managed by providing temporary flood protection and pumping during flood events (personal communication, Whatcom County, 2021).

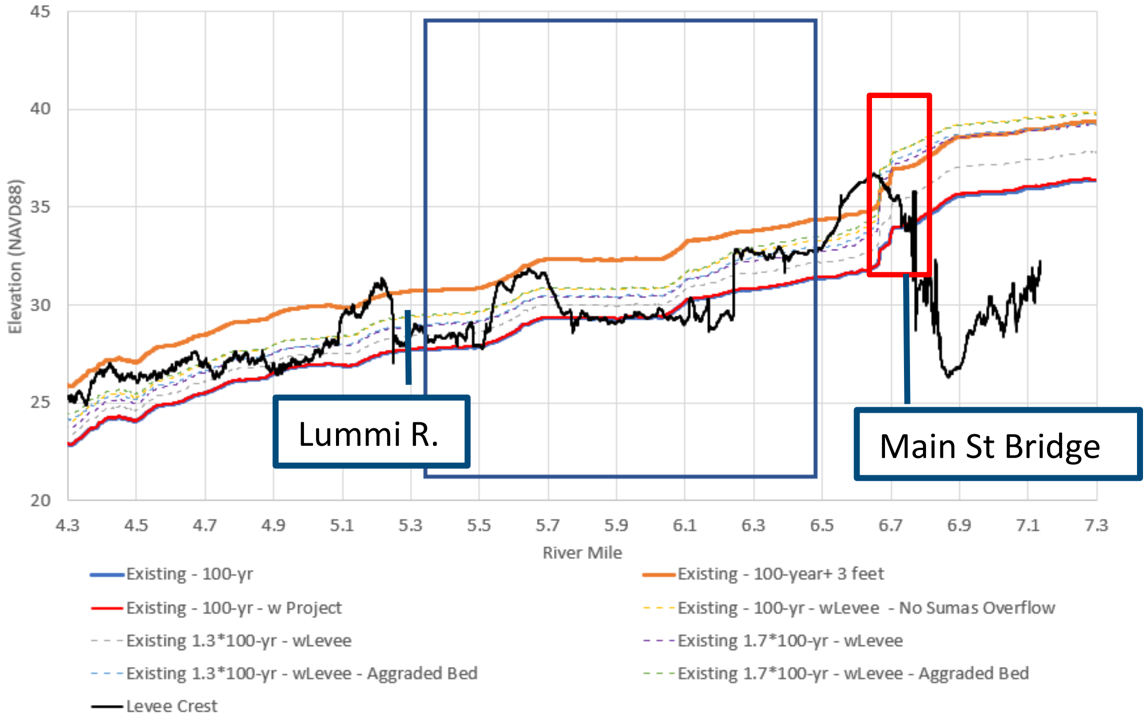


Figure 4.13 Design flow water surface elevation along the Nooksack centerline, blue box indicates project reach, red box indicates area where three feet of freeboard does not contain all simulated alternatives

4.5 Preliminary Levee Impacts on 100-year Flood Levels

A preliminary assessment of the impact of the proposed levee design on 100-year flood levels was completed. The assessment assumes no changes to the levee geometry or alignment and that right bank overflow along both the project levee and downstream to Slater Rd. will be completely prevented for the 100-year recurrence interval flow; this is generally consistent with the current Comprehensive Flood

Hazard Management Plan (CFHMP (1999)). This preliminary assessment may inform decisions about the start and end location of the levee improvements, level of service provided at different locations, and potential FEMA No-Rise impacts (Figure 4.14).

If the project provides complete protection along the length of the levee, the inundation area is reduced in the vicinity of the Ferndale Water Treatment Plant (Figure 4.15). However, flow can exit the levee system just upstream of the Main St. bridge where there is an opening in the railroad grade/underpass for Front Ave/Vista Dr through a section of low ground. Flow is then able to traverse through Ferndale and to the southwest. The complete right bank levee scenario reflects a case where the flow path under the railroad grade is blocked off, which is currently accomplished with temporary protection (Figure 4.15).

For the 100-year recurrence interval event this scenario creates an increase in WSEL of 0.05 feet through the majority of the project reach. However, this minor increase is amplified by the Main St and railroad bridges, which are sensitive to flow and downstream WSEL.

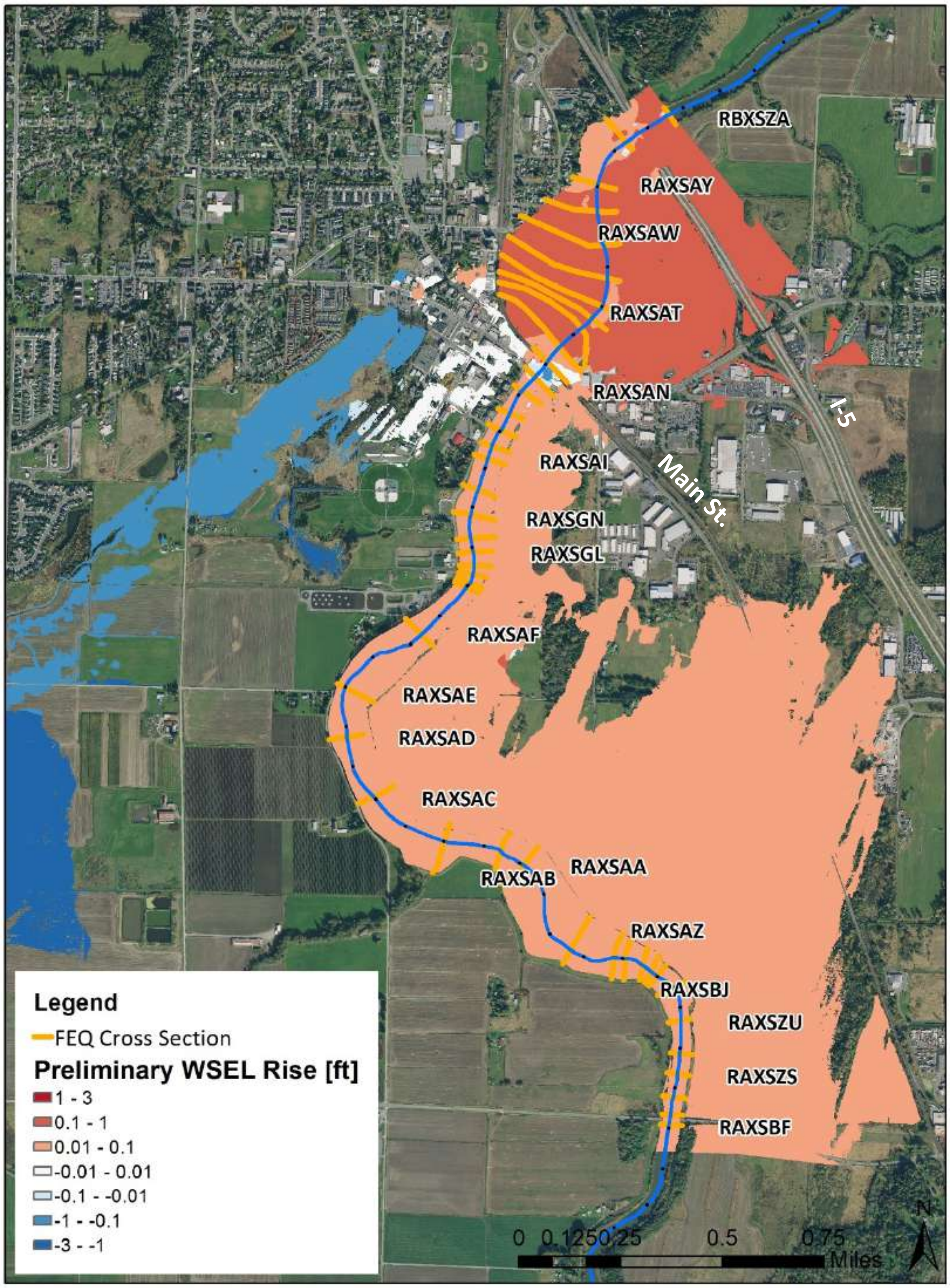


Figure 4.14 Difference in WSEL between existing and preliminary levee conditions for the 100-year recurrence interval event

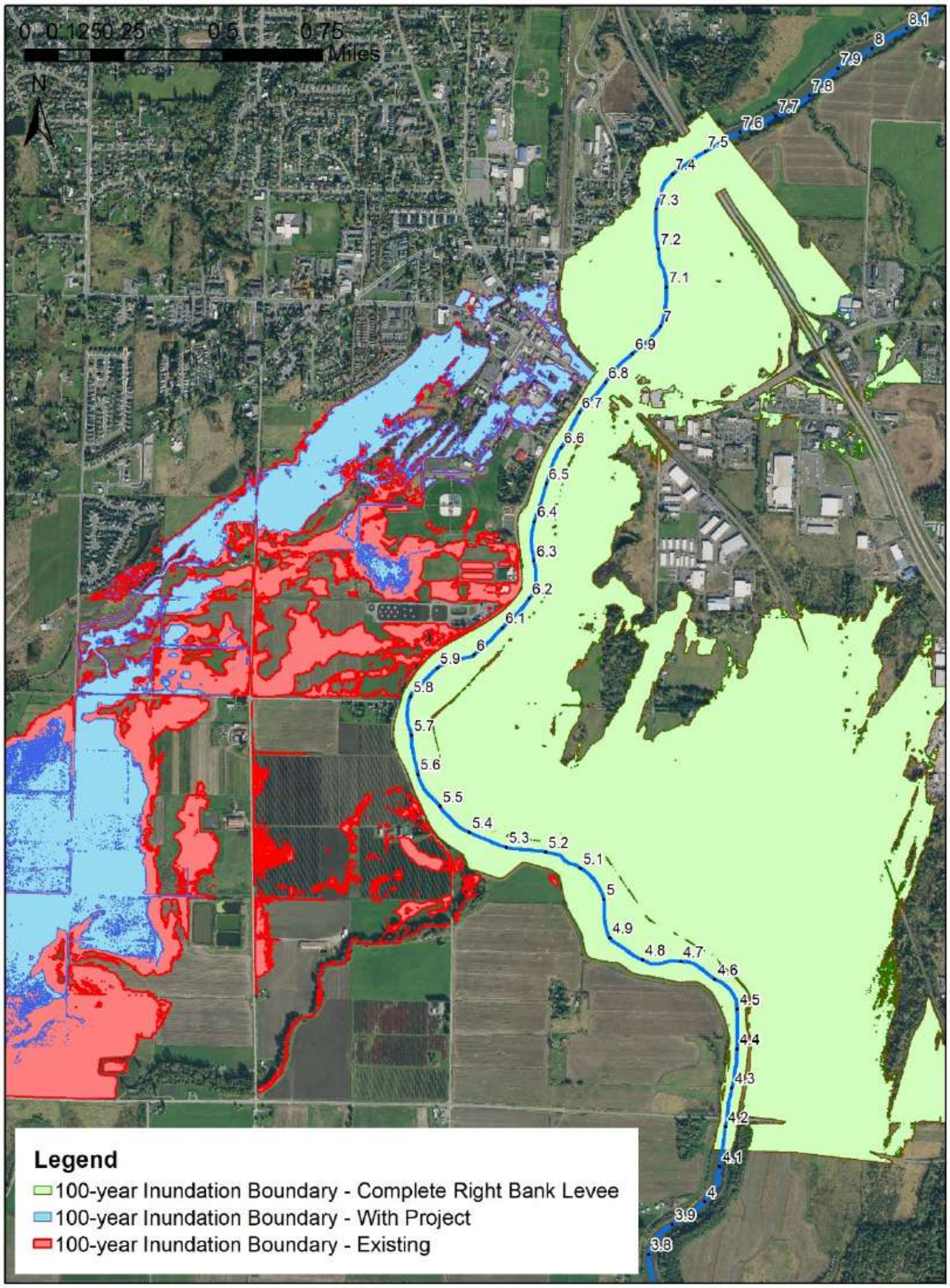


Figure 4.15 Difference in inundation boundary between existing and preliminary levee conditions for the 100-year recurrence interval event

5 GEOMORPHOLOGY, SCOUR, AND EROSION RISK

5.1 Geomorphology

5.1.1 Vertical Stability

The project reach is within Upper Reach 1 of the overall Nooksack system, where vertical stability is impacted primarily by two mechanisms. The first is delta progradation driven by sediment deposition in the delta, which propagates upstream. Anderson et al. (2019) estimated aggradation between Slater Rd. and Ferndale resulting from delta progradation to be about 0.13 feet per decade, which is slightly less than NHCs previous, but very preliminary estimate of a maximum plausible historical rate of about 0.2 ft per decade in the project vicinity (NHC 2015). Assuming a design life of 50 years, the total estimated change using Anderson et al's (2019) aggradation rate could reach 0.65 feet. This estimation does not account for hydraulic changes during floods or any changes in the shape of the riverbed profile.

In additional to secular aggradation driven by delta progradation, decadal-scale vertical bed waves affect the Nooksack River. Anderson et al. (2019) have documented a pattern of downstream-translating vertical bed waves that they hypothesize result from variability in sediment production due to regional climate variation. Stage residuals calculated at USGS gages show a wave of sediment moving downstream that has altered bed conditions substantially. The 2-3 foot high bed wave shows a lag between initial climate forcing and arrival at the Ferndale gage of 65 years; currently the bed wave is at or near the projected peak near Ferndale. Because the Ferndale reach is the terminus for large-scale gravel mobility in the channel (NHC 2015, NHC 2019) it is unclear whether the channel will incise following the period of elevated sediment supply that generated the downstream-propagating bed wave. Given the geomorphic setting, it is most likely that the rate of aggradation will slow but not substantially reverse. For this project the variability of bed conditions is the critical element given the long design life. Given uncertainty in the pattern of downstream bed wave propagation where it crosses the gravel-to-sand transition just downstream of the project reach, NHC recommends that the historical variability of the stage residual (2.6 feet) at the Ferndale gage (Figure 5.1) be added to the current bed condition to account for potential future variability. A long-term bed aggradation condition was simulated in the HEC-RAS model by modifying the underlying terrain dataset and running the 100-year event with climate change multipliers of 1.3 and 1.7. The resulting water surface profiles are shown in Figure 4.13 and are within the 3-feet of freeboard for the 100-year profile.

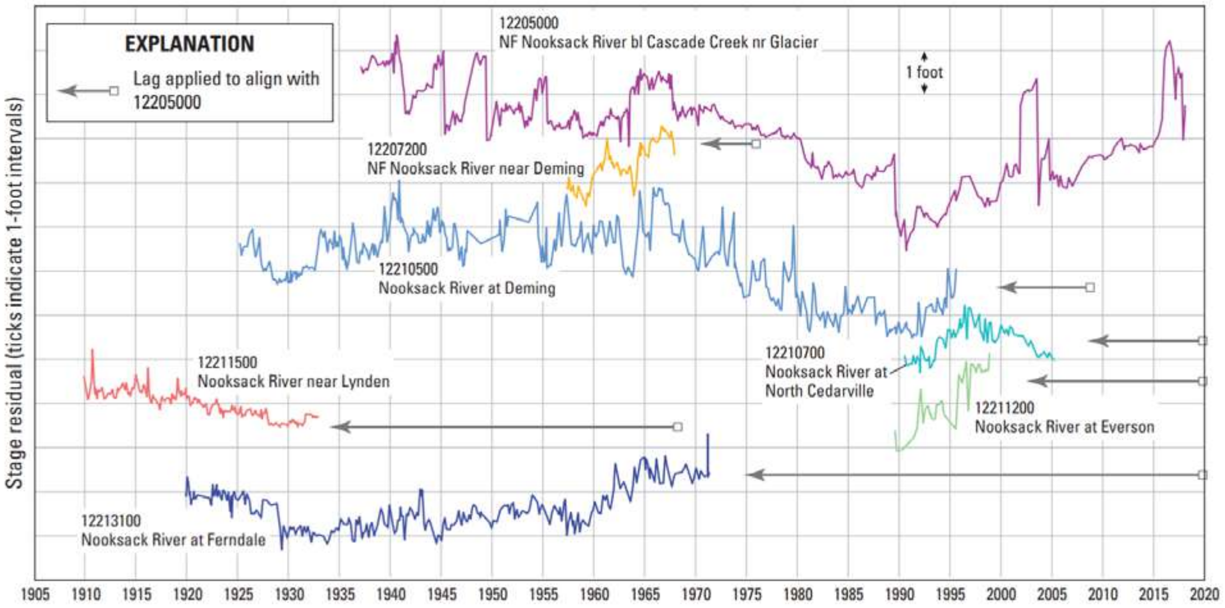


Figure 11. Changes in stage-discharge relations at all streamgages in the North Fork and mainstem Nooksack River, lagged to align with the upstream-most streamgage on the North Fork Nooksack River (12205000), northwestern Washington, 1938–2018. Lag times applied are based on cross-correlation analysis (table 7).

Figure 5.1 Source : Anderson et al. 2019

5.2 Scour and Erosion

Scour evaluation is used to inform the safe depth of design for the levee; there are multiple types of scour potentially applicable to this project. Bend and general scour were evaluated throughout the project reach where applicable. Abutment and contraction scour at the Public Utility District (PUD) No. 1 intake were also evaluated. If the project extends further upstream towards the Main Street bridge, pier and abutment/contraction scour may need to be evaluated. All scour conditions were evaluated for the 100-year recurrence interval flows.

5.2.1 Long Term Scour (Degradation)

Due to the geomorphic setting of the project reach, which is situated just above the gravel-to sand transition on the river, substantial future degradation is not expected. However, simple projection based on the bed wave pattern documented by Anderson et al. (2019) would suggest that on the order of two- to three feet of degradation may occur over the next couple of decades (See Section 5.1.1). Therefore, to represent bed variability 2.6 feet of degradation is accounted for on top of other types of scour. However, a 1-D sediment transport model evaluating sensitivity to bed change in this reach based on incoming bed load would provide greater certainty on long term degradation.

5.2.2 Bend Scour

Bend scour is the dominant scour mechanism along the Ferndale Levee which contains four bends (Figure 5.2). The upstream bend (Bend C) is a short bend with a relatively large radius of curvature just upstream of the PUD No. 1 intake at RM 6.3. The next bend (Bend D) impacts the opposite side of the bank of the project. Bends E and F represent a large compound bend extending from RM 5.9 to 5.4. The upstream of the two bends contains the tightest radius of curvature; both bends are separated by a short, straighter reach still within the larger meander.

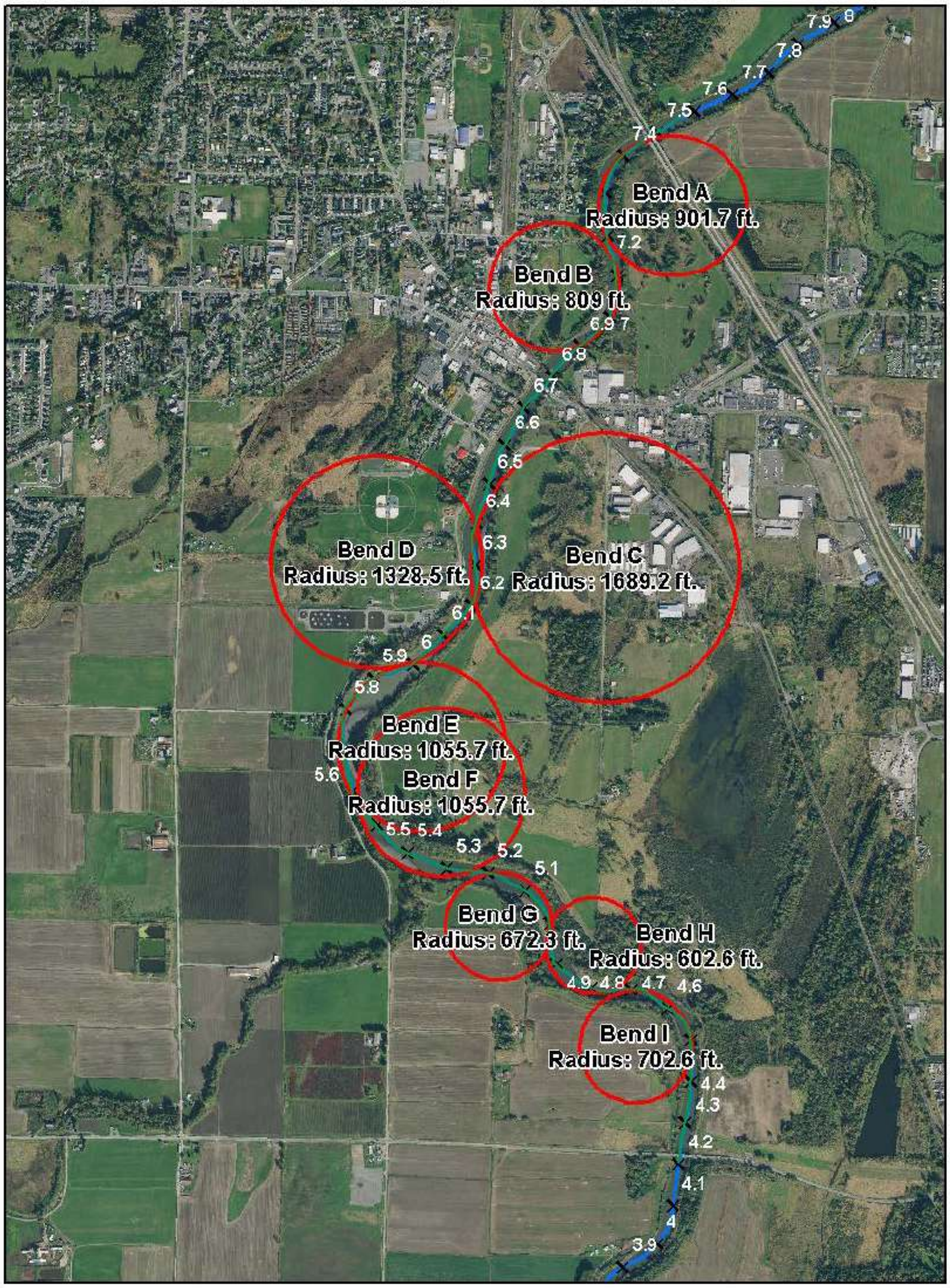


Figure 5.2 Bend scour locations and associated radius of curvature within the Ferndale Levee project reach

Bend scour was computed at bends upstream and downstream of the project reach to evaluate scour methodologies and to better understand the reach geomorphic dynamics. Four empirical best fit and one Safe Design Curve (SDC) equations were used in the bend scour analysis.

Table 5.1 General Scour estimation methods

Method	Reference	Notes	Key Variables
Maynord	(Maynord, 1996)	Developed for sand bed rivers. For W/D ratios below recommended limit of 20.	R_c/W, W/D
Soar and Thorne	(Soar and Thorne, 2001)	Used equation for W/D ratio < 60. For sand and gravel rivers.	R_c/W
Zeller	(Zeller, 1981)	Developed for sand bed rivers	$Rc/W,D,D_{max},V,E.G$
Froehlich	(Froehlich, 2020)	Developed for sand bed rivers	$R_c/W,Fr,D_{max}$
SDC – USACE	(USACE, 1994)	Used gravel bed river curve	R_c/W

Notes:

1. Rc = Radius of Curvature (ft), W = upstream cross section width (ft), D = Average upstream cross section depth (ft), D_{max} = Maximum depth at upstream cross section (ft), V = Average velocity at upstream cross section (ft/s), E.G. = Energy gradeline (ft/ft), Fr = Froude Number (dimensionless).

Results from the bend scour analysis indicate there is a range of potential scour values at all bends (Figure 5.3). It is difficult to use observed data to validate scour methodologies because of the tendency for sediment to fill in scour holes during the falling limb of a significant flow event. The Froehlich method tends to predict smaller scour values than the other methodologies but represents the relative shape of channel topography relatively well. The Thorne and Maynord methods generally produce similar results at most bends. However, Bends E and F are outside of the applicability of the Maynord W/D applicability. The Zeller method tends to fall between the Froehlich and Thorne/Maynord methods, though it is more variable. The USACE Safe Design Curve is not shown, as it is not intended to predict scour but rather represent safe elevations. In conclusion, equations for sand bed rivers tended to predict more scour than the Soar and Thorne method for gravel rivers, which may therefore represent a conservative estimate for scour.

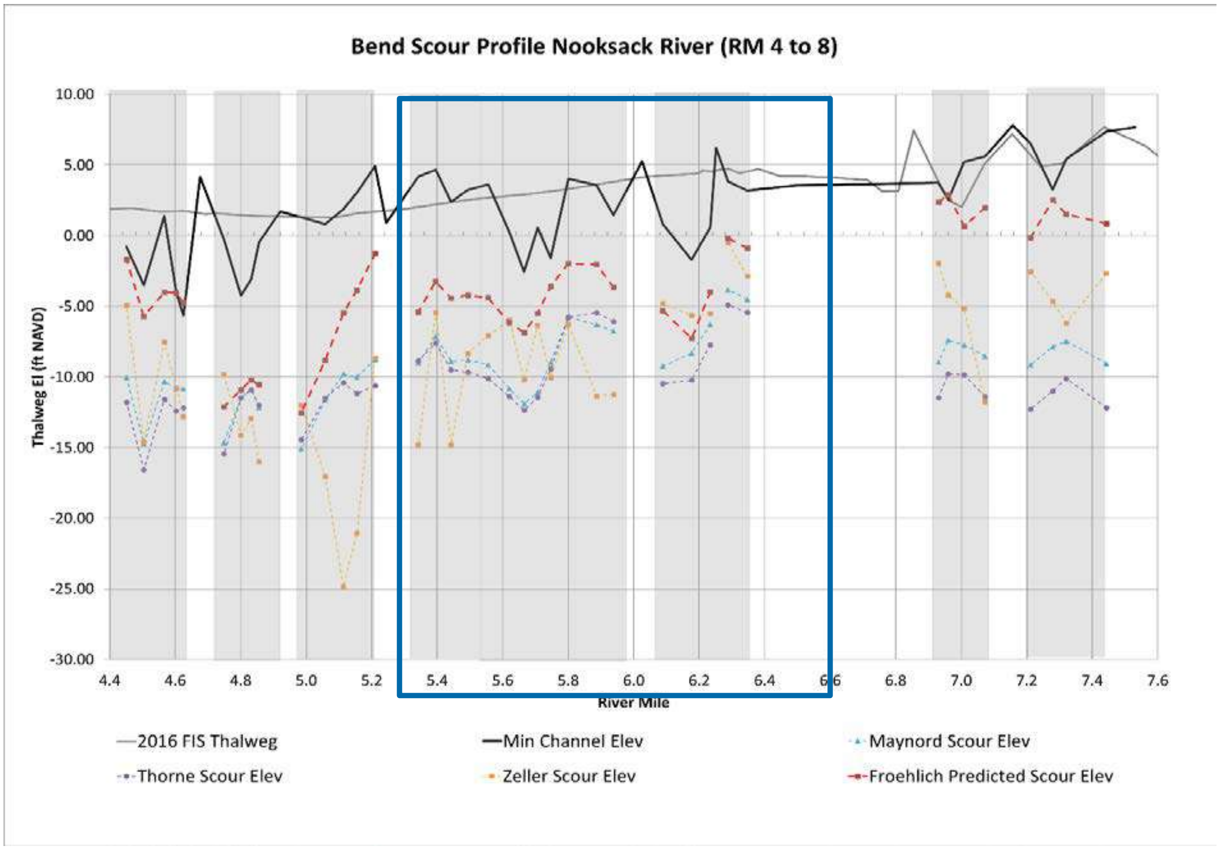


Figure 5.3 **Predicted bend scour elevations compared to minimum thalweg elevations through the project reach. The blue outline indicates the project reach, grey zones indicate bend locations, white zones indicate straight reaches.**

5.2.3 General Scour

Standard practice is to calculate both general and bend scour and take the greater of the two for design use. General scour ~~scour~~ equations include the effects of bend scour and so the two types of scour are not additive. Six methodologies were checked for general scour (Table 5.2), however they derive from two equations, Blench (1969) and Lacey (1930). Both equations were adapted by USBR (Pemberton and Lara, 1984) and NRCS (NRCS, 2007). The other typical general scour equation, Neill, is not applicable in this scenario because it pertains to general scour at bridges. The D_{50} for all scour locations was assumed to be 5.6 mm, the subsurface D_{50} based on AGI (2019), NHC (2015), and NHC (2019). Application of the measured D_{50} represents the best available data without detailed substrate mapping, however uncertainties in the results may occur due to inherent sediment variability within the reach. A check of the bends shows that bend scour was consistently greater than general scour, which is typically expected. For instance, at the RM 5.7 bend, the Lacey and Blench average general scour depth is 8.57 feet, while the average bend scour depth is 9.81 feet. General scour was therefore not considered in calculating design scour depth at bends but was used along straight reaches where applicable.

Table 5.2 General Scour estimation methods

Method	Reference	Notes	Key Variables
Blench	(Blench 1969)	Scour depth, developed from incised river	q, f_{b0}, C
USBR Blench	(Pemberton and Lara 1984)	Scour depth	q, f_{b0}, Z
NRCS Blench	(NRCS 2007)	Scour depth	$K, Q_d, a, b, c, W_f, D_{50}$
Lacey	(Lacey 1930)	Scour depth	Q, f, Z
USBR Lacey	(Pemberton and Lara 1984)	Scour depth	q, f, C, D_m
NRCS Lacey	(NRCS 2007)	Scour depth	$K, Q_d, a, b, c, W_f, D_{50}$

Notes:

1. Q = design discharge (cfs), q = unit discharge (cfs/ft).
2. C,K,Z = linear coefficients.
3. a,b,c = exponential coefficients.
4. f = silt or bed factors (function of D_{50}).
5. D_{50} = mean grain size of bed material by weight (mm).
6. W_f = width of flow (ft).

Both of the original equations Blench (1969) and Lacey (1930) solve for scoured depth, which includes water depth and scour depth; in all cases these equations predict less scour than the lowest bed elevation. These equations solve for scoured depths at any location along the cross section, rather than at the thalweg. The derived adaptations of these equations solve for scour depth, which is subtracted from the thalweg elevation. The range of results is typically substantial, with an average standard deviation at scour evaluation locations of 2.6 feet (Figure 5.4). However general scour is only applicable where bend scour is not applicable - from RM 6.55 to RM 6.35 and from RM 5.95 to RM 6.25. To contain the maximum average general scour, the scour elevation for RM 6.55 to RM 6.35 and from RM 5.95 to RM 6.25 are -4.6 feet NAVD88 and -9.6 feet NAVD88, respectively.

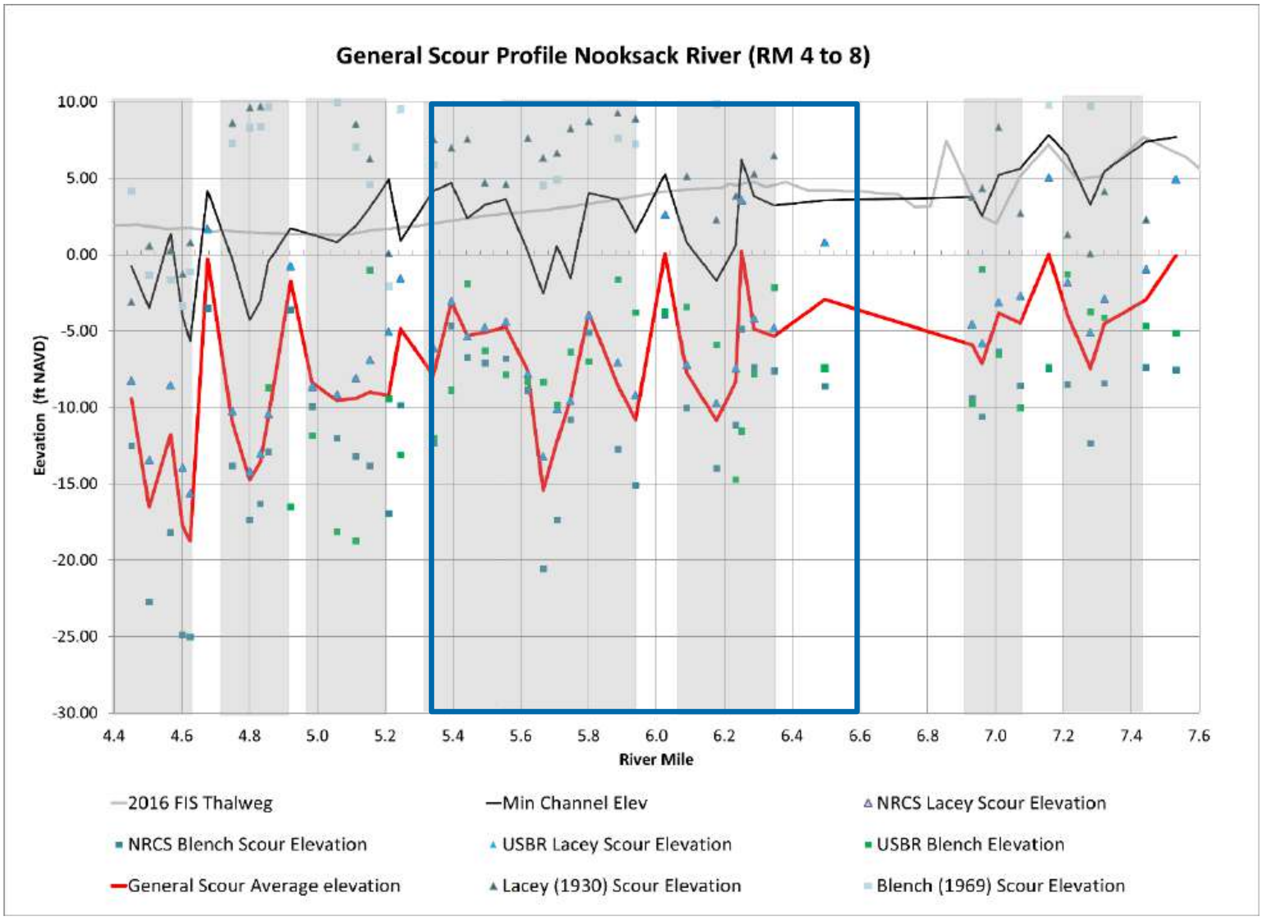


Figure 5.4 **Predicted general scour elevations compared to minimum thalweg elevations through the project reach. The blue outline indicates the project reach, grey zones indicate bend locations, white zones indicate straight reaches.**

5.2.4 Abutment Scour

Local abutment scour was calculated at the PUD No. 1 intake structure using the NCHRP method (FHWA, 2012). Scour depths shown are based on three substrate D_{50} sizes: subsurface, surface, and armored, a calculated clast size that will prevent scour, not a measured value for substrate. If the armored layer is undermined, or when no armor layer is present, surface or subsurface substrate could be impacted by scour. Contraction abutment scour of 1.31 feet was calculated utilizing HEC-18 methodology (FHWA, 2012) at the PUD No. 1 intake contracted section, resulting in a scour elevation of 3.69 feet NAVD88. Since the PUD No. 1 intake is located near the outside of Bend C, abutment scour acts in addition to bend scour at this location, resulting in a total scour depth of -10.31 feet.

Table 5.3 Local abutment scour estimation results

Substrate Size	D_{50} [mm]	Scour Depth [ft] (From Abutment Toe)	Scour Elevation [ft. NAVD88]
Subsurface	5.6	30.29	-14.37
Surface	14	26.81	-10.86
Armored[1]	680	0.00	5.00

Notes:

1. Armored value indicates size needed to prevent scour, not a measured substrate size

Figure 5.5 Ferndale PUD No. 1 intake location.

5.3 Scour and Erosion Protection Recommendations

Scour and erosion protection design accounts for three main types of scour- long-term, general/bend, and local scour-, where each type is applicable, and a factor of safety, if applicable. Long term scour values are added to the general/bend and local scour values to arrive at the design scour elevation, which includes factors of safety associated with the predicted scour elevations; a typical factor of safety is 1.5. Gage residual bed variability indicates 2.6 feet of potential long-term degradation (Section 5.2.1) throughout the reach. The recommended design elevation shown in Figure 5.6 selects the lowest average general scour (-3.0 feet NAVD88) when bends are not located along the levee. Where levee sections are located on the outside of a bend the average elevations from the Froehlich 90% confidence interval, Maynord, and Thorne design elevations were used (Table 5.4), resulting in an elevation of -9.0 feet NAVD88 for Bend C and -17.3 feet NAVD88 for Bend E and F (Figure 5.6). It should be noted that the USACE Safe Design Curve method designated safe elevations that are approximately 20 feet lower than other scour elevations. Erosion protection at the PUD No. 1 intake should either provide adequate armoring or scour protection to the design depth. Final design scour elevations are shown in Figure 5.6.

Table 5.4 Bend scour design elevation methods

Method	Bend E & F Lowest Elevation [ft. NAVD88]	Bend C Lowest Elevation [ft. NAVD88]
Froehlich 90% Confidence	-17.5	-8.8
Maynord (F.S. 1.5)	-16.9	-8.4
Thorne (F.S. 1.5)	-17.4	-9.8

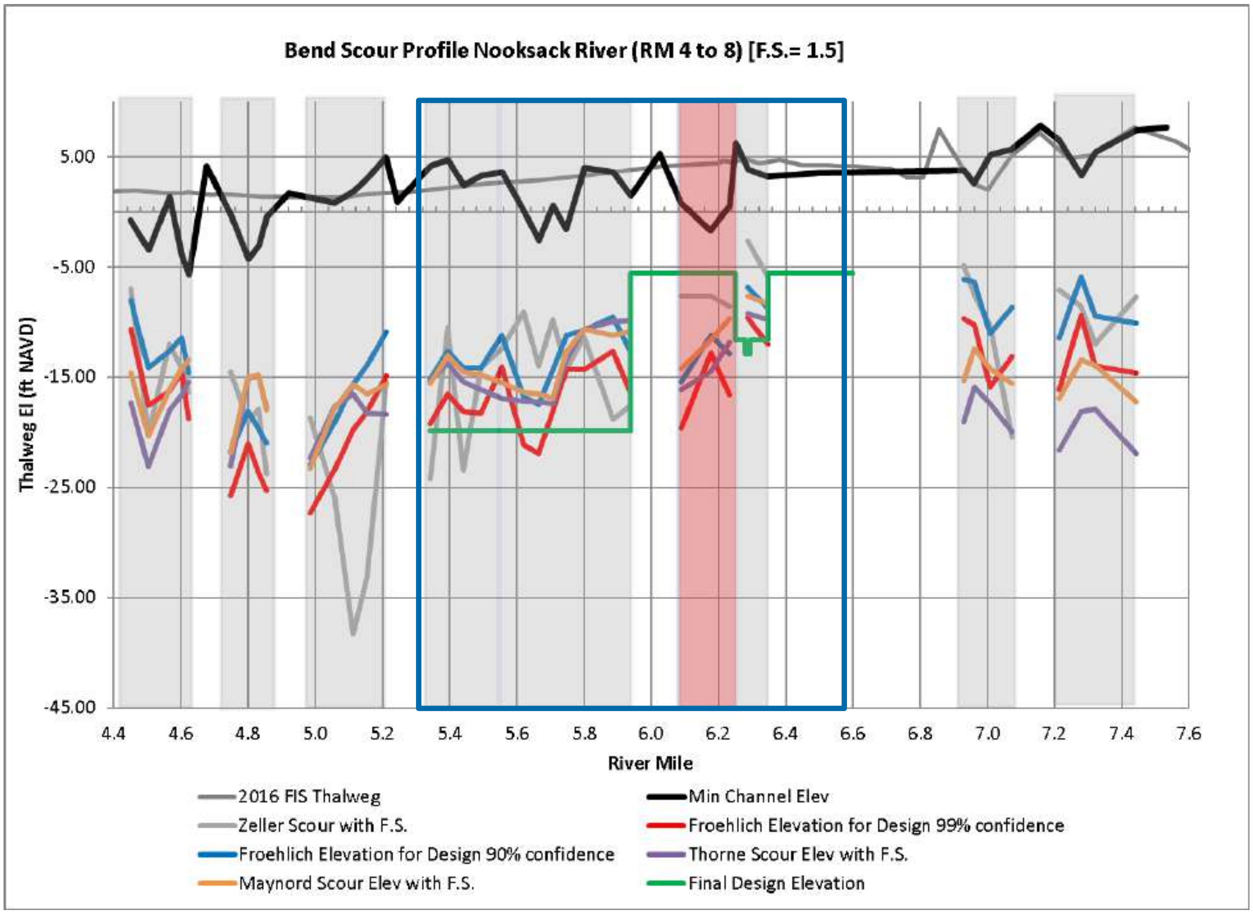


Figure 5.6 Design scour elevations compared to minimum thalweg elevations through the project reach. The blue outline indicates the project reach, grey zones indicate bend locations, white zones indicate straight reaches, and red zone indicates opposite bank bend.

6 REFERENCES

Anderson, S.W., Konrad, C.P., Grossman, E.E., and Curran, C.A., 2019, Sediment storage and transport in the Nooksack River basin, northwestern Washington, 2006–15: U.S. Geological Survey Scientific Investigations Report 2019-5008, 43 p., https://doi.org/10.3133/sir2019500Blench, T. (1969). "mobile-bed fluviology." The University of Alberta Press, Edmonton, Alberta, Canada.

Applied Geomorphology, Inc. 2019. Lower Nooksack River Geomorphic Assessment. Prepared for: Whatcom County Flood Control Zone District. February 11, 2019.

Delbert D Franz, Linsley, Kraeger Associates. "FLOOD FREQUENCY ANALYSIS AT DEMING, FERNDALE, AND EVERSON," 2005, 34.

Federal Emergency Management Agency. 2020. Guidance for Flood Risk Analysis and Mapping: Levees. Guidance Document 95. December 2020.

Froehlich, 2020. *Neural Network Prediction of Maximum Scour in Bends of Sand-Bed Rivers*. Journal of Hydraulic Engineering, Volume 146, Issue 10, October 2020.

Hamlet, A. F., and et al. (2013). An overview of the Columbia Basin Climate Change Scenarios Project: Approach, methods, and summary of key results. Atmosphere--Ocean, 51(4), 392–415. doi:10.1080/07055900.2013.819555.

Hawkins, E., and Sutton, R. (2010). The potential to narrow uncertainty in projections of regional precipitation change. Climate Dynamics, 37, 407–418. doi:10.1007/s00382-010-0810-6.

IPCC (2000). SRES (Special Report on Emissions Scenarios). Cambridge University Press, Cambridge, England, U.K. 570 pp. [online] Available from: https://www.ipcc.ch/report/emissions-scenarios/.

IPCC (2007). Contribution of Working Groups I, II and III to the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.). Geneva, Switzerland. 104 pp.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. 151 pp.

Kirchmeier-Young, M. C., Gillett, N. P., Zwiers, F. W., Cannon, A. J., and Anslow, F. S. (2019). Attribution of the influence of human-induced climate change on an extreme fire season. Earth's Future. doi:10.1029/2018EF001050.

KMC, Inc (1995). Nooksack River Flood History. Prepared for Whatcom County.

Whatcom County (1995). Lower Nooksack River. Comprehensive Flood Hazard Management PLAN. Prepared for Whatcom County Flood Control Zone District.

Kundewicz, Z. W., and Stakhiv, E. Z. (2013). Are climate models "ready for prime time" in water resources management applications, or is more research needed? Hydrological Sciences Journal, 55(7). doi:10.1080/02626667.2010.513211.

L.A. Arneson, L.W. Zevenbergen, P.F. Lagasse, P.E. Clopper. 2012. EVALUATING SCOUR AT BRIDGES Fifth Edition. FHWA-HIF-12-003 HEC-18. National Highway Institute. April 2012.

Lacey, G. (1930). "Stable Channels in Alluvium," Paper 4736, Proceedings of the Institution of Civil Engineers, Vol. 229, William Clowes and Sons Ltd., London, Great Britain, 259-292.

Mastin, M.C., Konrad, C.P., Veilleux, A.G., and Tecca, A.E., 2016, Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.2, November 2017): U.S. Geological Survey Scientific Investigations Report 2016–5118, 70 p., http://dx.doi.org/10.3133/sir20165118.

Mauger, G. S., Casola, J. H., Morgan, H. A., Strauch, R. L., Jones, B., Busch Isaksen, T. M., Whitely Binder, L., Krosby, M. B., and Snover, A. K. (2015). State of Knowledge: Climate Change in Puget Sound. Climate Impacts Group, University of Washington, Seattle. [online] Available from: http://cses.washington.edu/picea/mauger/ps-sok/PS-SoK_2015.uncompressed.pdf (Accessed 30 May 2017).

Maynord, S. T. 1996. *Toe-scour Estimation in Stabilized Bendways*. Journal of Hydraulic Engineering, Volume 122, Issue 8, August 1996.

Neill, C.R. (1973). "Guide to Bridge Hydraulics," Roads and Transportation Association of Canada, University of Toronto Press, Toronto, Canada.

NHC (2015). Appendix C: Geomorphic Characterization. Lower Nooksack River Project: Alternatives Analysis. Report prepared by The Watershed Company, LandC, Etc., Northwest Hydraulic Consultants, and Cardno for Whatcom County.

NHC (2019). Appendix D: River Processes: Hydraulics, Bed and Bank Material, Sediment Transport, and Regime. In Applied Geomorphology, Element Solutions, NHC, and DTM Consulting (Eds.), *Lower Nooksack River Geomorphic Assessment*. [online] Available from: http://www.co.whatcom.wa.us/DocumentCenter/View/39544/Lower-Nooksack-Geomorphic-Assessment-APPENDIX-D.

NRCS (Natural Conservation Resources Service). (2007). National Engineering Handbook Part 654 – Technical Supplement 14B, Scour Calculations, United States Department of Agriculture, NRCS, Washington, D.C. 20250.

Pemberton, E.L. and Lara, J.M. (1984). "Computing Degradation and Local Scour," Technical Guideline for Bureau of Reclamation, Engineering and Research Center, U.S. Bureau of Reclamation, Denver, CO 80225.

Reichart & Ebe. 2004. Ferndale Bridge Rehabilitation Plans. Prepared for City of Ferndale Public Works Department.

Snover, A. K., and et al. (2013). Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

Thorne, C.R., and S. R. Abt. 1993. *Velocity and Scour Prediction in River Bends*. Prepared for USACE. Contract Report HL-93-1. March 1993.

United Stated Army Corps of Engineers (USACE). 2021. HEC-RAS Version 6.0. U.S. Army Corps of Engineers. Hydrologic Engineering Center. Davis, CA.

United States Army Corps of Engineers (USACE). 2020. Levee System Summary Ferndale, Ferndale WTP, Sigardson, Rayhorst and Rainbow Slough. U.S. ARMY CORPS OF ENGINEERS – Seattle District 4735 E Marginal Way S, Seattle, WA 98134 http://www.nws.usace.army.mil/.

United States Army Corps of Engineers (USACE). 2010. Batched Nooksack Levee Repair Projects. Seattle District, Corps of Engineers Environmental Resources Section.

Whatcom County. 2020. Whatcom County Climate Action Plan: Summary of Observed Trends and Projected Climate Change Impacts. January 2020.

Zeller, J. 1967. *Meandering channels in Switzerland*. International Association of Scientific Hydrology, Symposium on River Morphology, Bern, 75, 174-186.

APPENDIX A

LEVEE SYSTEM SUMMARY

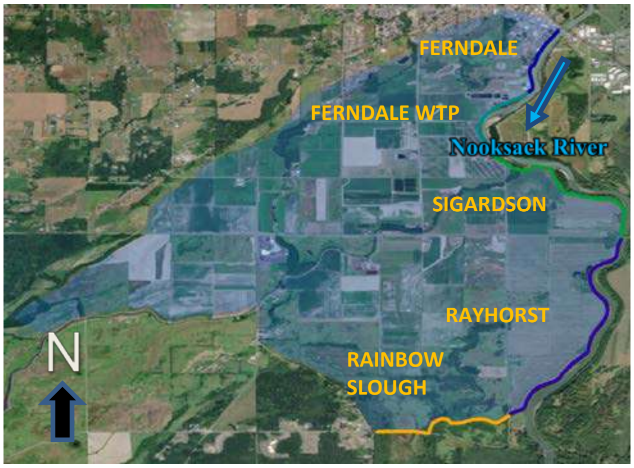
Levee System Summary

Ferndale, Ferndale WTP, Sigardson, Rayhorst and Rainbow Slough

U.S. ARMY CORPS OF ENGINEERS **BUILDING STRONG ®**

September 24, 20212020

Project Description: This levee system is a non-federally constructed, operated and maintained system located near Ferndale, WA. It consists of 5 levee segments located along the right bank of the Nooksack River from river mile 1.7 to 5.8 that tie into each other to form a complete system. From downstream to upstream the levee segments within the system are; Rainbow Slough, Rayhorst, Sigardson, Ferndale Water Treatment Plant, and Ferndale Levees. Construction of the levees was completed by the Works Progress Administration in the 1930s. The levee system primarily protects farmland with low to high value crops. It also provides protection for critical infrastructure including: a school, police station, 2 oil gas pipelines, and a wastewater treatment plant. Inundation of the wastewater treatment plant could have significant effects on the leveed area as well as communities downstream. Historically Rainbow Slough, Rayhorst, and Ferndale WTP have overtopped and breached experienced scour damage in the past. Repairs involved adding riprap and raising the levee profiles in some areas. Whatcom county is the listed local sponsor and is responsible for operations and maintenance of the system.



System Components:

Levee Segment	Length [feet]	Overtopping Frequency	*Latest Inspection*		*Status*	
			Date	Rating	USACE Eligibility	FEMA National Flood Insurance
Rainbow Slough	5,200	1 in 9 yrs	18 March 2019	M	Active	Not Accredited
Rayhorst	10,000	1 in 8 yrs	18 March 2019	M	Active	Not Accredited
Sigardson	6,900	1 in 12 yrs	18 March 2019	U	Active	Not Accredited
Ferndale WTP	3,500	1 in 5 yrs	18 March 2019	U	Active	Not Accredited
Ferndale	3,200	1 in 100 yrs	18 March 2019	M	Active	Not Accredited

A – Acceptable M – Minimally Acceptable, U - Unacceptable

Levee Segment	**Overall Risk Category**	**Driving Flood Scenario**	**Performance Risk Drivers**	**Actions to Manage Performance Risk***	**Maximum Flood Level [% Levee Height]**
Rainbow Slough	Low	Overtopping	Erosion	SE, RTV	100
Rayhorst	Low	Overtopping	Erosion	SE, RTV	100
Sigardson	Low	Overtopping	Erosion	SE, RTV	100
Ferndale WTP	Low	Overtopping	Erosion	SE, RTV	100
Ferndale	Low	Overtopping	Erosion	SE, RTV	68
***RTV – Remove Trees and Vegetation, ACP – Implement Animal Control Plan, SE – Monitor and Repair Scour and Erosion, SS – Monitor and Repair Slope Stability Issues**					

What is driving the risk? (Performance Issue)	**What is being done about it? (Risk Management)**
Embankment Erosion	Remove trees and vegetation that may affect riprap performance and slope stability. Consider raising the level of protection at the Ferndale and Ferndale WTP levees. Continue efforts in the System-Wide Improvement Framework to increase the protection provided by the levee system.

Risk Characterization: The Corps of Engineers assessed this levee system in 2017 using a screening level risk assessment and determined the overall risk characterization to be low. The system has been overtopped and breached in the Rainbow Slough, Rayhorst, and Sigardson segments. If inundation were to occur, approximately $24 million in property damages would accrue with 314 structures affected. Loss of life is expected to be low, but may be reduced further by developing a system specific flood response plan and engaging the stakeholders in the leveed area more directly. Reducing flood damages to buildings and infrastructure may be decreased by proactive efforts to improve the resiliency of these assets.

What Is Important to Know?
Levee Specific Information***:*** The following table provides specific information related to this levee system.

Latest Inspection and Rating:	A routine inspection completed on 18 March, 2017 for each segment assigned a minimally acceptable rating except for Sigardson and Ferndale WTP segments which were rated U based on the Red River Culvert and the sandbag closure.
Rehabilitation Program Eligibility:	All segments in this system are active in the Rehabilitation Program based on the condition assessment in the routine inspections and the County's participation in the SWIF program.
National Flood Insurance Program Status:	This levee system is not accredited in the FEMA National Flood Insurance Program within Region 10. There are no ongoing FEMA mapping projects occurring within leveed area at the current time.

Ongoing Activities and Studies: The sponsor is participating in a System Wide Improvement Framework plan with USACE and all segments in this system are included in that plan. There is currently a Lower Nooksack River Comprehensive Flood Plan development effort underway with various stakeholders led by Whatcom County.

Who Can I Contact? Info concerning this levee system may be obtained by contacting the following entities:

Local Emergency Management Agency	Whatcom County is the local emergency management agency responsible for warnin and evacuation of the leveed area.
Levee Sponsors	Whatcom County
Community/County	Deming, Whatcom County
FEMA National Flood Insurance Program	FEMA Region: Region 10 FEMA Region Contact: Ted Perkins FEMA Map Service Center website: https://msc.fema.gov/ FEMA Map Information eXchange (FMIX): 1-877-336-2627 (toll-free), or email at: FEMAMapSpecialist@riskmapcds.com https://www.fema.gov/living-levees-its-shared-responsibility
National Levee Database	http://nld.usace.army.mil

Appendix D: Levee Toe Inspection and Bathymetric Survey Memo

12787 Gateway Drive South | Seattle, WA 98168 | 206.241.6000 | www.nhcweb.com

nhc
northwest hydraulic consultants

MEMORANDUM

To:	**Nathan Zylstra, P.E.**	Date:	Nov 17, 2020
Company:	**REICHHARDT & EBE ENGINEERING INC.** 423 Front Street Lynden, WA 98264	NHC Ref. No.	2005590
Via email:	nathanz@recivil.com		
From:	Tyler Rockhill, EIT – NHC Jaron Brown, P.E. – NHC Vaughn Collins, P.E. – NHC		
Re:	**Ferndale Levee Improvement Project: Levee Toe Inspection and Bathymetric Survey Memorandum**		

1 OBJECTIVES

The Ferndale Levee Improvement Project includes conceptual design for improvements of the Ferndale and Treatment Plant Levees near Ferndale, WA to provide greater flood protection and enhance riparian habitat. Northwest Hydraulic Consultants (NHC) is scoped to provide services including inspection of existing conditions along the levee toe, bathymetric survey of the project site, hydraulic modeling of existing and alternative conditions, levee scour and erosion assessment, fluvial geomorphic assessment, and design support. This memorandum documents the levee toe inspection and bathymetric survey, including methodology, results and conclusions. It is accompanied by a Google Earth (.kmz) file with geotagged photographs systematically documenting conditions along the levee toe.

NHC visited the project site to perform bathymetric survey and to assess the toe condition of the Ferndale and Ferndale Water Treatment Plant levee segments (USACE, 2020) on October 9th, 2020. The flow during the time of survey based on Nooksack River at Ferndale (USGS Gage 12213100) was 1,300 cfs. Bathymetric survey and toe inspection were performed using a jet boat to access the river side of the levee; extent of the survey is shown in Figure 1.

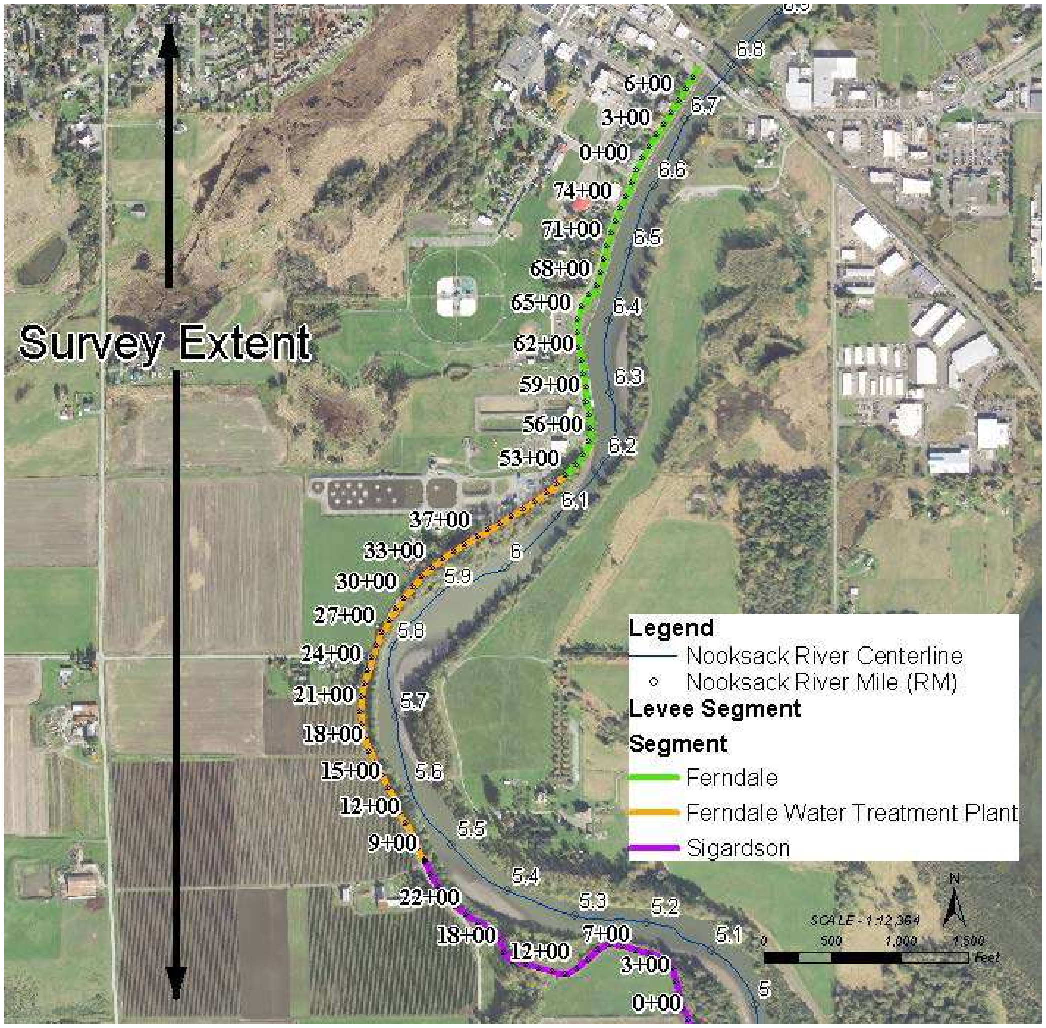


Figure 1: Vicinity map, including survey extents and levee stationing

2 METHODOLOGY

2.1 Bathymetric Data

The bathymetric survey was completed between Main Street in Ferndale, WA and the offtake of the Lummi River using a CEE-ECHO single frequency sounder coupled with HYPACK software for data processing. The 200 kHz transducer (Table 1) was mounted on the gunnel directly below an RTK-GPS receiver. The vertical offset between the RTK-GPS to the water surface and the bottom of the transducer to the water surface was recorded at the beginning of each survey segment. Calibration and corrections were collected consistent with best practices (USBR, 2019). Bathymetric elevations were typically collected in a zig-zag pattern supplemented with passes parallel to streamlines down the thalweg and along each bank. Longitudinal passes were completed along the toe of the levee to increase resolution at key locations. Additional boat passes were made along FEMA lettered cross sections (FEMA, 2019). Raw riverbed elevations were processed in HYPACK to filter multiple-return acoustic signals in shallow water, corrupt GPS signals, and erroneous spikes. Processed bathymetry data was then down sampled to 2-foot resolution to reduce the total number of points and ease the process of synthesizing with above-water topo data. Post-processed bathymetric data will be combined with project survey data by Reichhardt & Ebe Engineering (R&E) to create a final terrain surface that will be used for hydraulic modeling and scour and erosion assessment.

Table 1: CEE ECHO Single-Frequency Transducer Specifications and Operating Parameters

Parameter	Value
Frequency	200 kHz
Beam Angle	9°
Resolution	1 cm
Accuracy	1cm ± 0.1% of depth
Ping Rate	1-20 Hertz, depth dependent
Sound Velocity	4,429 – 5,741 ft/2
Depth Range	0.6 – 650 feet
Draft	0 - 10 m
Operating Temperature	32°F – 122°F

2.2 Levee Toe Inspection

The levee toe was inspected on the riverward side from the jet boat. Video footage was captured on two longitudinal passes along the levee toe, using HYPACK as a navigational aid to tie the video to National Levee Database (NLD) levee stationing. Photographic stills were extracted from the video at 25-foot stationing increments or more frequently when there was a change in levee toe conditions. The levee toe was inspected for armor and vegetation conditions, erosion, and slope stability. A summary of levee toe conditions can be found in Appendix A. A KMZ (.kmz) file is provided supporting this memo with the georeferenced photographs associated to levee stationing.

3 SUMMARY OF DATA COLLECTED

3.1 Bathymetric Data

Bathymetric data was collected from approximately River Mile (RM) 5.0 to RM 6.9 (Figure 2). Post-processed and down sampled bathymetry resulted in approximately 16,700 elevation points. Topographic comparison to the FEMA lettered cross sections and previously collected topobathymetry from LiDAR will be done at a later phase.

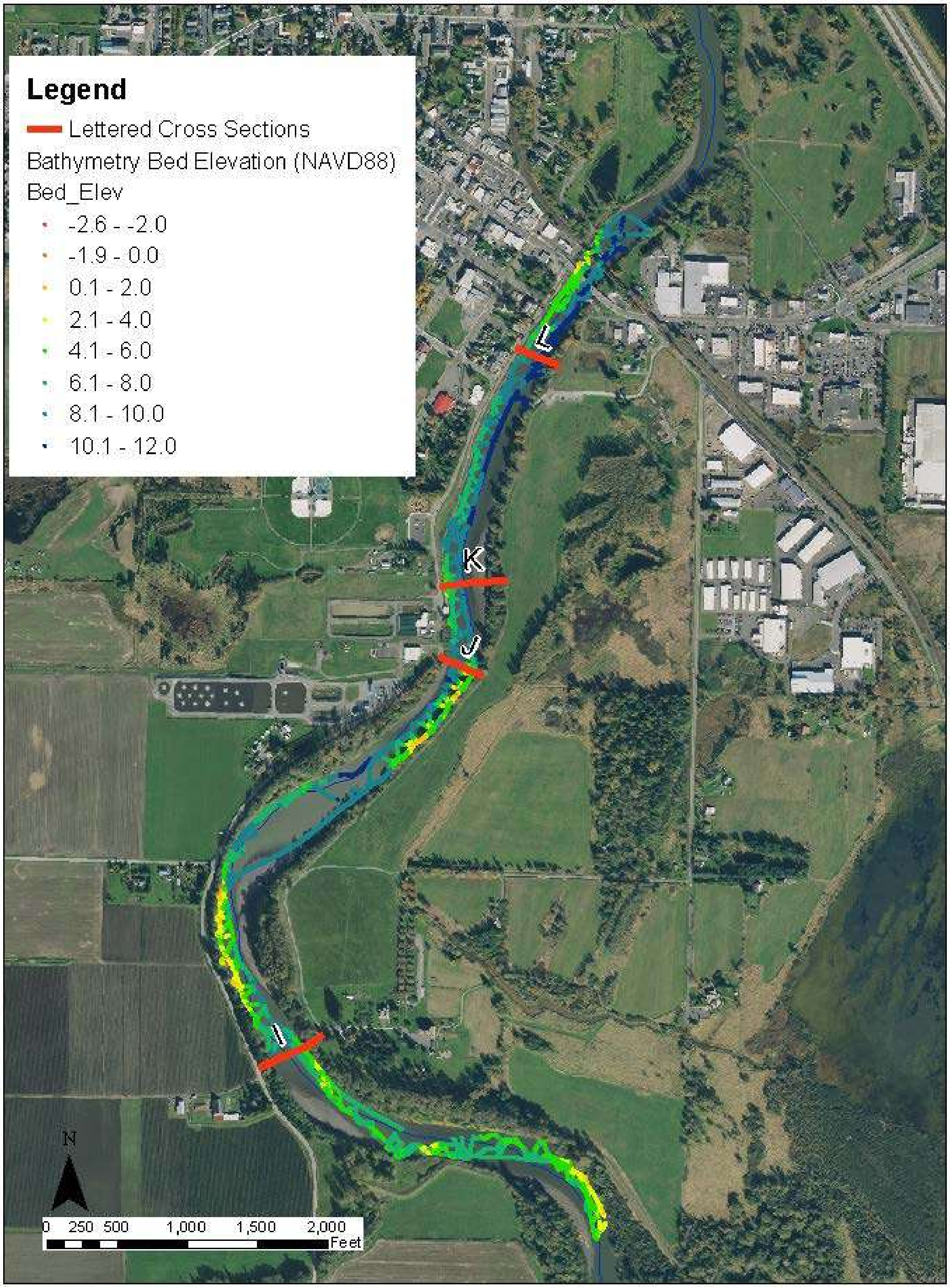


Figure 2: Bathymetric survey extent and bed elevation distribution, red lines indicate FEMA lettered cross sections

3.2 Levee Toe Inspection

Video of the levee toe was correlated to the NLD levee stationing and photographs were extracted where levee condition changed and at other key locations. Appendix A contains a tabular breakdown of levee conditions at specific locations.

Ferndale Levee Sta. 75+75 to Sta. 67+00 consists of relatively small rip-rap, with areas of sediment sloughing on top of the rip-rap, however some deeper sloughing areas appear to have pushed rip-rap down the levee (Figure 3). Large rip-rap is sparse and inconsistent. Vegetation mostly consist of grasses and shrubs and does not appear to be a main driver of levee degradation. The levee toe is consistently steep through this section indicating a potential history of scour and loss of revetment toe material.

Figure 3: Station 72+50, typical of Ferndale Sta. 75+75 to 67+00

Between Sta. 67+00 and Sta. 64+00 levee toe condition deteriorates significantly. In this section rip-rap size increases, however there are large holes where armor is missing (Figure 4). The large gaps in coverage are sometimes coincident with rotting wood, which may have been increasing stability before deteriorating.

Figure 4: Station 65+50, typical of Sta. 67+00 to Sta. 64+00

Sta. 64+00 to Sta. 59+25 has consistent coverage and is generally in decent condition (Figure 5). The levee toe is sufficiently armored with large rock to prevent vegetation growth, but shrubs are well established above the levee toe.

Figure 5: Station 62+50, typical of Ferndale Sta. 66+00 to 59+25

Downstream of the PUD water intake from Sta. 58+50 to Sta. 55+25 occasional rock along the levee toe has been lost and native soils have become exposed. Vegetation, predominantly trees and shrubs, has become well established in this section (Figure 6). Sloughing is seen where soils have been exposed and vegetation has not been established, or where silt is deposited. A depositional bar obscures the bank (and any revetment that may be on it) between station 55+25 and 52+75.

Figure 6: Station 57+50, typical of Ferndale Sta. 58+50 to 53+00

Station 53+00 of the Ferndale levee segment is equivalent to Sta. 45+00 of the Ferndale Water Treatment Plant levee. At this location a bar begins forming adjacent to the levee and the levee consists primarily of heavily vegetated native soil, with occasional small rip-rap until Sta 28+75 (Figure 7). Vegetation coverage and distance from the river make this levee section more difficult to observe at times. Throughout this and the next segment there are pile- and crib-type wood structures in various conditions, in general the wood structures are deteriorated to a level that they are no longer providing stability to the levee toe.

Figure 7: Station 38+50, typical of Ferndale WTP Sta. 45+00 to 28+75

From Sta. 28+75 to 09+50 large rip-rap and occasional wood pilings provide armor (Figure 8). Rip-rap does not extend up the levee very far and tree and shrubs are well established into the armor system. Levee toe coverage is inconsistent and native soil occasionally exposed. Portions of this segment are at greater than 1.5:1 slopes and rip-rap has fallen down the levee slope.

Figure 8: Station 17+50, typical of Ferndale WTP Sta. 28+75 to 09+50

In addition to typical levee locations there are specific areas of degradation along the levee toe. These areas are concentrated between Ferndale Sta. 75+75 and 67+00 and Ferndale WTP Sta. 33+00 to 9+00. Levee toe degradation is more consistent and visible between Ferndale Sta. 75+75 and 67+00 compared to Ferndale WTP 33+00 to 9+00. Figures 9-12 show examples of specific locations of degradation.

Figure 9 Station 75+50, location of significant sloughing and armor loss

Figure 10 Station 69+00, location of significant sloughing and armor loss

Figure 11 Ferndale WTP Sta. 11+50, location of significant armor loss and steep banks

Figure 12 Ferndale WTP Sta. 26+00, location of significant armor loss, steep banks, and wood piling degradation

4 CONCLUSIONS

Bathymetric survey along the levee toe provides updated levee toe topography as well as local channel changes since the 2015 topobathymetric survey. Results from the 2020 bathymetric survey will be compared to prior topobathymety and FEMA lettered cross sections to understand local and reach-wide geomorphic changes; as well as being used to update an existing hydraulic model to analyze alternatives in future phases.

The levee toe inspection indicates that in general the levees surveyed in this project show signs of sloughing, and have areas with missing armor. The levee toe slope is typically oversteepened and vegetation is prevalent. Levee toe inspection will be integrated with hydraulic model results and geotechnical investigation to inform design parameters. The observed conditions indicate an area of relatively high scour and erosion upstream of the water treatment plant. Levee design will need to mitigate for these conditions. Between the water treatment plant and Ulrich Rd, the river right bank appears to have a stable vegetation community providing a degree of inherent protection, this may be an area to optimize habitat enhancement features. Downstream of Ulrich Rd. the Nooksack River is more entrained along the levee toe. This has resulted in moderate scour and degradation along the levee toe. Entrainment at this location will need to be incorporated in design potentially while allowing for a balance of habitat and protection integrated with existing vegetation.

5 REFERENCES

Federal Emergency Management Agency (FEMA) 2019. *Flood Insurance Study Whatcom County, Washington And Incorporated Areas*. Flood Insurance Study Number 53073cv001c Version Number 2.3.2.1. Revised: January 18, 2019.

United Stated Army Corps Engineers (USACE). 2020 National Levee Database. *https://levees.sec.usace.army.mil/#/*. Accessed 10/29/2020.

United States Bureau of Reclamation (USBR). 2019. *Best Practices in Hydrographic Surveying. Living Quick Users Guide for Survey Equipment, Version 1.0.* U.S. Department of the Interior Bureau of Reclamation Technical Service Center Denver, Colorado. September 2019.

Washington State Department of Transportation (WSDOT). 2021. *2021 Standard Specifications M 41-10.* Construction Administration Office, Engineering and Regional Operations Division. Olympia, WA. Revised 11/03/2020.

APPENDIX A: LEVEE CONDITION ASSESSMENT

Levee Name	***Start Station***	***End Station***	***Riverward Slope***	***Vegetation Condition***	***Armor Condition[1]***	***Notes***
Ferndale Levee	75+75	72+50	1.5:1	80% Grass, 20% Shrub, Middle of levee only	Class A Rip-Rap along toe, localized small areas of sloughing	
	72+50	72+00	1.5:1	100% Grass, Shrub, Middle of levee only	Class A Rip-Rap along toe, consistent sloughing, sometimes deeper	
	72+00	67+00	1.5:1	100% Grass, Shrub, Middle of levee only	Class A Rip-Rap along toe, consistent sloughing, sometimes deeper	
	67+00	63+50	2:1	80% Grass, 20% Shrub, Top half of levee	Class C Rip-Rap up to halfway up levee,	Set back begins Occasional wood pilings
	63+50	60+50	2:1	100% grass, levee top only	Class A Rip-Rap, 3/4 way up levee	Set back ends
	60+50	59+25	1.5:1	No vegetation	Class A Rip-Rap covers entire levee	Gap for structure
	58+50	57+75	2:1	50% Tree, 35% Shrub, 15% Grass	Class A Rip-Rap, lower ¼ levee, sparse coverage, steep toe	
	57+75	55+75	1.5:1	50% Tree, 35% Shrub, 15% Grass	Class A Rip-Rap, lower ¼ levee, sparse coverage, sloughing, steep toe	
	55+75	53+00	2:1	50% Tree, 35% Shrub, 15% Grass	Fines covering levee material	Set back begins

Ferndale Water Treatment Plant Levee	45+00	39+25	2:1	50% Tree, 35% Shrub, 15% Grass	Fines	Riparian buffer begin
	39+25	38+50	1.5:1	50% Tree, 50% Shrub	Class A – Class C Rip-Rap , lower ¼ levee, occasional gaps	
	38+50	36+00	2:1	50% Tree, 50% Shrub	Class A Rip-Rap, lower ¼ levee, fine bar in front, occasional sloughing	Large wood racking
	36+00	33+00	2:1	50% Tree, 35% Shrub, 15% Grass	Fines	Large wood
	33+00	29+25	2:1	50% Tree, 35% Shrub, 15% Grass	Fines	Riparian buffer end Set back end
	29+25	26+00	1.5:1	50% Tree, 50% Shrub	Class A – Class C Rip-Rap , lower ¼ levee	
	26+00	24+50	1.5:1	50% Tree, 35% Shrub, 15% Grass	Class A –Rip-Rap , lower ¼ levee, occasional gaps	Wood piling start
	24+50	18+50	1.5:1	50% Tree, 35% Shrub, 15% Grass	Class B –Rip-Rap , lower ¼ levee, occasional gaps, occasional sloughing, vegetation growing through	Riparian buffer begins Set back begins
	18+50	16+50	1.5:1	50% Tree, 35% Shrub, 15% Grass	Class B –Rip-Rap , lower ¼ levee, areas of sparse coverage	Riparian buffer end Set back ends
	16+50	09+50	1.5:1	50% Tree, 35% Shrub, 15% Grass	Class B –Rip-Rap , lower ¼ levee, vegetation growing through	Wood piling end

[1] Rip-Rap sizing classification from WSDOT 2021 Standard Specifications M 41-10 Section 9-13.4(2)

Appendix E: Cultural Resources Report

CULTURAL RESOURCES REPORT COVER SHEET

DAHP Project Number: 2020-09-05931

Author: Garth L. Baldwin, and Marsha R. Hanson

Title of Report: Cultural Resource Review of the Nooksack River Levee Restoration Project, Ferndale, Whatcom County, Washington

Date of Report: October 29, 2020

County(ies): Whatcom Section: 29, 30, 31 Township: 39N Range: 2 E

Quad: Ferndale, WA Linear Miles: 1.05

PDF of report submitted (REQUIRED) ☒ Yes

Historic Property Inventory Forms to be Approved Online? ☐ Yes ☒ No

Archaeological Site(s)/Isolate(s) Found or Amended? ☐ Yes ☒ No

TCP(s) found? ☐ Yes ☒ No

Replace a draft? ☐ Yes ☒ No

Satisfy a DAHP Archaeological Excavation Permit requirement? ☐ Yes # ☒ No

Were Human Remains Found? ☐ Yes DAHP Case # ☒ No

DAHP Archaeological Site #:

_____
_____
_____
_____
_____

- Submission of PDFs is required.
- Please be sure that any PDF submitted to DAHP has its cover sheet, figures, graphics, appendices, attachments, correspondence, etc., compiled into one single PDF file.
- Please check that the PDF displays correctly when opened.

DRAYTON ARCHAEOLOGY

Cultural Resource Review of the Nooksack River Levee Restoration Project, Ferndale, Whatcom County, Washington

Prepared By:
Garth L. Baldwin, M.A., RPA 16248
and Marsha R. Hanson

Prepared For:
Nathan Zylstra, P.E.
Reichhardt & Ebe Engineering Inc.
423 Front Street Lynden, Washington 98264

Washington Department of Ecology Grant:

SEAFBD-2019-WhCoPW-00054, The Nooksack River: Floodplains that Work

Drayton Archaeology Report: 0820G

October 29, 2020

PO Box 782 - Blaine, WA 98231-0782 - www.draytonarchaeology.com

CONTENTS

FIGURES AND TABLES

LIST OF PHOTOS

Cultural Resource Review of the Nooksack River Levee Restoration Project, Ferndale, Whatcom County, Washington

Author:	Garth L. Baldwin and Marsha R. Hanson
Date:	October 29, 2020
Location:	Ferndale, Whatcom County, Washington
USGS Quads:	Ferndale (1994)
Legal:	Township 39 North, Range 2 East, Sections 29, 30, 31

INTRODUCTION

Drayton Archaeology (Drayton) was retained by Reichhardt & Ebe Engineering Inc., on behalf of Whatcom County Flood Control Zone District (WCFCD) to conduct a cultural resources assessment for the proposed restoration of the Nooksack River levee. The following assessment was designed to locate and identify any cultural resources (cultural, historical, or archaeological materials or sites) in the project area. The regulatory environment for the work is to assist WCFCD with compliance to Washington State Governor's Executive Order 05-05 (GEO 05-05). They will be receiving grant funding for the work from Washington Department of Ecology (DOE). As such, all work must comply with GEO 05-05 with formal review through Department of Archaeology and Historic Preservation (DAHP). The order requires all state agencies contributing state funds or permits consider how the proposed projects may impact cultural and historic sites (DAHP n.d.). The following review presents the effort to locate any cultural resources on the property and at the end of the document is a general inadvertent discovery plan (IDP) for the information of all concerned.

Drayton's cultural resources assessment consisted of background review, field investigation, and production of this report. Background review determined the project area to be in an area high probability for cultural and historic properties. This probability is lessened as the area, and the levee have undergone numerous repairs and rebuilding events. Field investigation included pedestrian and subsurface survey. During background and field research, no evidence of precontact archaeological deposits were identified. Modern to historic-era artifacts were encountered during the review, however, none were diagnostic, nor were they considered significant. Modern to historic-era trash was encountered in six probe locations, however, none of the material was diagnostic, and therefore, not significant. Based on the results of the present review Drayton recommends the DOE approve the proposed project. Further archaeological oversight appears unwarranted as currently designed.

REGULATORY CONTEXT

The project is subject to Executive Order (EO) 05-05. This order requires all state agencies to review capital construction projects with the DAHP and affected Tribes to determine the potential impacts to cultural resources. In accordance with the EO, when state funds are used for a project, the proponent is required to consult with the DAHP and interested tribal organizations to determine whether there are known cultural resources or if there is a potential for such sites within the project area. It is the responsibility of the agency to assure proper consideration for cultural resources and to develop archaeological survey and mitigation strategies.

It should also be recognized that Washington State law provides for the protection of all archaeological resources under RCW Chapter 27.53, Archaeological Sites and Resources, which prohibits the unauthorized removal, theft, and/or destruction of archaeological resources and sites. This statute also provides for prosecution and financial penalties covering consultation and the recovery of archaeological resources. Additional legal oversight is provided for Indian burials and grave offerings under RCW Chapter 27.44, Indian Graves and Records. RCW 27.44 states that the willful removal, mutilation, defacing, and/or destruction of Indian burials constitute a Class C felony. Further, Washington legal code could also become applicable. RCW 68.50.645, Notification, provides a strict process for the notification of law enforcement and other interested parties in the event of the discovery of any human remains regardless of perceived patrimony.

AREA OF POTENTIAL EFFECT AND PROJECT DESCRIPTION

The project area is in Ferndale, Washington, in Sections 29, 30, and 31 of Township 39 North, Range 2 East, Willamette Meridian (Figure 1). The project proposes to improve 1.05 miles of levee located adjacent to the Nooksack River just south of downtown Ferndale (Figure 2). Improvements will provide reliable flood protection to critical infrastructure, roads, parks, residences, and farmland. Proposed plans are still underway, but may include shifting of Ferndale Road, moving the levee beneath Ferndale Road, and potentially realigning road segments off 2nd Avenue (Figures 3 – 5).

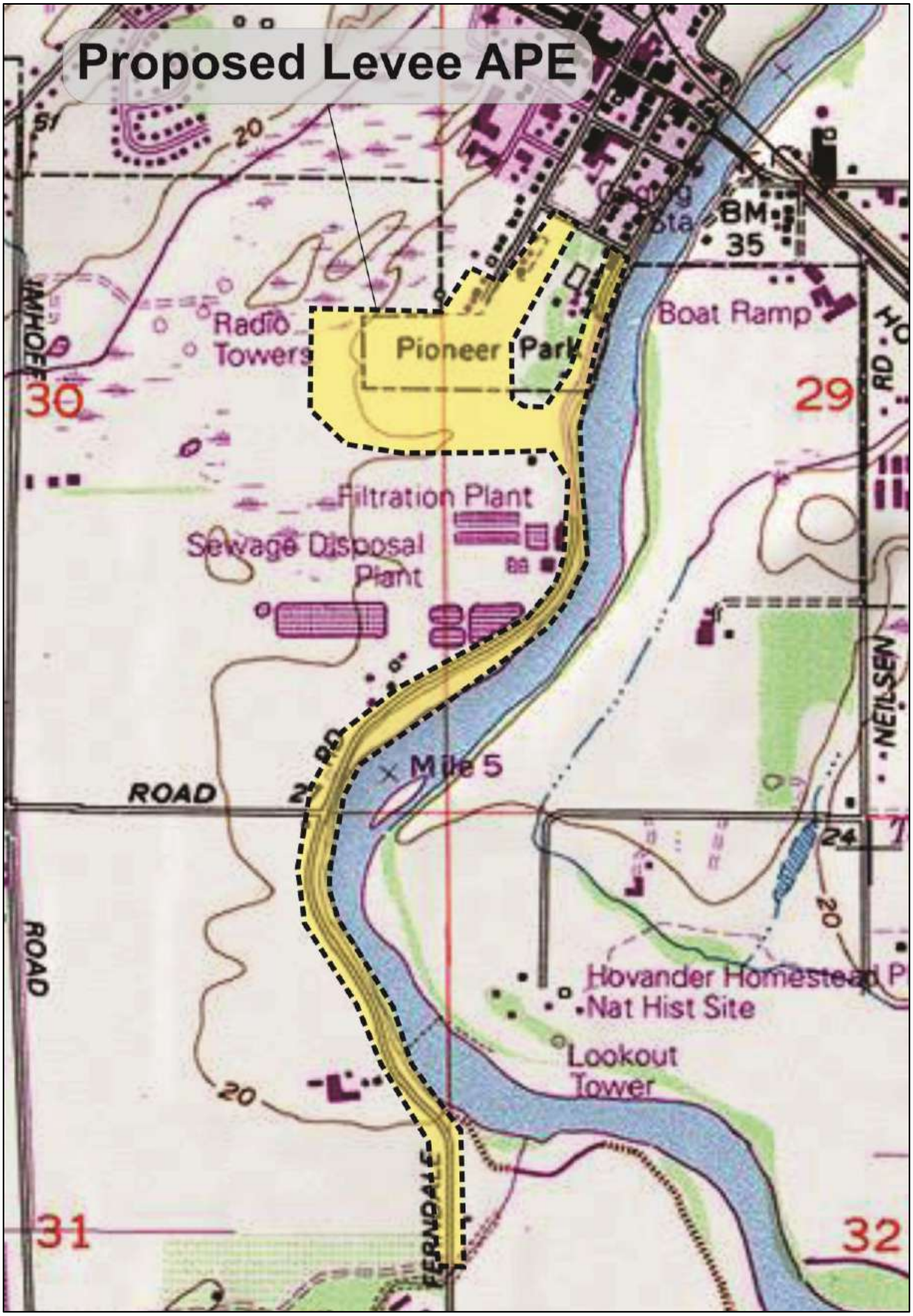


Figure 1. A portion of the Ferndale, WA USGS topographic map detailing the project area.

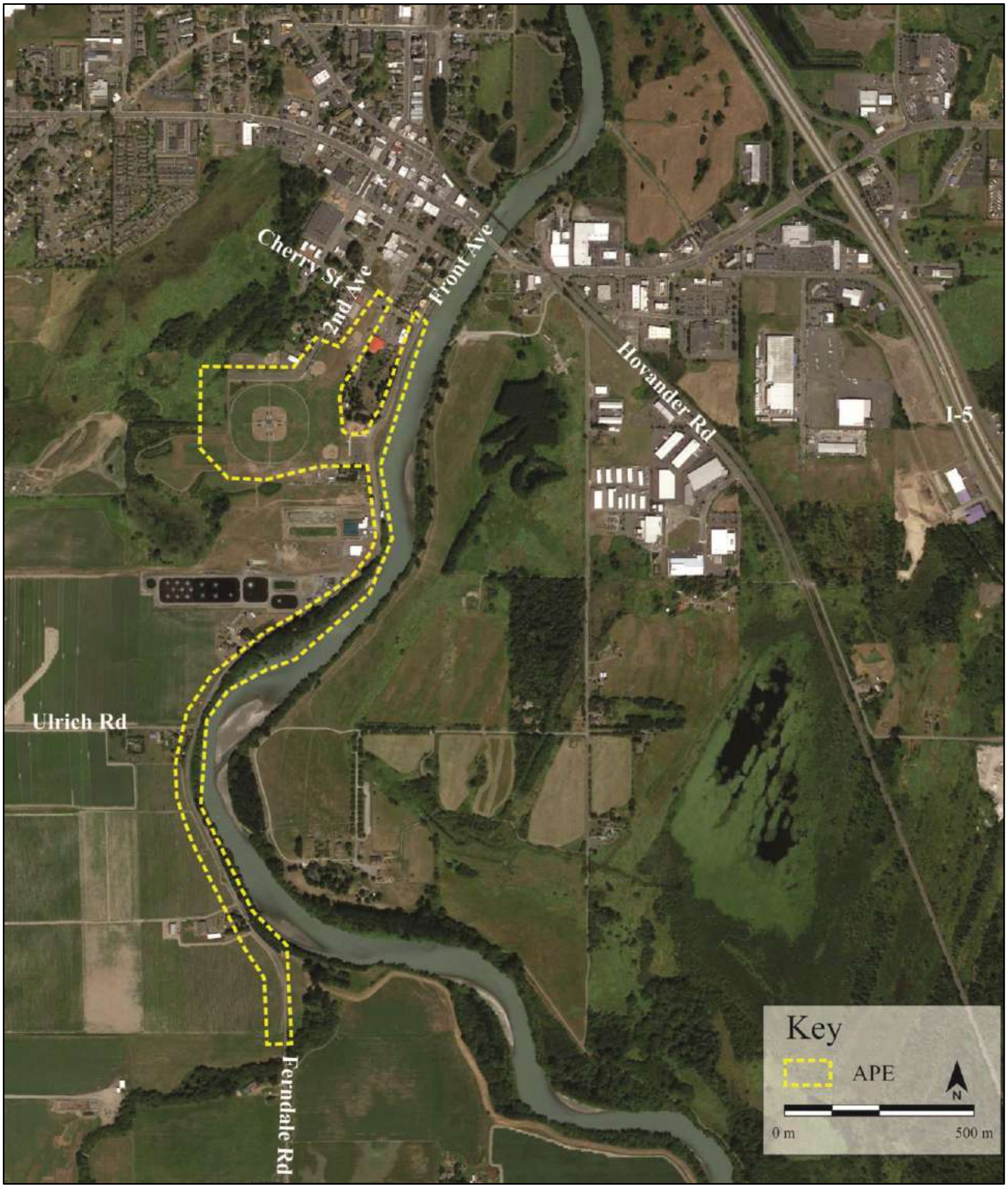


Figure 2. A Google Earth aerial image illustrating the location of the project (adapted by Drayton).

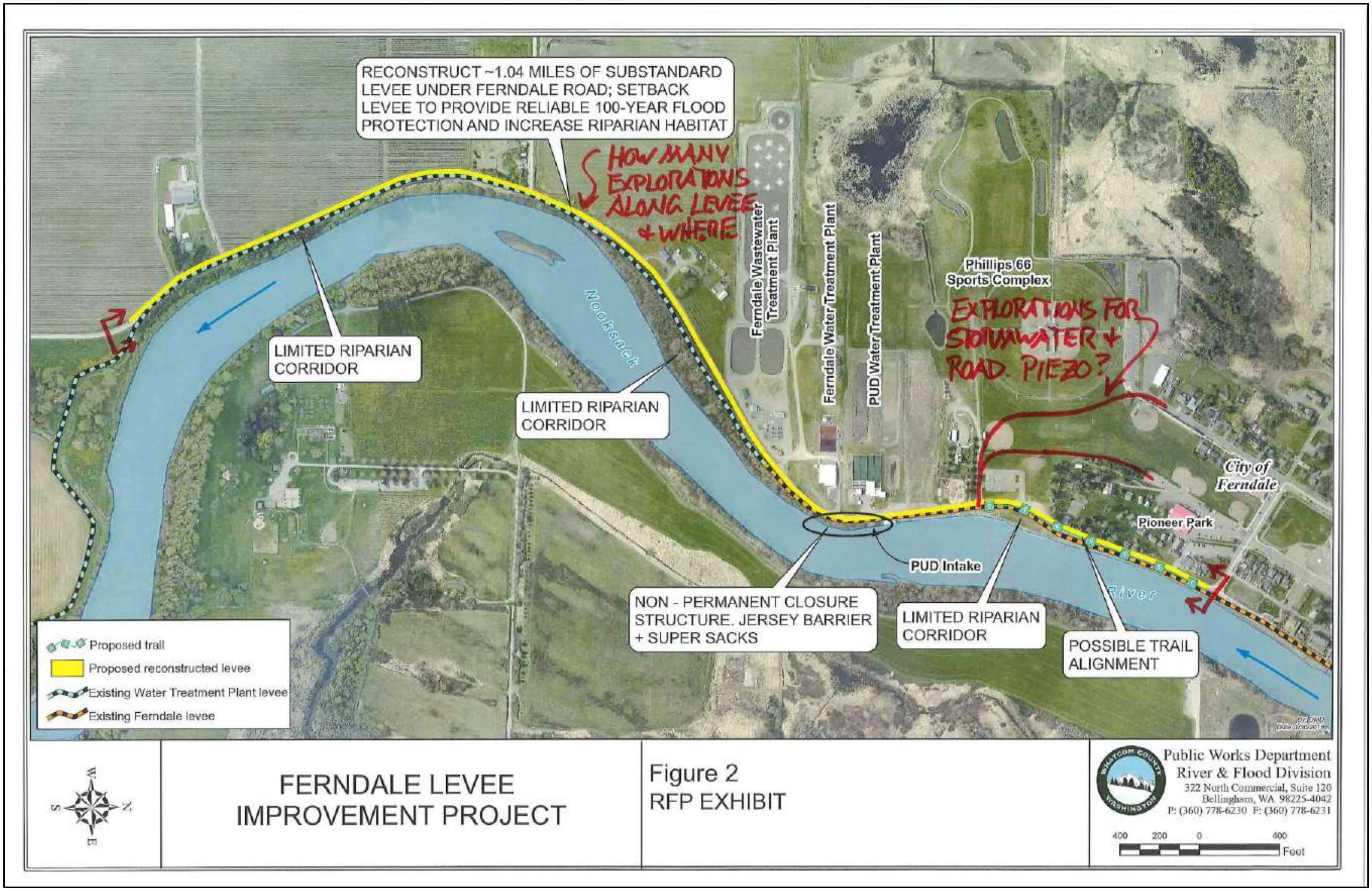


Figure 3. Site plan for the proposed project, courtesy of Reichhardt & Ebe Engineering Inc.

Ferndale Levee Improvements

Roadway Alignments through Ferndale

Alternative A – Second Street Extension

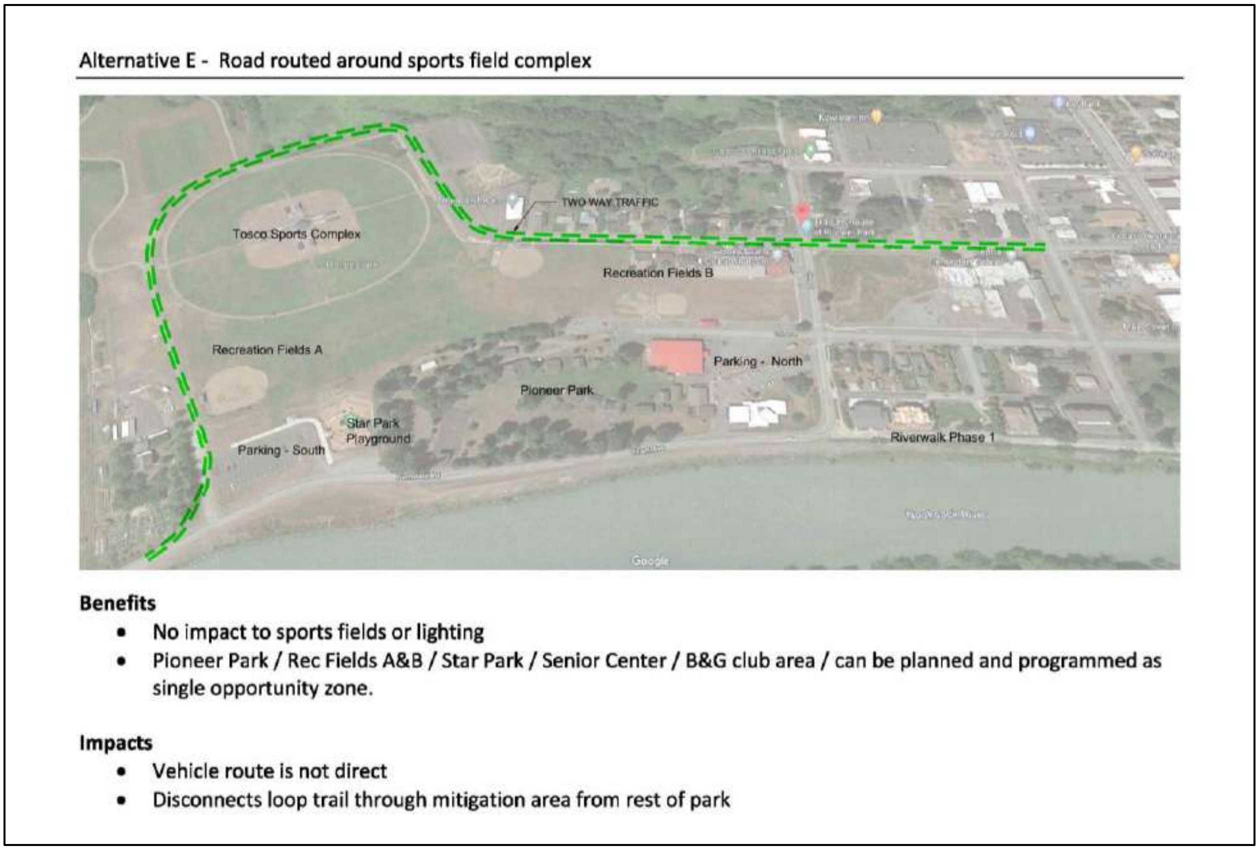
Benefits

- Allows design flexibility for the Levee and Riverwalk in the Front Avenue footprint
- Front Avenue becomes the Riverwalk / Trail
- The Riverwalk can be expanded in a similar design as the existing Riverwalk north of Cherry Street
- The Park is more connected to the Riverwalk
- Pioneer Park / Rec Fields B / Star Park / Senior Center / B&G club area / expanded Riverwalk can be planned and programmed as single opportunity zone
- Traffic loads on to Main Street further west

Impacts

- Recreation fields are bisected by road
- Impact to sports lighting at Recreation Field A
- Traffic routed closer to Star Park Playground

Figure 4. Alternative A of road realignments extending off 2nd Avenue.



Alternative E - Road routed around sports field complex

Benefits

- No impact to sports fields or lighting
- Pioneer Park / Rec Fields A&B / Star Park / Senior Center / B&G club area / can be planned and programmed as single opportunity zone.

Impacts

- Vehicle route is not direct
- Disconnects loop trail through mitigation area from rest of park

Figure 5. Alternative E of road realignment off 2nd Avenue and around the sports complex.

BACKGROUND REVIEW

Determining the probability for cultural resources to be present within the project area was based upon review and analysis of the environmental and cultural contexts of the area, as well as previous cultural resource studies and sites recorded in or near the project area. Consulted sources included the Department of Archaeology and Historic Preservation’s (DAHP) online database, the Washington Information System for Architectural and Archaeological Records Data (WISAARD), for information regarding previously conducted cultural resources studies, archaeological sites, historical sites, historic property inventory (HPI) forms, and cemetery / burial records.

Environmental Context

Topography and Geology

The project area lies within the Puget Lowland physiographic province. The Puget Lowland is a physiographic province that was shaped by several periods of extensive glaciation during the Pleistocene (Easterbrook 2003). The bedrock was depressed and deeply scoured by glaciers. Sediments were deposited and often reworked as the glaciers advanced and retreated and glacial till and outwash deposits were left across much of the region at the end of the last glacial period, the Fraser Glaciation (Easterbrook 2003). Approximately 18,000 years ago, the ice sheet created by the Frasier glaciation advanced from British Columbia to just south of Olympia and the entire Puget Lowland was enveloped. In western Whatcom County, glacial ice reached a thickness greater than 5,500 feet (Easterbrook 2003). This tremendous volume of ice scoured underlying bedrock and helped shape the present-day landscape. By 13,500 years ago, the ice had retreated to present day Seattle. Large areas south of Seattle were covered by recessional outwash sands and gravels. At about the same time, thinning ice allowed marine waters to return to the Puget Lowland, and seawater lifted the ice causing it to fracture into berg ice. Sediment trapped within the retreating glaciers flowed out onto the newly formed marine floor of Puget Sound and western Washington, leaving behind dense layers of glacial till and drift deposits (Booth and Goldstein 1994).

The series of outwash terraces that cover the area south and west of the Fraser River Valley are a direct result of the Frasier Glaciation (Easterbrook 1971). Some of this outwash flowed southward thru the Sumas Valley, creating the Lower Nooksack River channel of today (Dragovich et al. 1997). Thick deposits of bed-load gravels underlie much of the Sumas Valley, suggesting that the Nooksack River once occupied the valley, flowing north and into the Frasier River for a portion of the Holocene (Cameron 1989; Pittman et al. 2003). At some point in the mid-Holocene (~ 5000 - 6000 years ago) the Nooksack River appears to have avulsed from the Sumas Valley into a remnant glacial outwash channel; its present day course to Bellingham Bay (Pittman et al. 2003). Throughout the early Holocene the shoreline differed significantly from its current configuration. Shortly after assuming its current course, the Nooksack River delta likely terminated near what is now present-day Ferndale. The landform of the Lummi peninsula would have existed as an island. As the Nooksack River delta prograded seaward throughout the middle and late Holocene, tidal flats would have initially connected the island with the mainland. With continued delta progradation, the island eventually became joined with the mainland.

Over the last several thousand years the Nooksack River has emptied into both Bellingham Bay and Lummi Bay via the Lummi River. When the distance from the junction of the two rivers to the mouth of one of the courses became significantly longer than the other, flow would shift into the shorter (and steeper) route (Easterbrook and Rahm 1970). By alternately occupying both courses, the Nooksack River prograded seaward into both Lummi Bay and Bellingham Bay.

Soils

The University of California Davis Agriculture and Natural Resources, in conjunction with the United States Department of Agriculture Natural Resource Conservation District (USDA-NRCS) developed an interactive soil survey application. According to the UCDavis SoilWeb database (n.d.), soils within the project area have been mapped as Mt. Vernon fine sandy loam, 0 to 2 percent slopes.

Mt. Vernon series soils consist of deep, moderately well drained soils formed in recent alluvium with an admixture of volcanic ash in the upper part. These soils are located on river flood plain splays and natural levees at elevations of 3 to 30 meters (10 to 100 feet) above mean sea level. Slopes are 0 to 3 percent. A typical pedon consists of an Ap horizon from 0 to 25 cm (0 to 10 inches) of dark brown, very fine sandy loam, a C1 horizon from 25 to 36 cm (10 to 14 inches) of dark yellowish brown, stratified fine sandy loam and very fine sandy loam, a C2 horizon from 36 to 74 cm (14 to 29 inches) of grayish brown, stratified very fine sandy loam, loamy fine sand, and fine sandy, a 2C3 horizon from 74 to 107 cm (29 to 42 inches) of grayish brown, stratified fine sandy loam, loamy fine sand, silt loam, and a 2C4 horizon from 107 to 152 cm (42 to 60 inches) of olive gray, stratified sand, loamy fine sand, and very fine sandy loam (UCDavis n.d.).

Flora

The project area is located within the *Tsuga heterophylla* vegetation zone. Native vegetation would have included, but not have been limited to Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), salal (*Gaultheria shallon*), and vine maple (*Acer circinatum*). Other locally important and available species would have included bracken fern (*Pteridium aquilinum*), black raspberry or blackcap *(Rubus occidentalis*), currants and gooseberries (*Ribes spp.*), deer fern (*Blechnum spicant*), devil’s club (*Oplopanax horridus*), huckleberries (*Vaccinium spp.*), Indian plum or Oso berry (*Oemleria cerasiformis*), oceanspray (*Holodiscus discolor*), red elderberry (*Sambucus racemosa*), snowberry *(Symphoricarpos albus*), sword fern (*Polystichum munitum*) and trailing blackberry (*Rubus ursinus*) (Franklin and Dyrness 1973:44-5; Pojar and MacKinnon 1994). Large areas would have differed from the broader regional pattern, however, with areas of prairie, oak woodland, and pine forest being distributed throughout the southern Puget Sound basin (Franklin and Dyrness 1973:88).

Fauna

Terrestrial animals in the area would have included black tailed deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), black bear (*Ursus americanus*), beavers (*Castor canadensis*), as well as other small game and many species of waterfowl. Fish, especially salmon, were a staple food source (Suttles 1990), and the project area is located along the Nooksack River. Along the shoreline of the Puget Sound, approximately five miles west, or south, a variety of marine resources were available. Herring (*Clupea pallasii)*, smelt or eulachon (*Thaleichthys pacificus*), halibut (*Hippoglossus stenolepis*), flatfish and rockfish would have been abundant in the area. Shellfish including littleneck clams (*Protothaca staminea),* butter clams (*Saxidomus giganteus),* horse clams (*Tresus capax*), bay mussels (*Mytilus edulis)*, cockles (*Clinocardium nuttallii)*, and native oysters (*Ostrea lurida*) would have been harvested as well as crab (*Crustacea*).

Cultural Context

In any investigation of the history of an area, a discussion of the past inhabitants is necessary to appreciate the full spectrum of possible occupational remnants. It is also important to broadly discuss the history of land use in the area.

Precontact

Puget Lowland archaeology can be subdivided into three phases that include early (end of the last ice age to 5,000 years BP), middle (5,000 to 1,000 BP) and late stages of development (1,000 to 250 BP). The early period is characterized by an emphasis on the use of flaked stone tools including fluted projectile points, leaf-shaped points and cobble-derived tools. In the regional area, these artifacts are often attributed to the "Olcott" phase, named after the site type near Arlington and Granite Falls (Baldwin 2008; Kidd 1964; Mattson 1985). Olcott sites are generally found some distance from modern shorelines and on terraces of major river valleys. Besides the lithic assemblage, little faunal or organic evidence remains that date to this period. While the paucity of evidence beyond a lithic assemblage suggests a specialization of generalized terrestrial hunting, it is likely that littoral evidence from this time period is not as extensive and does not preclude some exploitation of marine resources. During this phase, camps were frequently established along river terraces or outwash channels.

The middle period coincides with a stabilization of the environment to something similar to today. The broad cultural patterns include a larger suite of specialized tools including smaller notched points and groundstone, and bone or antler implements used for working with wood. Although lithic manufacture of stemmed bifaces and cobble tools is maintained in this period, ground stone tools are less common. Shell midden sites first appear during this period indicating a transition to a more maritime-based subsistence pattern. Although structural elements such as post molds have been identified, habitation structures have not yet been excavated. The middle period is noted for its increased artifact and trait diversity including a full woodworking toolkit, art and ornamental objects, status differentiation in burials, and extremely specialized fishing and sea-mammal hunting technologies.

The late period is dominated by a settlement pattern along the coastline and along streams and rivers. Trade goods also appear indicating extensive trade networks up and down the coast as well as with inland Plateau peoples. Salmon became a primary food source at this time as sea levels had risen and riparian environments supported large runs of salmon and provided plentiful food for native populations. The late period is recognized by an apparent decrease in artifact diversity. Stone carving and chipped stone technologies nearly disappear, while increased habitation fortifications are common.

Ethnographic

The project area is located within the traditional territory of the Nooksack and the Lummi (Suttles 1990:454-456). The Nooksack Tribe of today is an amalgamation of a number of individual groups that occupied the interior of northern Whatcom County and southern British Columbia (Ruby and Brown 1992; Reid 1987; Spear 1977; Suttles 1990; Tremaine 1975). The Lummi initially resided in villages on the southern Gulf Islands and the San Juan Islands. However, subsequent disease and competition for local resources forced the Lummi to move inland, and eventually defeat and assimilate inland tribal groups (Ruby and Brown 1992:187).

The name Nooksack probably originated from the indigenous word for the bracken fern root that was very important to the diet of the people (Ruby and Brown 1992:153). The name, as it is applied to the people, was probably a name applied by Euroamericans to all those Native people living in the Nooksack River Valley (Ruby and Brown 1992:152). However, the origin of the name 'Nooksack', as presently spelled and applied, has been presented in many forms and as having a multitude of origins (Amos 1972:13; Hawley 1945:35; Jeffcott 1995:25, 54; Suttles 1990:474). Previous literature may be consulted to provide a more detailed background applicable to the project area (Montgomery 1979; Reid 1987; Spear 1977; Suttles 1990; Tremaine 1975).

The Nooksack once lived as semi-sedentary people throughout the larger Fraser River Valley interior, of which the Nooksack River watershed is a part. The late precontact Nooksack people were associated with at least 3 and as many as 9 reported village locations where they relied on riverine resources related to root gathering, hunting, and fishing (Jeffcott 1995:11-15; Suttles 1990:454-455; Tremaine 1975:43-71). In the early settlement period (1860s-1870s), as many as 50 different pit house locations were known along the Nooksack River, with 10-15 houses at each site (Tremaine 1975:54-55). This house form was dissimilar to the traditional large wooden structures of their coastal neighbors as well as the later house forms adopted after contact with Euro-Americans. Both house forms and the language of the Nooksack clearly demonstrate that they are a distinct cultural group from the Coast Salish.

Ethnographically, there were numerous Nooksack villages in the north interior of Whatcom County. A large smokehouse, or longhouse, was historically located at the confluence of Anderson Creek and the Nooksack River (Jeffcott 1995:12; Tremaine 1975:46-47). This location is a short distance north of present-day Goshen and about 12 miles east of the current project area. According to Jeffcott, this village was the "chief center of [the] native population, from which the others seemed to radiate" (Jeffcott 1995:12). Jeffcott (1995:14) reports the name of Everson as "*Qu-an-ish*". He also claims that the longhouse at this location was still partially standing in the 1940s (Jeffcott 1995:12-13), and according to David Johnson, Jeffcott's Nooksack contact, the longhouse was at one time 500 feet long, and located on the east bank of the river prior to the river changing course, at which point the longhouse was then on the west bank. Jeffcott reproduces photos of this structure in his *Nooksack Tales and Trails* (1995:12-14). The former longhouse site is likely the same location recorded with the DAHP as 45WH03 from the 1950s (Emmons 1951, 1952).

A long-term work in progress was completed by Richardson and Galloway (2011), in which all Nooksack place names were recorded and published. Place names located nearest the project area include; *T'elt'a'law7*: where the Nooksack River splits at the head of its delta [many arms], *Tiytásem*: river crossing at Ferndale [upriver], *Xwx̲ách'tem*: location at or near Ferndale on the northwest bank of the Nooksack River, also a camp 1 ½ miles upriver on the same bank [always-fireweed-place to get]. Additional place names recorded on the east side of the river include *Sq'eláx̲en*: an area on the southeast bank of the Nooksack River that includes the prairie between Tennant Lake and Barrett Lake [fenced off or go around/over the side], *Solá7atsich*: settlement at the north end of Tennant Lake [largest willow mat/in the back], *Nek'iyéy*: Ten Mile Creek, *Nuxwq'écheqsem*: Barrett Lake [always place of Coho salmon], and *íletxwey*: a location three to five miles above Ferndale on the southeast bank of the river [plank-place] (Figure 6).

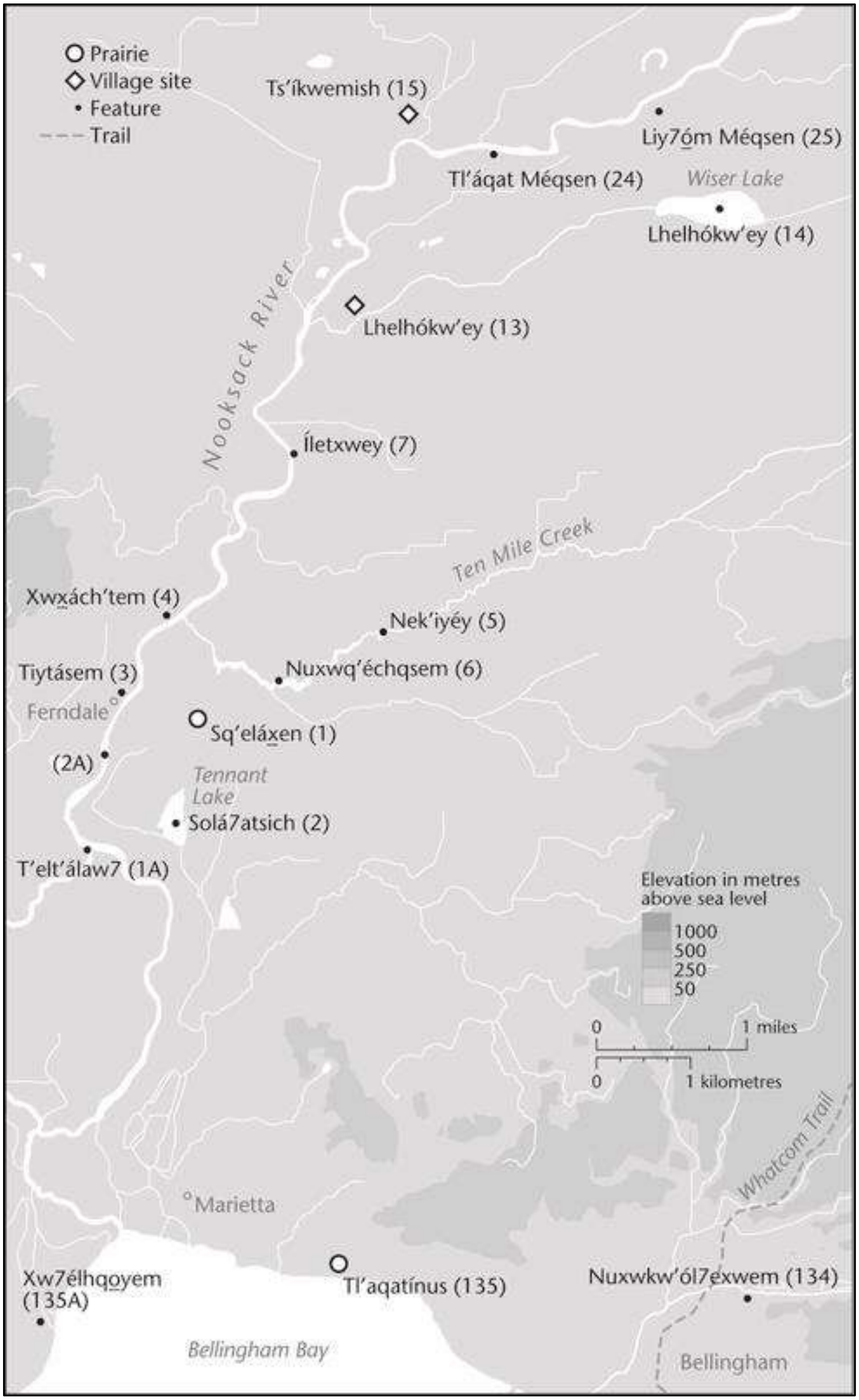


Figure 6. Place names in the Ferndale area from Richardson and Galloway (2011: Map 6).

Typical of Native people of the Pacific Northwest, salmon was important to the Nooksack, but they also hunted terrestrial mammal like wapiti (C*ervus elaphus)*, deer (*Odocoileus hemionus*), and black bear (*Ursus americanus*). Another significant contributor to subsistence was gathering and cultivating vegetable foods. The Nooksack utilized root crops, such as camas (*Camassia quamash*), Sagittaria (*Sagittaria latifolia*), and later the white potato or *wapato* and various ‘wild onions’ (Amos 1972: 12-13; Hawley 1945:35; Suttles 1987:142; Tremaine 1975:51-52). They also made use of the great number of different berries found in the area. The variety of berries locally available includes blackberries (*Rubus vitifolia*), blackcaps (*Rubus leucodermis*), elderberry (*Sambucus racemosa ssp. pubens*), huckleberries (*Vaccinium spp*.), salal (*Gautheria shallon*), salmon berries (*Rubus spectabilis*), and Thimbleberry (*Rubus parviflorus*) (Amos 1972:12-13; Pojar and MacKinnon 1994; Suttles 1951:63).

The Nooksack are one of the few Native groups that staked homestead claims alongside Euro-Americans. Increased pressure from the incoming Euro-American settlers was met with uncertainty and discontent by the Nooksack who recognized they would have to make a place or make way (Amos 1972:38; Suttles 1990:474). In the Nooksack Valley a few Nooksack took homesteads around what today is Lynden, Everson, Nooksack, Lawrence, Deming, and Van Zandt (Royer 1982:14-15). Many prominent Nooksack people acquired land under the 1875 Homestead Act; however, Euroamericans eventually purchased many of those properties. The 1884 Indian Homestead Act provided a way for some Nooksack people to acquire land in 1891, and much of that land has since remained in Native control (Amos 1972:38; Royer 1982:14-15; Suttles 1990:472). The Nooksack were reportedly unable to attend the winter signing of the Point Elliot Treaty of 1855 due to poor weather conditions on the river and thus the United States Government denied them status as a federally recognized Indian Nation (Amos 1972:38; Suttles 1990:474). The Bureau of Indian Affairs finally recognized the sovereignty of the Nooksack Tribe in 1971 (Amos 1972:38).

The Lummi Tribe also frequented the project vicinity. The Lummi, or *Lhaq'temish,* are a Central Coast Salish group that speaks a dialect of Northern Straits. *Xwlemi Chosen* is the language of the Lummi people. Traditionally the Lummi, Songhees, Saanich, and Samish lived in winter villages within the southern Gulf and San Juan Islands (Suttles 1990). The Lummi later moved to the mainland, date unknown, however it is estimated the event took place around 1725 (Suttles 1951). The tradition of the Lummi coming to the mainland is reflected in the story of *Skalaxt* / *Sxəla’qst* who nearly wiped out the *Skalakin* / *SKəlE’xən* people who lived along Lummi Bay and Bellingham Bay in order to avenge his brother’s death. Two battles ensued resulting in the Lummi taking control of the mainland shore and an important fishing site. Those who survived intermarried with the Lummi or moved upriver (Suttles 1951:35; Stern 1934:115-120). After the move to the mainland survivors of the Klalakamish and Swallah groups who also resided on the San Juan Islands joined the Lummi (Suttles 1990:456). The Lummi also maintain close affinal ties to the Nooksack Tribe, the Semiahmoo Band of Canada, and the Clallam, and their origin myth may relate to the ancestry of the Saanich and Songish as well (Suttles 1951:33).

At the time of European contact, Lummi territory included a few miles of mainland shoreline in northwest Washington and about half the area of the San Juan Islands (Suttles 1951). This includes the northern and eastern shores of San Juan Island, the western shores of Lopez Island, all of Shaw and Orcas Islands, possibly Waldron and Blakely Islands, and the smaller islands northeast of Orcas and Lummi Island. On the mainland, Lummi traditional territory included the shore from Cherry Point to Chuckanut Bay and inland as far as Lake Terrell and perhaps the outlet of Lake Whatcom, and up the Nooksack River to a spot below Ferndale (Suttles 1951:33). When white settlers arrived on Bellingham Bay in 1852 three major Lummi winter villages were located on the mainland at *T'Emxʷeəqsən*, Gooseberry Point, and at Portage (Suttles 1951).

The Straits Salish way of life is characterized by a seasonal exploitation of resources based on a specialized adaptation to life on the Straits' protected saltwater channels (Suttles 1951). The most significant of the resources exploited by the Straits Salish were the diverse fresh and saltwater fish populations, marine mammals, and inter-tidal shellfish species (Patterson-Griffin 1984:18). The Lummi were seasonally mobile, occupying community-centered villages located close to fresh water in the late fall and early winter months and spending the remainder of the year in temporary camps located at specific fishing, hunting and gathering locations in the San Juan Islands (Suttles 1951:33-35). Winter villages were composed of multi-family cedar plank longhouses (Patterson-Griffin 1984:118-19). Summer seasonal camps were composed of less elaborate, portable structures constructed of reed mats and poles. However, larger, more substantial structures capable of housing groups to process large quantities of fish were constructed at summer and fall fishing villages (Patterson-Griffin 1984:19). Additional resource and village sites are listed in Stern (1934) and Suttles (1951). Stern (1934:126) lists seven reef net fishing locations that were owned and managed by specific Lummi individuals or families including *Tceltenem* on Point Roberts, *Sqalekwca* (Village Point) on Lummi Island, *Xwtcixom* north of Sandy Point, *Tlqwoloqs* (Point Doughty) on Orcas Island, *Xoxolos* on Orcas Island south of Freeman Island, *Xwitcosang* in Upright Channel south of Shaw Island, and *Sxoletc*, a point on Lopez Island.

Historic

Non-native settlement of Whatcom County was initially restricted to the coastal areas as dense stands of old growth timber inhibited inland expansion until the early 1840s. As logging technology became more sophisticated and the number of immigrants to the area grew, land was cleared further inland from the coastline. Early settlement in the Nooksack River valley was tightly linked to the logging and mining industries. The Bellingham Bay Coal Company Roeder sawmill offered support for those whose luck had failed in the Fraser gold fields (Jeffcott 1995; Koert and Biery 2003; Moles 2014). The Sehome mine was worked from 1855 to 1878 but had a habit of catching fire and flooding out (Koert and Biery 2003:254). Roeder's sawmill burned in 1873 and five years later the Bellingham Bay Coal Company closed its doors, forcing a number of men to leave the area or set out along the Nooksack Valley to try their hands at farming (Koert and Biery 2003; Moles 2014).

Among the first settlers in what would become Ferndale was John A. Tennant, an Arkansas native educated in law and civil engineering, who came to work for the Bellingham Bay Coal Company following the California Gold Rush. Tennant served as deputy sheriff during the Fraser River Gold Rush and in the Territorial Legislature in 1859. He later returned to Whatcom where he worked as assistant Indian agent at Lummi. In late 1859 Tennant and his wife Clara, daughter of George Chelick and niece of the Lummi Chief *Chowizit*, settled on her allotment approximately one mile south of Ferndale, the first known settlement in the area (Jeffcott 1995:136-137). Tennant spent his remaining years serving the county as County Commissioner, Superintendent of Schools, Probate Judge, civil engineer, and surveyor. Tennant surveyed and platted Ferndale and served on many committees that were responsible for organizing the first school, Sunday school, and church. In 1878 Tennant converted to the Methodist Church and served as pastor in San Juan County and later in Ferndale (Jeffcott 1995:137).

Another early homesteader, Thomas Wynn, a blacksmith from Philadelphia, came to Sehome to work for Henry Roeder, who operated the sawmill at the mouth of Whatcom Creek (Roth 1926). He later established a claim on Whidbey Island before moving to Utsalady where he was active in the logging business (Jeffcott 1995:138). Following this venture Wynn returned to Sehome where he worked in the mines until the Fraser River gold boom, when he started selling canoes to miners. After the gold mines dried up Wynn returned to coalmines until 1863 when he moved to the Ferndale area, married a Lummi woman, and took up 240 acres of land near John Tennant. Wynn was also active in public affairs, serving as assessor, sheriff, and numerous committees (Jeffcott 1995).

There were no other settlers recorded in the area until 1870 when John Plaster, returning from the Fraser River gold fields, and M.T. Tawes, who had been working on the Western Union Telegraph, decided to settle outside Ferndale after they were stranded by bad weather at the confluence of the Red and Nooksack Rivers (Jeffcott 1995:139). Plaster went on to become instrumental in removing the Big Jam, served as probate judge, and worked on his farm. Additional settlers came to the Ferndale area, many after the closure of the coal mine, including prominent members such as George Slater, Reuben Bizer, Thomas Barrett, Darius and Ambrose Rogers, William Clark, John Evens, Hohn Hope, and William Jarman (Jeffcott 1996:136). A list of early settlers in Ferndale and Ten Mile Township (1870s - 1880s) can be viewed in Siegel (1948).

Early settlement of the Nooksack Valley was dependent upon river travel, which was blocked by the Big Jam located three to four miles above the mouth of the Nooksack River. The Jam consisted of a conglomeration of logs, stumps, and brush, which extended another mile upriver, forcing portage along a trail either side. In 1873 Edward Eldridge introduced a bill to memorialize congress for removal of the Big Jam and though it passed, no action followed. The Big Jam on the Nooksack was talked about throughout Whatcom County and the rest of the territory, leading the area to become known as the Jam Precinct after the County Commissioners were petitioned for a voting precinct in 1874 (Jeffcott 1995: 124). The citizens of Jam again petitioned for help from territorial legislature in 1875, and again no action followed. Early in 1876 Mrs. Phoebe Judson, the “Mother of Lynden”, proposed raising funds by subscription and gathered $200 in 3 weeks (Jeffcott 1995:125). In the fall of the same year J.A. Tennant was appointed committee secretary of the Jam removal, with power to act. Judge John Plaster was contracted to remove the Jam for $450 and began work shortly after, taking on James Lynch as assistant. The Jam was officially cleared on February 20th, 1877 (Jeffcott 1995:128). Shortly after the removal of the Big Jam, Lynden pioneers gathered to remove the remaining jams located upriver (Jeffcott 1995:129). The name Ferndale was introduced by Alice Eldridge, the first teacher on the Nooksack River, and was officially adopted as the new name of Jam Precinct after the removal of the Big Jam (Jeffcott 1995; Moles 2014). The removal of the jam also opened steamboat travel for business and a few small steamers made the trip up the Nooksack River, though it was not very profitable, and none kept a regular schedule. The coming of the railroad in 1891 and construction of passable roads ended the steamer days (Jeffcott 1995:134).

While settlers had taken claims in the Ferndale vicinity, William “Billy” Clark was the first to settle west of the river where the city was originally platted. Clark had also tried his luck in the Fraser, followed by a stint in the coal mines, where he met his Semiahmoo wife. By 1873 Clark had moved to his claim on the Nooksack where he operated a canoe ferry known as Clark’s Crossing or Billy Clark’s Landing beginning in 1875, anticipating business from the new road from Whatcom to Semiahmoo (Jeffcott 1995: 171; Moles 2014). While attempting to make final settlement on his claim, it was discovered that Clark had relinquished his American citizenship while working for the Hudson’s Bay Company at Fort Langley, and therefore, had no rights to file (Jeffcott 1995:152; Moles 2014). In 1882 Darius Rogers received the property’s patent. Rogers and his brother, Ambrose, had been settled on the east side of the river by 1879, where they built two homes and operating a store. In 1880 D. Rogers purchased Clark’s ferry license and started a scow ferry and steamboat operation with John Hardan and D.E. Follett. Failure of the steamboat service resulted in Rogers losing his claim and ferry service to Hardan, forcing him to relocate to the west side of the river. The rivalry of East and West Ferndale had begun, with Tennant platting both sites in 1883 and an ensuing fight over the location of the post office location. Darius Rogers quickly promoted business in West Ferndale, with many business owners building or relocating to West Ferndale (Jeffcott 1995; Moles 2014). Eventually West Ferndale became Ferndale and Hardan continued operating the ferry service until the bridge was constructed in around 1893 (Jeffcott 1995:162). Ferndale, both east and west, was incorporated into Whatcom County on March 19, 1907 (Dougherty 2009).

Recent Land Use

Historic aerial images, T-Sheets, topographic maps, and plat maps were utilized to determine recent land use in the proposed project area and surroundings. With the exception of the park used by the Old Settler’s Association, land adjacent to the project area(s) consisted largely of agricultural land, until the early stages of public utility installation in the mid-1960s (Figure 7), though recreation may be present off of 2nd Ave in the form of a track. Development of public utilities continued through the 1970s and into the 1980s (Figure 8), and recreation shifted from what was likely a track to baseball/softball fields in the north western portion.

Little information regarding the initial building of the levee was found. Topographic maps from the area indicate that much of the Ferndale Levee was installed prior to the 1950s (USGS 1952), however, the portion along Ferndale Rd between the public utility areas and Pioneer Park are absent. History of Whatcom County levee construction presented by KCM, Inc. (1995) indicates that early levee construction was largely done in a piecemeal fashion to meet emergencies as they arose. Expenditure data from the US Army (1935) indicates that County funding was being used to repair flood control facilities since 1918. While the construction date of the Ferndale Levee is unknown, it has undergone a series of repairs and upgrades throughout time.

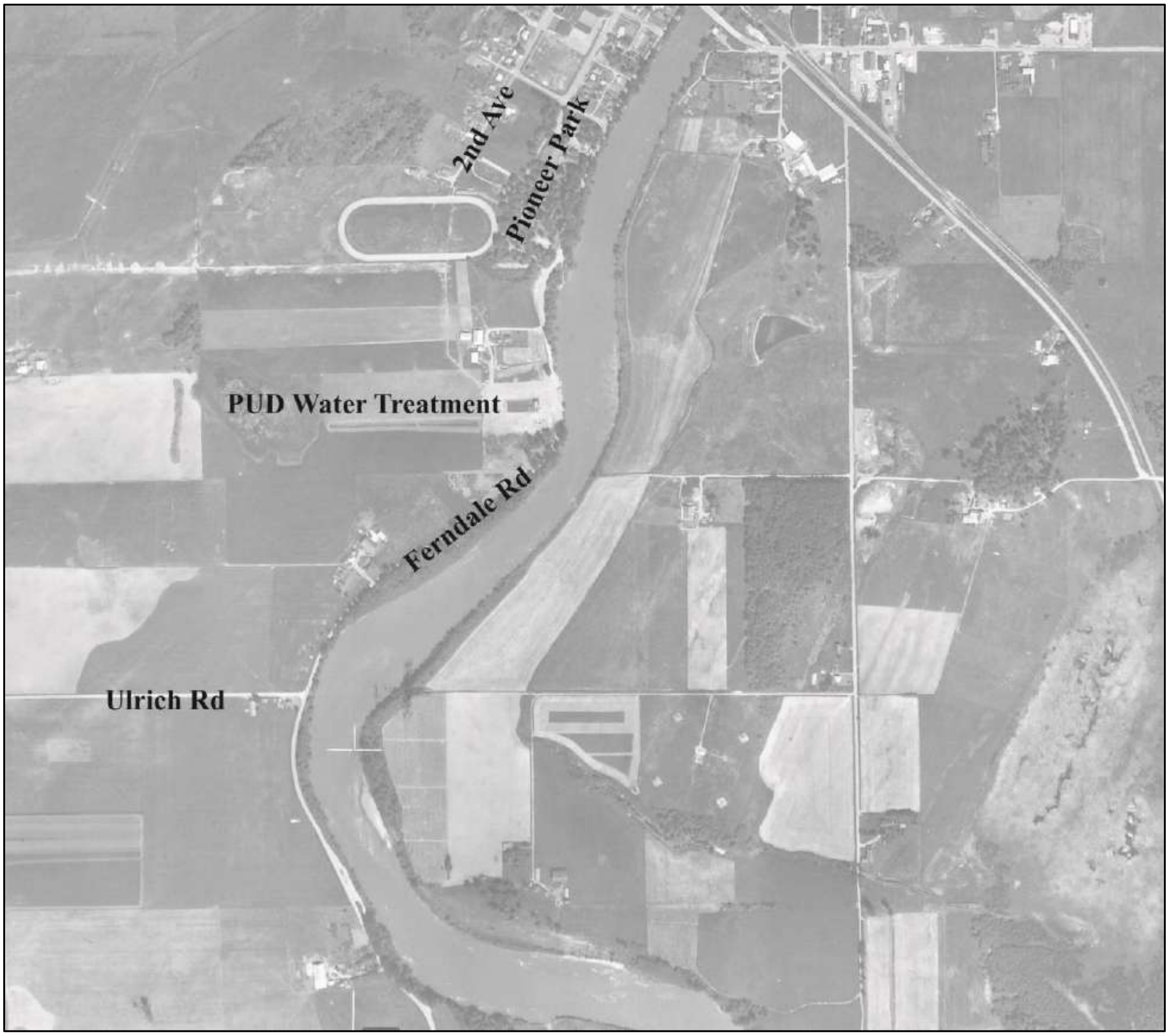


Figure 7. A portion of a 1966 aerial image illustrating land use in the area. Image from Whatcom Conservation District, adapted by Drayton.

Figure 8. A portion of a 1983 aerial image illustrating land use changes along Ferndale Road. Whatcom Conservation District image adapted by Drayton.

Previous Archaeology and Cultural Resources Studies

According to the Washington State Department of Archaeology and Historic Preservation's (DAHP) Washington Information System for Architectural and Archaeological Records Data (WISAARD) database, at least 36 cultural resources surveys have been conducted within an approximate 1.6 km (1 mile) radius of the project area (Table 1). A total of nine previously recorded archaeological sites and three register properties are also located within this boundary.

Cultural surveys most pertinent to the current project include Baldwin (2016), Baldwin and Hanson (2018), Chambers and Baldwin (2010), Koziarski and Baldwin (2010), and Munsell (2017). Some historic-era objects were identified during these projects; however, none were deemed significant enough to be recorded as a site.

Table 1. Cultural resources surveys recorded on WISAARD within a 1.6 km radius.

Author(s)	**Report Title**	**Results**
Baldwin, G., and M. Hanson 2018	A Cultural Resources Assessment of the Proposed Pioneer Sidewalks Project, Ferndale, Whatcom County, Washington	Negative
Baldwin, G. M. Hanson, and O. Patsch 2017	A Cultural Resource Assessment of the Gateway Drainage Outfall Project, City of Ferndale, Whatcom County, Washington	Negative
Munsell, D. 2017	NRCS Cultural Resources Srurvey for the Three Micro-Irrigation Project in Whatcom County, Washington – 2017; Travis Linds, Celeste Monk, and Gurtej Sangha	Negative
Baldwin, G. L. 2016	Cultural Resources Assessment for the Proposed Pacific Fern Business Park, Ferndale, Whatcom County, Washington	Negative
Baldwin, G. L. 2016	A Cultural Resource Assessment of the Natural Way Chiropractic Center Redevelopment Project, 1943 & 1949 Main Street, TPNs: 390229212424 and 390229218423, Ferndale, Washington	Historic Debris Scatter
Baldwin, G.L. 2016	Cultural Resources Review for a Proposed Addition at Superfeet Worldwide Inc., Ferndale, Whatcom County, Washington	Negative
Baldwin, G.L. 2016	A Cultural Resource Assessment of the Proposed Riverwalk Place Development at 2002 & 2004 Cherry Street, Ferndale, Washington	Negative
Baldwin, G. and K Solmo 2015	Cultural Resources Review of the City of Ferndale Sewer Pump Station # 3 Rebuild Project, Ferndale, Washington	Negative

Author(s)	Report Title	Results
Mather, C. and E Arthur 2015	Archaeological Survey and Assessment for the Proposed Gabriela’s Long Plat Housing Development (TPN390219 492216), Vista Drive, Ferndale, Washington	Negative
Baldwin, G. and K. Solmo 2014	Cultural Resources Review for the Ferndale Property Investment, LLC Canfield Apartments Development, Ferndale, Whatcom County, Washington	Negative
Arthur, E. and C. Mather 2014	Results of an Archaeological Survey and Evaluation of the Proposed Sunnyside Apartments, 2312 Mountain View Road, Ferndale, Washington	Negative
Meidinger, B and G. Baldwin 2011	Archaeological Investigation of the Hovander Park Trail in Hovander Homestead Park (TPN: 39022919019), Ferndale, Washington	Negative
Koziarski, R and G. Baldwin 2011	Archaeological Investigation of Lot A of the Proposed Ferndale Towncenter Location in Ferndale, Washington (TPNs: 390220485053 and 390220478105)	Negative
Moreno, M and G. Baldwin 2011	Archaeological Assessment for the Riverplace on the Nooksack Development Project, Ferndale, Whatcom County, Washington	45WH905
Preston, J, N Bryant, and G. Baldwin 2011	Archaeological Assessment for the Ferndale Public Library Project on Main Street, Ferndale, Whatcom County, Washington	Negative
Preston, J. and G. Baldwin 2011	Archaeological Assessment for the Sawarne Lumber Mill Project, Whatcom County, Washington	Negative
Chambers, J. and G. Baldwin 2010	Cultural Resources Assessment for the City of Ferndale’s Manganese Treatment and Pipeline Project, Ferndale, Whatcom County, Washington	Negative
Koziarski, R. and G. Baldwin 2010	Archaeological Assessment of 2130 Main Street, (TPN 3902305174950000), Ferndale, Whatcom County, Washington	Negative
Koziarski, R. and G. Baldwin 2010	Archaeological Assessment of the Proposed Nooksack River Levee Repair Location South of Downtown Ferndale, Whatcom County, Washington	Negative
Baldwin, G., F. Haney, and S. Neil 2009	Archaeological Investigation for the City of Ferndale, Main Street-Church Road Improvements Project, Whatcom County, Washington	Negative

Author(s)	Report Title	Results
Baldwin, G., S. Neil, and C. Kaiser 2009	Archaeological Investigation for the 2nd Avenue Road Improvements Project, Ferndale, Whatcom County, Washington	Negative
Chambers, J., G. Baldwin, and J. Watrous 2009	Archaeological Assessment for the Superfeet Park, Ferndale, Whatcom County, Washington	Negative
Kelly, K, L. McCroskey, and A. Dailide 2009	Hovander Park Levee Project, Whatcom County, Washington	Historic levee
Baldwin, G. 2008b	Interim Results: Archaeological Testing of the Proposed New Clubhouse, Ferndale Boys and Girls Club, Ferndale, WA	Negative
Reid, A 2007	Letter Report of Opinion on Cultural Resource Management of the Proposed People’s Bank Branch Development at 1895 Main Street in Ferndale, Whatcom County, Washington	Negative
Bush, K., J. Elder, and J. Ferry 2006	Archaeological Investigation Report: 5912 Portal Way, Ferndale, Washington Parcel #390220380318, #390220292300	45WH34, 45WH37, 45WH38, 45WH39
Reid, A. and S. Nored-Pratschner 2006	Cultural Resources Monitoring of the City of Ferndale Southwest Sewer Interceptor Project, Ferndale, Whatcom County, Washington	Negative
Reid, A. 2006	Addendum Report of Property Portions to the Cultural Resource Assessment at 5470 Nielsen Avenue in Ferndale for the Construction of the B-B Meat and Sausage Company Processing Facility Development, Ferndale, Whatcom County, Washington	45WH748
Reid, A. 2006	RE: Cultural Resource Monitoring of the Apartment Development at 5623 Front Street in Ferndale, Whatcom County, Washington. City of Ferndale Project Number: 04004.SE	Negative
Reid, A., D. Hammon, and S. Nored-Pratschner 2006	Cultural Resource Assessment of the Whatcom Humane Society Shelter at 5431 Hovander Road in Ferndale, Whatcom County, Washington	Rock alignment, possible structure
Reid, A., K. Claborn, J. Hillegas, and S. Nored 2005	Cultural Resource Assessment of the Proposed City of Ferndale Southwest Sewer Interceptor Project in Ferndale, Whatcom County, Washington	Negative

Author(s)	Report Title	Results
Reid, A 2004	Report of Cultural Resource Assessment of Two Apartment Developments on Front Street at Ferndale, Whatcom County, Washington	Negative
Reid, A. and J. Hale 2004	Cultural Resource Investigations for the City of Ferndale Main Street Improvement Project, Ferndale, Whatcom County, Washington, 2001-2004	Historic Main Street Bridge, structures, artifacts
Nokes, R. 2004	Mid-Holocene Terrestrial Animal Use in the Gulf of Georgia Region: A Case Study from the Ferndale Site, Lower Nooksack River, Washington	45WH34
Reid, A. 2001	Cultural Resource Assessment of the Vanderyacht Park Pond and Storm Drain Project, Ferndale, Whatcom County, Washington	Negative
Reid, A. 2001	Cultural Resource Assessment of the Douglas and Main Street Intersection Reconstruction Project, Ferndale, Whatcom County, Washington	Negative

A total of nine archaeological sites have been recorded within 1.6 km (1 mi) of the current project area, encompassing precontact and historic materials (Table 2). Most of the sites near the project are located along the shoreline of the Nooksack River or other water ways, while others are located on terraces above the river. The sites nearest the project are 45WH737 and 45WH738, located across the river to the northeast of the current project area.

Site 45WH737 is the East Ferndale Historic Settlement or the “Jam” Town Site. It was the original Euroamerican settlement of the Ferndale area. The site was situated on the east bank of the Nooksack River. It has been largely impacted by a retention pond and greenhouse construction from an adjacent nursery (Reid 2001a). Site 45WH738 is situated just east of 45WH737 on the east bank of the Nooksack River. The site is a precontact shell midden and lithic material site that was dated to approximately 2,500 to 3,000 years BP based on recovered projectile points (Reid 2001b). It has been partially impacted by greenhouse and landscaping developments (Reid 2001b).

Table 2. Archaeological sites recorded on WISAARD within a 1.6 km radius.

Site Number	Citation	Site Type	Component	Site Description
45WH34	Grabert, G.F. 1972	Precontact Camp, Precontact Lithic Material, Precontact Shell Midden	Precontact	FCR, Points, Cores, Chipping waste, Maul, shell
45WH39	Wiggs, J., and G. Grabert 1972	Precontact Lithic Material	Precontact	Cores, Choppers, Flakes
45WH95	Grabert, G.F. 1980	Precontact Camp, Precontact Feature, Precontact Lithic Material	Precontact	Three Choppers, One flake implement, Rock-lined hearth
45WH96	Grabert, G.F. 1980	Precontact Camp	Precontact	FCR, similar to 45WH34

Site Number	Citation	Site Type	Component	Site Description
45WH737	Reid, Alfred 2001	Historic Townsite	Historic	East Ferndale Historic Settlement/Jam Town Site, Historic Townsite
45WH738	Reid, Alfred 2001	Precontact Lithic Material, Precontact Shell Midden	Precontact	East Ferndale Precontact Shell Midden, Lithic Scatter
45WH748	Reid, Alfred 2006	Precontact Isolate, Precontact Lithic Material	Precontact	Precontact Lithic Isolate, Quartzite Cobble
45WH905	Preston, Justin 2011	Precontact Lithic Material	Precontact	Precontact Lithic Material, Scatter
45WH1008	Arthur, Ed 2014	Precontact Camp	Precontact	FCR, mammal bone, antler tine, fish bone, shell fragments

The proposed project is near Pioneer Park, a historic park listed on the Washington State Heritage Register. The park consists of a series of 12 early pioneer cabins/houses, a meeting/dance hall, the Zion Congregational Church, a granary, jail, and a post office. Additional non-contributing buildings are located on site. Pioneer Park is significant to the regional history in three areas, a land parcel and distinct location associated with a distinguished social organization, the Old Settlers Association, a natural and man-made landscape reflective of the region in the early settlement/pre-railroad era, and the site of an important assembly of buildings reflecting construction methods and materials unique to the far Pacific Northwest (Sullivan and Sivinski 1999). The Old Settler’s Association was created in 1895 and consisted of original settlers in Whatcom County such as John Tennant and Thomas Wynn, along with the children of settlers who also became of note in the county. Among them were Victor Roeder, John Tarte Jr., Charles Tawes, and John and Thomas Slater.

A growing number of attendees at the Old Settler’s picnics drove the group to seek a permanent facility for social events. In 1901 the Old Settler’s purchased the 4 acres of the park due to its association with the large jam on the Nooksack River. Picnics and social events took place at the park from 1902 until present day, although the park was transferred to the City of Ferndale in 1972 (Sullivan and Sivinski 1999). Over the years, especially the 1970s to 1990s, preservation of slab cedar buildings became the mission of the park, and most of the buildings at the park now were moved there during that period.

Approximately ½ mile south of the project area is the Hovander Homestead built by Holan or Hoakan Hovander, a Swedish architect, in the late 1890s to early 1900s. The Homestead consists of the stick style farmhouse, hay barn, fruit drying shed, water tower, milking parlor, tool shed, and machine shed. Hovander bought 100 acres of land on the Nooksack River in 1898 and the house was completed by 1903. Mr. Hovander died in 1915 and following the death of his wife in 1936, their youngest son sold 60 acres of the farm to the Whatcom County Park Board (Ellingson 1973).

Less than ½ mile west of and across the river from the Hovander Homestead is the Angelo Hovander Barn. The Hovander farm was built circa 1910 with Holan/Hoakan Hovander assisting with the architecture of his son's farmstead. This farm represents the hub of the Hovander Family's stretch of farming in the Nooksack Valley, which continues today in its fifth generation and for over 100 years (Hovander 2008).

CULTURAL RESOURCE EXPECTATIONS

Review of environmental and cultural contexts, and previously conducted cultural resources studies indicates that the project area is located in an area of high probability for additional subsurface archaeological materials, however, being that the project consists of a built and re-built environment, that probability is somewhat lessened. Past archaeological work from the local area and the region suggest the survey location could possibly contain both precontact and historic cultural resources. Historic cultural resources might include historic trash scatters, structural remains, or artifacts associated with the development of the Jam Townsite or early Ferndale, as well as agricultural materials. In addition, numerous ethnographic names have been recorded in the area, as well as several precontact archaeological sites, including but not limited to campsites, resource acquisition and processing areas, or lithic tool manufacture. In addition, the Nooksack River served as a major transportation line from precontact times until the railroad and automobiles made county travel more accommodating.

FIELD INVESTIGATION

The physical archaeological assessment of an area is conducted through visual reconnaissance of a project area, examination of existing ground disturbances and subsurface excavation as needed. Surface survey of an area proposed for ground alteration or other impact is employed to locate any surficial cultural materials or structures with any historic or archaeological importance or cultural concern. When utilized, shovel probes or mechanical excavation can assist in providing a wider sample of subsurface soil conditions for determining the potential for, or presence/absence of, buried archaeological deposits. The employment of probes or trenches is most often dependent upon considerations of the landform, topography, project proposal and subsurface geologic conditions.

Fieldwork was conducted on October 15, 2020 by Drayton archaeologists Marsha Hanson, Oliver Patsch, Jeff Hillstrom, Emily Hill, and Simon Schultheis. Field conditions were mostly cloudy and cool, with occasional sunbreaks. Fieldwork consisted of a pedestrian survey and the excavation of subsurface shovel probes where they could be placed. Pedestrian survey was completed to gain an overall overview of the area, to identify any surficial features or cultural materials that might be present and locate areas best suitable for subsurface survey.

Most of the area consists of a built-up levee adjacent to Ferndale Road, located to the west (Photos 1 – 3). Portions of the levee contain riprap, sandbags, and concrete walls and eco-blocks have been installed to protect Ferndale Road in certain places (Photos 4 – 6). At times, the riverbank drops steeply from the levee to the river, and at other locations the riverbank extends toward the river and drops more gradually. Utilities were located mostly on the west side of Ferndale Road, but were also observed along portions to the east (Photos 7 – 8). Shoulders along Ferndale Road are mostly non-existent, with the east side adjacent to the levee or private property fence lines. The west shoulder is wide enough to accommodate utilities (Photo 9), and typically drops steeply to agricultural fields below.

Photo 1. Overview of the northern portion of the levee, viewing south.

Photo 2. An overview of the middle portion of the project area, view is south.

Photo 3. Overview of the southern portion of the road corridor section, view is south.

Photo 4. Overview of riprap along the levee. View is south.

Photo 5. Sandbags, concrete, and eco-blocks installed along the levee. View is south.

Photo 6. Concrete and sandbags installed along the levee and Ferndale Rd. view is south.

Photo 7. Example of utilities located along the west side of Ferndale Rd. View is north.

Photo 8. Petroleum pipeline crossing Ferndale Road, view to the south-southeast.

Photo 9. Example of narrow shoulder along west side of Ferndale Road, view north.

The remainder of project area consists of the recreational areas surrounding the sports complex, the parking lot near the American Legion and 2nd Ave. The alignment for Alternative A runs between one of the baseball/softball fields and the soccer fields, before connecting to the parking area and 2nd Avenue (Photos 10 – 11). Sewer manholes and irrigation lines are in the area. Alternative E follows a single-track gravel road around the south end of the recreational fields before looping north around the sports complex and meeting with the existing parking lot (Photos 12 – 16). Water and sewer lines, as well as irrigation lines have been installed in the field areas, and power is in the area, running to tower lights.

Photo 10. Overview of Alternative A alignment, looking north across the recreation fields.

Photo 11. Overview south-southeast, of Alternative A looking back across the recreation fields.

Photo 12. Overview west of a portion of Alternative E.

Photo 13. Overview northwest of Alternative E where it loops around the sports complex.

Photo 14. Overview of Alternative E along walking path west of sports complex where it meets the parking lot; view is north.

Photo 15. Overview east of Alternative E across existing parking lot.

Photo 16. Overview northeast of Alternative E, at 2nd Avenue.

Following the visual inspection, 27 shovel probes were excavated (Figures 9 – 10). Standard shovel probes consist of cylindrical pits measuring approximately 40 cm in diameter. Depths of shovel probes are ultimately determined by the geological conditions and other factors, such as degree of disturbance, presence of ground water, glacial sediments, etc., present at each location. All sediment excavated from probes was screened through ¼” mesh hardware screen. Details regarding the location, depth, sediments encountered, and material content were recorded for each probe. A detailed description of the sediments observed in the shovel probes can be viewed in Appendix A.

Narrow shoulders, private property fencing, utilities, and steep slopes to the river or agricultural fields largely determine where probes could or could not be placed. Places along the west side of the road that consisted of more open shoulder areas were chosen, as were areas located on the east side of the levee where the bank did not drop directly to the river, and were located above the ordinary high water mark (OHWM). Probes in the recreational areas were placed along the alternative alignments. Observed soils varied slightly across the project area but consisted of dark brown to dark grayish brown, very fine to fine grained alluvial deposits and ranged mostly in the silt, sand, and clay ratios (Photos 17 – 19). Few probes diverged from this trend, but those that did included those located nearest the parking area (ex. MH1, EH1, JH2). These probes largely reflected disturbance associated with road building and installation of the parking lot (Photo 20). Modern to potentially historic-era trash was observed in six probes, though nothing diagnostic was observed (Photo 21). No significant cultural materials were observed during sub-surface or pedestrian survey.

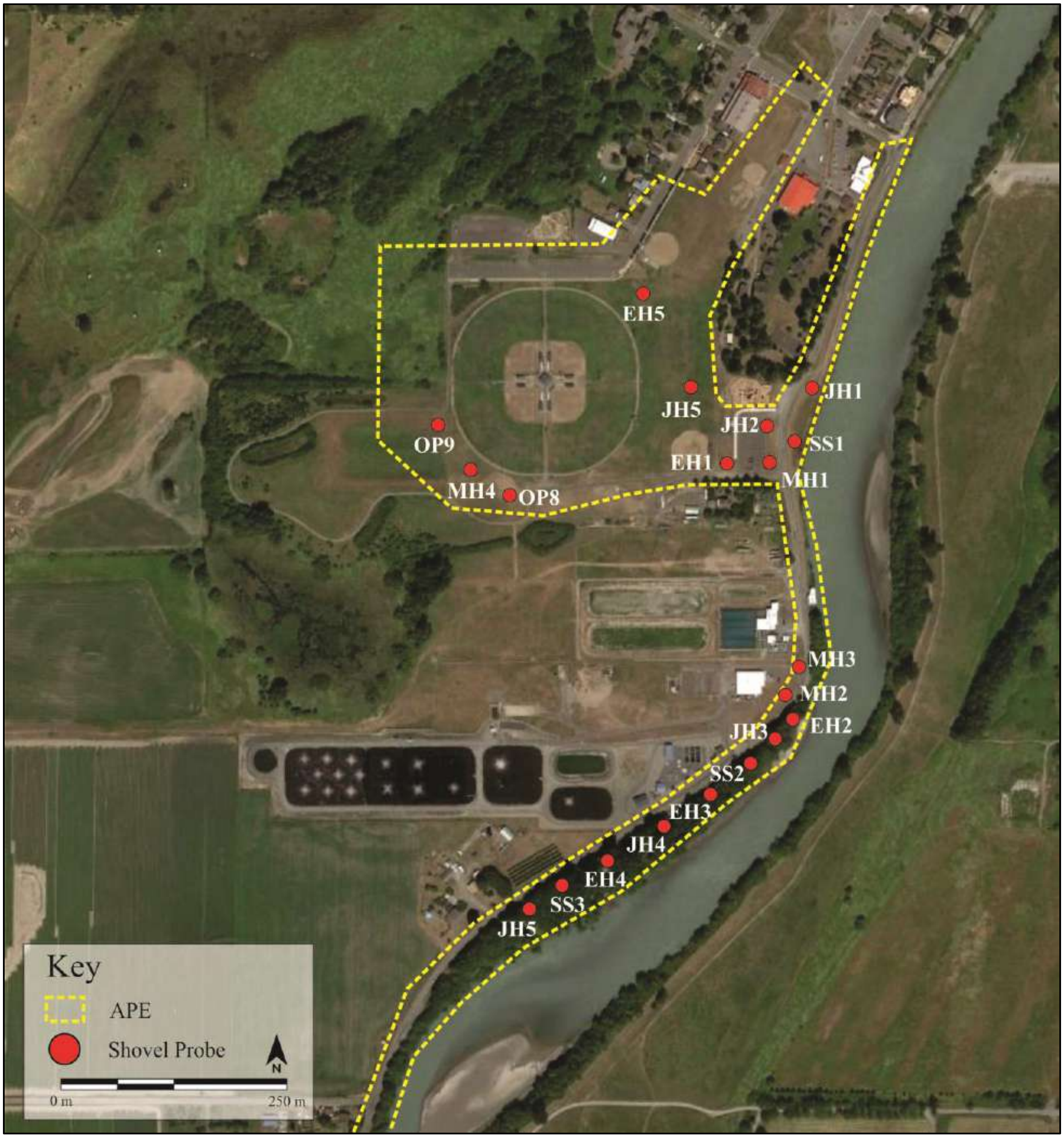


Figure 9. Google Earth aerial image depicting the probe locations in the northern project area.

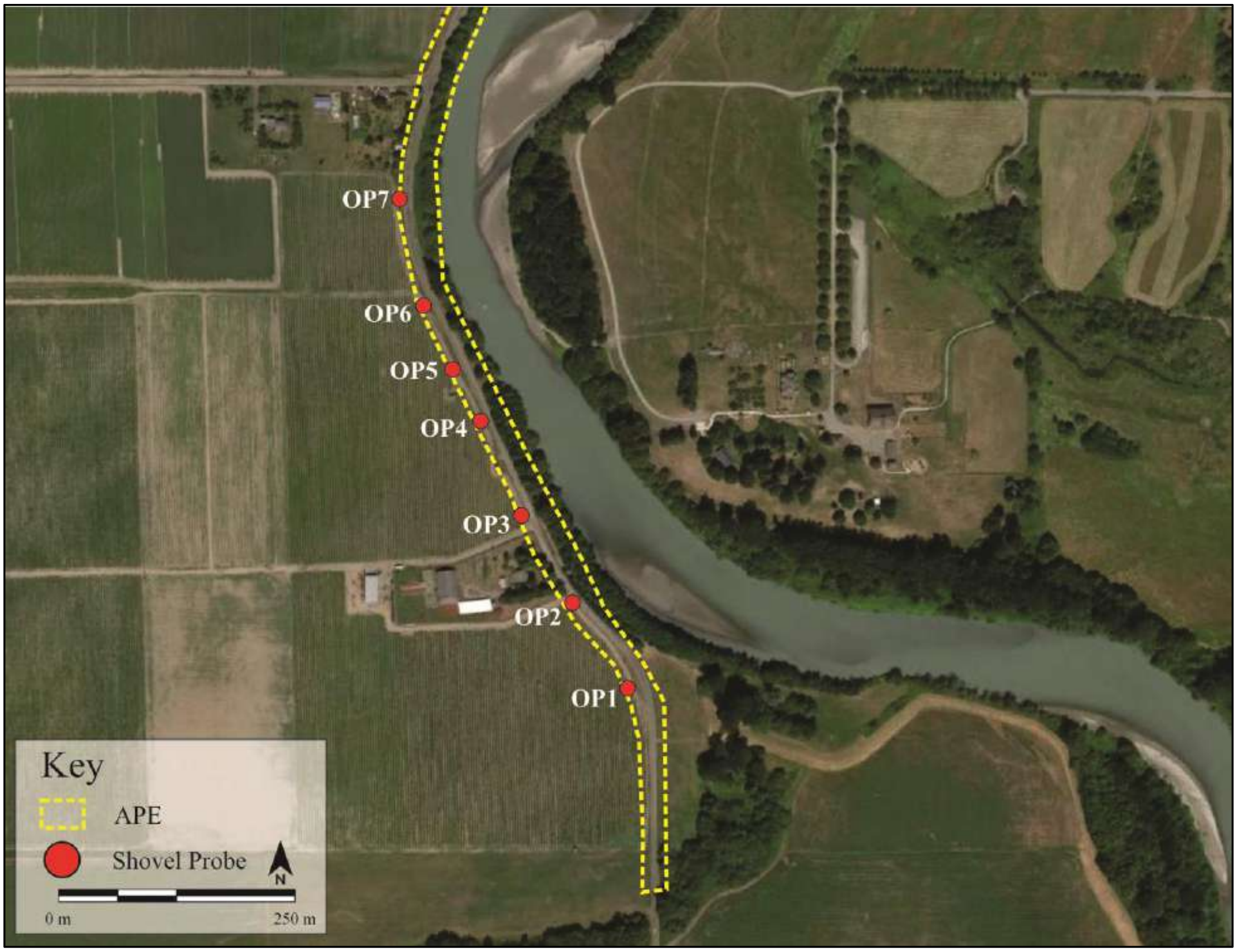


Figure 10. Google Earth aerial image depicting the probe locations in the project corridor following Ferndale Road to the south.

Photo 17. Overview of MH2 illustrating sediments commonly observed.

Photo 18. Overview of SS3, another example of the typical sediments.

Photo 19. Overview of JH6 illustrating soil profile observed within the recreational field area.

Photo 20. Asphalt and gravels observed in MH1.

Photo 21. Example of non-diagnostic materials encountered during the field investigation. Contents are from MH3.

RECOMMENDATIONS

The present cultural resources assessment consisted of background review, field investigation, and production of this report. Background review determined the project area to be in an area of high probability for cultural resources, although the development and redevelopment of the area considerably lowers that probability. No evidence of precontact cultural material was observed. Modern to historic-era artifacts were encountered during the review, however, none were diagnostic, nor were they considered significant. Modern to historic-era trash was encountered in six probe locations, however, none of the material was diagnostic, and therefore, not significant. Based on the results of the present review Drayton recommends the DOE approve the proposed project. Further archaeological oversight appears unwarranted as currently designed.

Washington State law which provides for the protection of all archaeological resources. It is further recommended that proponents become familiar with Washington State laws, particularly Revised Code of Washington (RCW) Chapter 27.53.060, RCW 27.44.040 and RCW 68.50.645. The statute RCW Chapter 27.53, Archaeological Sites and Resources prohibits the unauthorized removal, theft, and/or destruction of archaeological resources and sites Additional legal oversight is provided for Indian burials and grave offerings under RCW Chapter 27.44, Indian Graves and Records. RCW 27.44 states that the willful removal, mutilation, defacing, and/or destruction of Indian burials constitute a Class C felony. Further, Washington legal code, RCW 68.50.645, Notification, provides a strict process for the notification of law enforcement and other interested parties in the event of the discovery of any human remains regardless of perceived patrimony. The assessment of the property has been conducted by a professional archaeologist and meets or exceeds the criteria set forth in RCW: 27.53 for professional archaeological reporting and assessment.

INADVERTANT DISCOVERY PROTOCOLS

Archaeological Resources:

In the event that archaeological materials (e.g. shell midden, faunal remains (bones), stone tools, historic glass, metal, or other concentrations) are encountered during the development of the property, an archaeologist should immediately be notified and work halted in the vicinity of the find until the materials can be inspected and assessed. The project archaeologist should be contacted immediately to review the find and contact the relevant parties. An assessment of the discovery and consultation with government and tribal cultural resources staff is a requirement of law. Once the situation has been assessed steps to proceed can be determined.

Human Burials, Remains, or Unidentified Bone(s)

In the event of inadvertently discovered human remains or indeterminate bones, pursuant to RCW 68.50.645, all work must stop immediately, and law enforcement should be contacted. Any remains should be covered and secured against further disturbance, and communication should be immediately established with the Ferndale Police Department and the State Physical Anthropologist at DAHP for coordination with interested Native Tribe(s).

The area surrounding the discovery should be secured and of adequate size to protect the discovery from further disturbance until the State provides a notice to proceed. The discovery of any human skeletal remains must be reported to law enforcement immediately. The county medical examiner/coroner will assume jurisdiction over the human skeletal remains to decide whether those remains are forensic or non-forensic. If the county medical examiner/coroner determines the remains are non-forensic, then the State Physical Anthropologist at DAHP assumes the jurisdiction over the remains. The DAHP will notify any appropriate cemeteries and all affected tribes of the find. The State Physical Anthropologist will determine whether the remains are Native or Non-Native origin and report that finding to any appropriate cemeteries and the affected tribes. The DAHP will then handle all consultation with the affected parties as to the future preservation, excavation, and disposition of the remains. DAHP will also authorize when work may proceed.

REFERENCES

Amos, Pamela Thorsen

1972 The Persistence of Aboriginal Beliefs and Practices among the Nooksack Coast Salish. Ph.D Dissertation, Department of Anthropology, University of Washington, Seattle.

Baldwin, Garth L.

2008a *RE: Archaeological Testing of 45SN417 at the Woodhaven Residential Development, Granite Falls Washington*. Drayton Archaeology. Submitted to Woodhaven Estates. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

2008b *Interim Results: Archaeological Testing of the Proposed New Clubhouse, Ferndale Boys and Girls Club, Ferndale, WA.* Drayton Archaeology. Submitted to Reichhardt and Ebe Engineering, Inc.

2016 *A Cultural Resource Assessment of the Proposed Riverwalk Place Development at 2002 & 2004 Cherry Street, Ferndale, Washington*. Drayton Archaeology. Submitted to Riverwalk Ferndale LLC. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Baldwin, Garth L., and Marsha R. Hanson

2018 *A Cultural Resources Assessment of the Proposed Pioneer Sidewalks Project, Ferndale, Whatcom County, Washington.* Drayton Archaeology. Submitted to Reichhardt & Ebe Engineering, Inc. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Booth, D.B. and B. Goldstein

1994 Patterns and Processes of Landscape Development by the Puget Lobe Ice Sheet. Regional Geology of Washington State: Washington Division of Geology and Earth Resources, Bulletin 80: 227.

Cameron, Valerie J.

1989 The late Quaternary geomorphic history of the Sumas Valley. Master's Thesis, Department of Archaeology, Simon Fraser University, Burnaby.

Chambers, Jennifer, and Garth L. Baldwin

2010 *Cultural Resources Assessment for the City of Ferndale's Manganese Treatment and Pipeline Project, Ferndale, Whatcom County, Washington.* Drayton Archaeology. Submitted to Widener and Associates. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Dougherty, Phil

2009 Ferndale incorporates on March 19, 1907. Electronic document, http://historylink.org/File/9067, accessed October 2020.

Dragovich, Joseph D. and Ralph A. Haugerud, David K. Norman, Patrick T. Pringle

1997 Geologic map and interpreted geologic history of the Kendall and Deming 7.5minute quadrangles, western Whatcom County, Washington. Washington State Division of Geology and Earth Resources Open File Report 97-2, 39 p., 3 plates.

Easterbrook, Donald J.

1971 *Geology and Geomorphology of Western Washington Whatcom County*. Western Washington State College Press, Bellingham.

2003 Cordilleran Ice Sheet Glaciation of the Puget Lowland and Columbia Plateau and Alpine Glaciation of the North Cascade Range, Washington. In *Western Cordillera and Adjacent Areas*, ed. T. W. Swanson, pp. 137-157. Geological Society of America, Boulder, Colorado.

Easterbrook, Donald J., and D.A. Rahm

1970 *Landforms of Washington: The Geologic Environment*. Western Washington State College, Bellingham.

Ellingson, Roger

1973 National Register of Historic Places Inventory-Nomination Form: 45WH203, Hovander Homestead. On file at the Department of Archaeology and Historic Preservation, Olympia.

Emmons, Richard V.

1951 Western Washington State College Archaeological Site Survey Form 45WH3. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

1952 Western Washington State College Archaeological Site Survey Form 45WH3. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Franklin, J.F. and C.T. Dyrness

1973 *Natural Vegetation of Oregon and Washington*. USDA Forest Service General Technical Report PNW-8, Portland, Oregon.

Hawley, Robert Emmett

1945 *Skquee Mus or Pioneer Days on the Nooksack*. Miller and Sutherlen, Bellingham.

Hovander, Star

Washington State Heritage Barn Register: 45WH783. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Jeffcott, Percival R.

1949 *Nooksack Tales and Trails*. Whatcom County Pioneer Association, Ferndale, Washington.

KCM, Inc.

1995 *Whatcom County Lower Nooksack River Comprehensive Flood Hazard Management Plan: Nooksack River Flood History*. KCM, Inc. Submitted to Whatcom County Transportation Services Department, Disvision of Engineering, River and Flood Control Section. Copies available from Whatcom County, http://www.whatcomcounty.us/DocumentCenter/View/25543/Nooksack-River-Flood-History?bidId=, accessed October 2020.

Kidd, Robert S.

1964 A Synthesis of Western Washington Prehistory from the Perspective of Three Occupation Sites. Master's Thesis. Department of Anthropology, University of Washington, Seattle.

Koert, Dorothy, and Galen Biery

2003 *Looking Back, the Collector's Edition: Memories of Whatcom County/Bellingham*. Grandpa's Attic, Bellingham.

Koziarski, Ralph, and Garth L. Baldwin

2010 *Archaeological Assessment of the Proposed Nooksack River Levee Repair Location South of Downtown Ferndale, Whatcom County, Washington.* Drayton Archaeology. Submitted to the US Army Corps of Engineers- Emergency Management Branch. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Mattson, John L.

1985 Puget Sound Prehistory: Postglacial Adaptation in the Puget Sound Basin with Archaeological Implications for a Solution to the "Cascade Problem". Ph.D Dissertation, Department of Anthropology, University of North Carolina at Chapel Hill.

Moles, Kathleen

2014 Ferndale - Thumbnail History. Electronic document, http://www.historylink.org/File/10806, accessed October 2020.

Montgomery, Keith R.
1979 Prehistoric Settlements of Sumas Valley, Washington. Master's Thesis, Department of Anthropology, Western Washington University, Bellingham.

Munsell, David A.
2017 NRCS Cultural Resources Srurvey for the Three Micro-Irrigation Project in Whatcom County, Washington – 2017; Travis Linds, Celeste Monk, and Gurtej Sangha. NRCS. Submitted to NRCS. Copies available from the Washington State Department of Archaeology and Historic Preservation, Olympia.

Patterson-Griffin, Kristen
1984 Archaeological survey and analysis of prehistoric settlement on the lower Lummi River, Whatcom County, Washington. Master's Thesis, Department of Anthropology, Western Washington University, Bellingham.

Pittman Paul D., and Michael R. Maudlin, Brian D. Collins
2003 Evidence of a Major Late Holocene River Avulsion. Paper No. 154-29 presented at the annual meeting of the Geological Society of America, Seattle.

Pojar, Jim, and Andy MacKinnon (editors)
1994 *Plants of the Northwest Coast: Washington, Oregon, British Columbia and Alaska*. Lone Pine Publishing, Vancouver, British Columbia, Canada.

Reid, Alfred
1987 An Ecological Perspective of the Intergroup Relations of an Inland Coast Salish Group: The Nooksack People. Master's Thesis, Department of Anthropology, Western Washington University, Bellingham.

2001a Washington State Archaeological Site Inventory Form or Site 45WH737. On file at Department of Archaeology and Historic Preservation, Olympia.

2001b Washington State Archaeological Site Inventory Form or Site 45WH738. On file at Department of Archaeology and Historic Preservation, Olympia.

Richardson, Allan and Brent Galloway
2011 *Nooksack Place Names: Geography, Culture, and Language*. UBC Press, Vancouver.

Roth, Lottie Roeder
1926 *History of Whatcom County*, Vol. II. Pioneer Historical Publishing, Chicago.

Royer, Marie Hamel

1982 *The Saxon Story: Early Pioneers on the South Fork*. Whatcom County Historical Series, Volume 2. Whatcom County Historical Society, Bellingham, WA.

Ruby, Robert H. and John A. Brown

1992 *A Guide to the Indian Tribes of the Pacific Northwest*. University of Oklahoma Press, Norman.

Siegel, Chris C.

1948 *Early History of Ferndale and Ten Mile Townships, Whatcom County, Washington*. Cox Brothers & Williams, Inc., Bellingham.

Spear, Robert

1977 A Prehistoric Site Cluster in Western Whatcom County, Washington. Unpublished Master's Thesis, Department of Anthropology, Western Washington University, Bellingham.

Stern, Bernhard J.

1934 *The Lummi Indians of Northwest Washington*. Columbia University Press, New York.

Sullivan, Michael, and Valerie Sivinski

1999 National Register of Historic Places Registration Form: 45WH616, Pioneer Park. On file at the Department of Archaeology and Historic Preservation, Olympia.

Suttles, Wayne P.

1951 *Economic Life of the Coast Salish of Haro and Rosario Straits*. Ph.D. dissertation Washington State University, Seattle.

1987 The Early Diffusion of the Potato among the Coast Salish. In *Coast Salish Essays*. University of Washington Press, Seattle.

1990 Central Coast Salish. In *Handbook of North American Indians* Vol. 7 *Northwest Coast*, edited by Wayne P. Suttles pp.453-475. Series editor W.C. Sturtevant, Smithsonian Institute, Washington D. C.

Tremaine, David G.

1975 Indian and Pioneer Settlement of the Nooksack Lowland, Washington to1890. Occasional Paper #4. Center for Pacific Northwest Studies, Western Washington State College, Bellingham Washington.

United States Army (US Army)

1935 Letter from the Secretary of War on Preliminary Examination of Nooksack River Flood Control. Chief of Engineers, US Army.

United States Geologic Survey (USGS)

1952 *Ferndale, Washington*. 1:2400 topographic map. USGS, Washington, D.C.

1994 *Ferndale*, *Washington* 1:24,000 7.5-Minute Series. USGS, Washington, D.C.

University of California Davis SoilWeb Map

n.d. UC Davis California Soil Resource Lab's SoilWeb Interactive map, displaying Natural Resource Conservation Service (NRCS) soils data. Electronic resource, http://casoilresource.lawr.ucdavis.edu/gmap/, accessed October 2020.

Whatcom Conservation District

1966 Aerial image. Historic Scanned Aerials for Whatcom County Database. Electronic resource, https://cdn.whatcomcd.org/aerials-historical/1966/BBK-IGG-73_date6-7-66.jpg, accessed October 2020.

1983 Aerial image. Historic Scanned Aerials for Whatcom County Database. Electronic resource, https://cdn.whatcomcd.org/aerials-historical/1983/31-246_date5-12-83.jpg, accessed October 2020.

APPENDIX A: SHOVEL PROBE TABLE

DEPTH BELOW SURFACE (CM)	SEDIMENT DESCRIPTION	RESULTS
EH1		
0 – 19	10YR 3/3, dark brown, coarse-grained, silty loam with some smaller pebbles and organic materials	Negative
19 – 35	10YR 4/2, dark grayish brown, gravelly fine-grained clayey silt, disturbed, some 10YR 4/6, dark yellowish-brown mottling present	Negative
35 – 45	10YR 4/3, brown, fine-grained sandy silt, compact	Negative
45 – 54	10YR 6/2, light brownish gray, fine-grained sand, extremely compact, disturbed	Negative
EH2		
0 – 8	10YR 3/3, dark brown, coarse-grained silty loam with small gravels and organics	Negative
8 – 49	10YR 5/3, brown, fine-grained, sandy silt with few small gravels	Negative
49 – 90	10YR 4/2, dark grayish brown, fine-grained sand with roots present	Negative
EH3		
0 – 19	10YR 3/3, dark brown, fine-grained silty loam with organic materials	Negative
19 – 79	10YR 5/3, brown, fine-grained, silty clay with tree roots present, compact	Negative
79 – 97	10YR 4/2, dark grayish brown, fine-grained sand, extremely compact	Negative
EH4		
0 – 39	10YR 3/3, dark brown, silty loam with roots and small gravels present	Negative
39 – 105	10YR 5/3, brown, fine-grained, very compact, sandy silt with few small pebbles and tree roots	Negative
EH5		
0 – 22	10YR 3/3, dark brown, coarse-grained silty loam, compact	Negative
22 – 27	10YR 4/6, dark yellowish brown, coarse-grained sand with small gravels	Negative
27 – 32	10YR 4/1, dark gray, coarse-grained sand with small gravels	1 brown glass fragment
32 – 54	10YR 4/2, dark grayish brown, fine-grained silty clay, disturbed, some 10YR 4/6, dark yellowish-brown mottling present	1 metal fragment, 1 clear glass fragment
54 – 78	10YR 3/3, dark brown, fine-grained sand, extremely compact	1 brown glass fragment
OP1		
0 – 92	10YR 3/3, dark brown, sandy alluvium	Negative
OP2		
0 – 84	10YR 4/2, dark grayish brown, sandy alluvium	Negative
80 – 92	10YR 5/4, dark yellowish-brown sand	Negative
OP3		
0 – 80	10YR 4/2, dark grayish brown, sandy alluvium	Negative
84 – 91	10YR 5/4, dark yellowish-brown sand	Negative
OP4		
0 – 90	10YR 4/2, dark grayish brown, sandy alluvium	Negative
OP5		
0 – 92	10YR 4/2, dark grayish brown, sandy alluvium	Negative

OP6		
0 – 90	10YR 4/2, dark grayish brown, sandy alluvium	Negative
OP7		
0 – 90	10YR 4/2, dark grayish brown, sandy alluvium	Negative
OP8		
0 – 90	10YR 4/2, dark grayish brown, sandy alluvium	Negative
OP9		
0 – 70	10YR 4/3, brown, sandy loam	1 brown glass fragment
70 – 84	10YR 5/4, dark yellowish-brown sand, very compact	Negative
JH1		
0 – 22	10YR 3/3, dark brown, sandy silt loam with imported quarry spalls and fine roots	Negative
22 – 100	10YR 4/2, dark grayish brown, very fine silty sand, compact	Negative
JH2		
0 – 29	10YR 4/2, dark grayish brown, silt loam with few gravels	Negative
29 – 39	10YR 4/2, dark grayish brown, very fine silty sand, extremely compact with imported angular gravel fill	Negative
JH3		
0 – 44	10YR 4/2, dark grayish brown, sandy silt loam with fine to coarse roots, low to moderate gravel	4 thin plastic fragments, 6 brown glass fragments, 1 green glass fragment, 2 milk glass fragments, 14 clear glass fragments
44 – 78	10YR 5/2, grayish brown, sandy silt loam, fine to coarse roots, low to moderate gravel content	Negative
JH4		
0 – 48	10YR 4/2, dark grayish brown, clayey silt loam, fine to coarse roots, low gravel content	Negative
48 – 69	10YR 4/2, dark grayish brown, very fine sandy loam, fine to coarse roots, low gravel content	Negative
JH5		
0 – 95	10YR 4/2, dark grayish brown, clayey silt loam, fine to coarse roots, low gravel content	Negative
JH6		
0 – 61	10YR 4/2, dark grayish brown, clayey silt loam, fine to coarse roots, low gravel content	Negative
61 – 75	10YR 5/2, grayish brown, fine silty sand, low gravel content	Negative
SS1		
0 – 26	10YR 3/3, dark brown loam imported spall rock, extremely compact, small roots present	Negative
26 – 53	10YR 4/4, dark yellowish brown, very fine-grained sandy loam, small amounts of rounded gravel	Negative
53 – 87	10YR 5/1, gray, fine grained sand, little silt present, little to no gravel	Negative
87 – 95	2.5YR 4/3, olive brown, and 10YR 5/1, gray, sand	Negative
SS2		
0 – 12	10YR 3/3, dark brown loam with decomposing organics	Negative
12 – 47	10YR 4/4, dark yellowish brown, very fine- grained sandy loam, few small rounded gravels and roots present	Negative
47 – 94	10YR 5/2, grayish brown, very fine-grained sand, little silt present	Negative

SS3		
0 – 3	Decomposing organics	Negative
3 – 27	10YR 3/3, dark brown loam, few rounded gravels	Negative
27 – 60	10YR 4/4, dark yellowish brown, very fine-grained sandy loam	Negative
60 – 99	10YR 5/2, grayish brown, very fine-grained sand with little silt present	Negative
MH1		
0 – 45	10YR 3/2, very dark grayish brown, to 10YR 3/3, dark brown, fine grained silty sand with fine roots and few sub-angular to well-rounded gravels, inclusions of 10YR 5/1, gray, clayey sand with oxidation present from 38 – 45 cmbs	Asphalt fragments
45 – 60	10YR 4/3, brown, fine grained gravelly sandy silt, ashy	Asphalt fragments
Notes: Terminated at asphalt impasse		
MH2		
0 – 42	10YR 2/2, very dark brown, very fine to fine-grained silty sand, very few small, well-rounded gravels present, charcoal flecking, fine rootlets	Negative
42 – 66	10YR 3/1, very dark gray, to 10YR 3/2, very dark grayish brown, fine to medium grained silty sand, very few small, well-rounded gravels	Negative
66 – 76	10YR 3/2, very dark grayish brown, to 10YR 4/2, dark grayish brown, very fine to fine grained silty sand with very few small, well-rounded gravels	Negative
76 – 80	10YR 3/1, very dark gray, to 10YR 3/2, very dark grayish brown, fine to medium grained silty sand, very few small, well-rounded gravels	Negative
80 – 89	10YR 3/2, very dark grayish brown, to 10YR 4/2, dark grayish brown, very fine to fine grained silty sand with very few small, well-rounded gravels	Negative
89 – 95	10YR 3/1, very dark gray, to 10YR 3/2, very dark grayish brown, fine to medium grained silty sand, very few small, well-rounded gravels	Negative
95 – 102	10YR 3/2, very dark grayish brown, to 10YR 4/2, dark grayish brown, very fine to fine grained silty sand with very few small, well-rounded gravels	Negative
MH3		
0 – 55	10YR 2/2, very dark brown, very fine to fine-grained silty sand, very few small, well-rounded gravels present, charcoal flecking, fine rootlets	2 asphalt fragments, 3 plastic fragments, 8 clear glass fragments, 3 brown glass fragments
55 – 85	10YR 2/1, black, to 10YR 2/2, very dark brown, very fine to coarse-grained sand, very little silt	Negative
85 – 98	10YR 3/2, very dark grayish brown, very fine-grained silty sand with very few small, well-rounded gravels	Negative
98 – 105	10YR 2/1, black, to 10YR 2/2, very dark brown, very fine to coarse-grained sand, very little silt	Negative
105 – 110	10YR 3/2, very dark grayish brown, very fine-grained silty sand with very few small, well-rounded gravels	Negative
MH4		
0 – 19	10YR 3/2, very dark grayish brown, to 10YR 3/3, dark brown, fine grained sandy silt with moderate amount of sub-angular to well-rounded gravels	1 clear flat glass fragment, 1 terra cotta fragment
19 – 37	10YR 3/2, very dark grayish brown, very fine to fine-grained silty sandy loam, low-moderate amount of sub-rounded gravels, and inclusions of 10YR 4/2, dark grayish brown, very fine-grained ashy silt	Negative
37 – 48	10YR 3/3, dark brown, very fine-grained sandy silt with few well-rounded gravels	Negative
48 – 78	10YR 4/2, dark grayish brown, very fine-grained ashy sandy silt with oxidation, no gravels, very compact	Negative

Appendix F: Traffic Analysis

MEMORANDUM

Date: July 23, 2021 **TG:** 1.20041

To: Nathan Zylstra, PE Reichhardt & Ebe
Eric Vavra, PE Reichhardt & Ebe

From: Brent Turley, PE Transpo Group
Patrick Lynch, AICP Transpo Group

cc:

Subject: Ferndale Levee Improvement Traffic Analysis

The purpose of this memorandum is to document the traffic analysis related to the Ferndale Levee Improvement Project. As part of planned improvements to the levee along the Nooksack River in and south of Ferndale, WA, the adjacent roadway network will be impacted. Several roadway network alternatives are being considered that close the Front Avenue/Ferndale Road section of roadway between Cherry Street and Star Park, and relocate the roadway to the west. Baseline traffic conditions are first discussed, then the alternatives analysis is provided.

Baseline Traffic Conditions

This section summarizes baseline traffic conditions in the study area. The network, traffic volumes, collision history, Central Elementary School considerations, pedestrian activity, and truck activity are discussed.

Study Area Network

Figure 1 shows the study area network. The area includes the downtown area of Ferndale west of the Nooksack River and south of Main Street and extends south to Ulrich Road.

Within the study area city streets are two lanes with a posted 25-mph speed limit. This includes the Front Avenue/Ferndale Road corridor within city limits. Outside of the city, Ferndale Road is two lanes with a posted speed of 35 mph. The functional classification of the Front Avenue/Ferndale Road corridor is Urban Minor Arterial within the city and Rural Major Collector in the county.

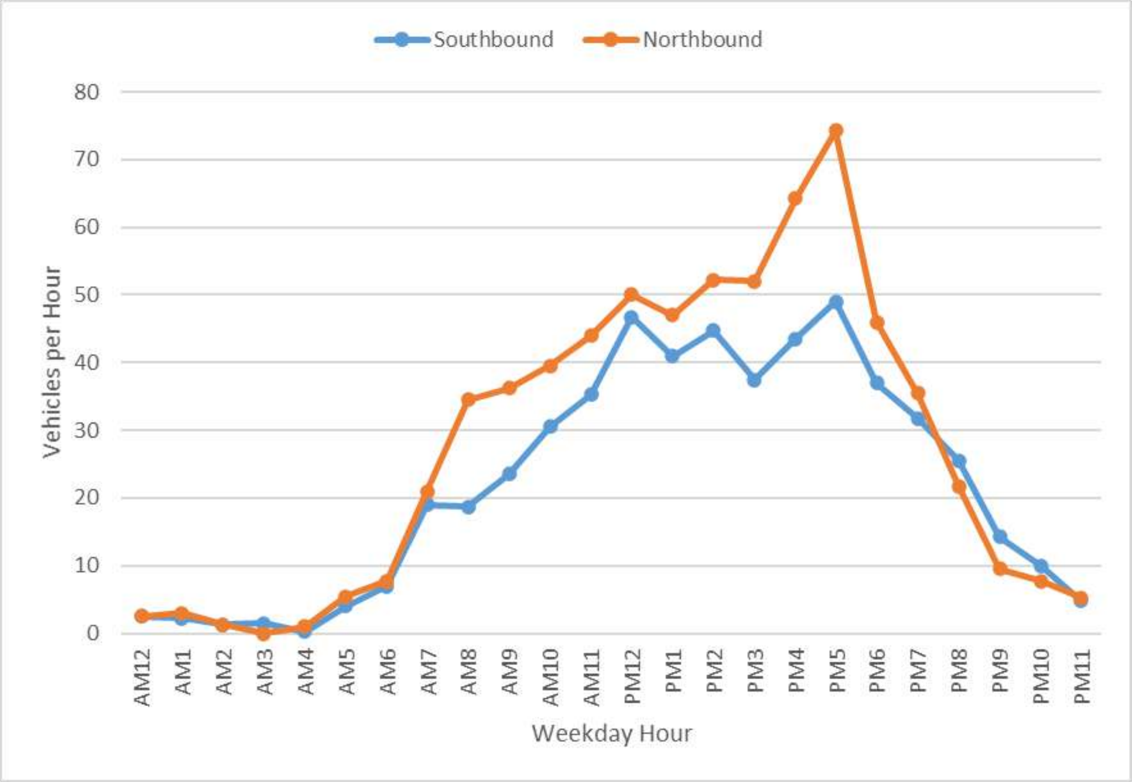
There are traffic signals along Main Street at 3rd Avenue and 2nd Avenue. The traffic signal at Main Street/1st Avenue was recently removed as part of a Main Street improvement project. The 2nd Avenue-Cherry Street-Front Avenue corridor is considered the primary route through the study area, but 1st Avenue is also used about the same as 2nd Avenue.

Traffic Volumes

Due to unique traffic conditions during the COVID-19 pandemic, new traffic counts were not collected as part of this project. The most recent traffic counts along the corridor were from August 2014 and located at Ferndale Road south of the city limits (WCOG Count Database, 2021). This count showed weekday daily volume of 1,190 vehicles, which is considered a low volume for arterial roadways. Based on land use growth in the area and related traffic conditions, the volume growth between 2014 and 2021 is expected to be very minor.

(Source: Open Street Map, 2021)

Figure 1. Study Area



(Source: WCOG Count Database, Transpo Group, 2021. Count from August 2014.)

Figure 2. Hourly Traffic Volumes on Ferndale Road at South City Limits

Figure 2 shows the hourly fluctuation of traffic volumes for the corridor at the city limits. The highest traffic volumes are generally in the afternoon with peaks during the typical PM peak hour. This is likely related to recreational land uses in the area. The sharp peak in PM peak hour volumes during commute suggest some drivers may be using this route as a back door into downtown Ferndale to bypass Main Street. However, these traffic volumes are relatively minor.

Using the Ferndale Travel Demand Model, traffic forecasts for the Front Avenue/Ferndale Road corridor were developed for 2040 conditions. It is anticipated that daily traffic volumes would grow to 3,080 in the northern section of the corridor (north of Ferndale City Limits) and 2,490 in the southern section. This level of traffic is still well below the typical capacity of a two-lane roadway (about 15,000 for an urban street).

Collision History

Historical collision records were gathered for the intersections and roadways within the study area for the past five years of available data (2015 to 2019). Table 1 summarizes the intersections with collisions, the five-year totals and annual average. There were no fatalities and very few injury collisions reported. The intersection with the highest collisions was at 2nd Avenue/Alder Street which primarily involved collisions related to parking.

It should be noted that in 2021 there was a double fatality vehicle accident within the study area. The vehicle was traveling southeast on Cherry Street and appeared to be going too fast for the curve where Cherry Street becomes Front Avenue. The vehicle left the roadway and traveled over the levee into the Nooksack River.

Table 1. Collision Summary

	Annual Collisions[1]					5-Year Total	
Location	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**	**Annual Average**
Intersections							
1st Ave/ Cherry St	0	1	2	0	1	4	0.80
1st Ave/ Maple St	0	0	0	0	1	1	0.20
1st Ave/ Alder St	1	0	0	0	0	1	0.20
2nd Ave/ Cherry St	1	0	1	2	0	4	0.80
2nd Ave/ Maple St	0	0	0	0	0	0	0.00
2nd Ave/ Alder St	1	0	0	0	4	5	1.00
Front Ave/ Cherry St/ Ferndale Rd	0	1	0	0	0	1	0.20
Front Ave/ Ulrich Rd	0	0	0	0	0	0	0.00
Roadway Segments							
Ferndale Road south of Front Ave	0	0	1	0	2	3	0.60

Source: WSDOT, Transpo Group, 2021

1. Under 23 U.S. Code § 148 and 23 U.S. Code § 409, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

Central Elementary School Considerations

Central Elementary School is located between 2nd Avenue and 1st Avenue south of Alder Street. As noted previously, the 2nd Avenue-Cherry Street-Front Avenue corridor is considered the primary route through the study area, but 1st Avenue is also used about the same as 2nd Avenue. Any changes in traffic patterns within the study area should consider Central Elementary School traffic patterns.

The primary entrance to the school is located on 2nd Avenue. In addition, school bus loading and unloading is located along 2nd Avenue. Parking is located on the north and west side of the school. Most parent drop-off and pick-up activity is located along 1st Avenue. In other words, the more structured school related traffic activity occurs along 2nd Avenue, and less structured activity occurs on 1st Avenue. This suggests that any potential alternative that may push more traffic to 1st Avenue, may also need to work with the school to ensure continued safe operations with the parent drop-off/pick-up area.

Pedestrian Activity

Based on conversations with city and county staff, there is a substantial level of pedestrian activity in the study area. On the north end, the Riverwalk trail along the river is well used. There is also pedestrian activity associated with the Central Elementary School. On the south end, Star Park is also well used, and is an origin point for many people to walk the levee along the river (pedestrians crossing Front Avenue). Pioneer Park is also a regional recreational facility with baseball fields and soccer fields. This creates high pedestrian activity between the play fields and parking facilities. Pioneer Park is also home to historical buildings and gathering areas.

Truck Activity

Due to the nature of the roadways in the vicinity, this area is not considered a major truck route. Most truck trips in the corridor are related to land uses within the corridor. On the south end of the study area are the water and wastewater treatment plants for the City of Ferndale and Public Utility District No. 1. Most traffic to/from these sites are oriented to the north including truck trips. One exception is that most trucks that deliver chemicals to the treatment plants come from the south. Truck activity is considered relatively minor within the study area.

Alternatives Analysis

The Ferndale Levee Improvement Project would potentially close Front Avenue and create a new roadway somewhere to the west. The purpose of the alternatives analysis is to understand the traffic impacts of each roadway alignment alternative. The planned network alternatives are first explained, then discussions about traffic patterns and safety implications are provided.

Network Alternatives

The following network alternatives were considered in this traffic analysis. Additional network alternatives were developed but removed during the initial screening process.

- **Alternative A – 2nd Avenue Extension**. This alternative would close Front Avenue between Cherry Street and Star Park and create a new road to the west. The alignment would extend 2nd Avenue through the middle of Pioneer Park and connect to Ferndale Road south of Star Park. See Figure 3.

- **Alternative B – 1st Avenue Extension**. This alternative is similar to Alternative A, but 1st Avenue would be extended through Pioneer Park. See Figure 4.

- **Alternative D – Front Avenue Rebuild**. This alternative would keep the Front Avenue alignment. This roadway would have to be rebuilt along with the levee structure. See Figure 5.

- **Alternative E – 2nd Avenue Extension Western Route**. This alternative is similar to Alternative A, but the new road would be routed to the west of the ball fields. See Figure 6.

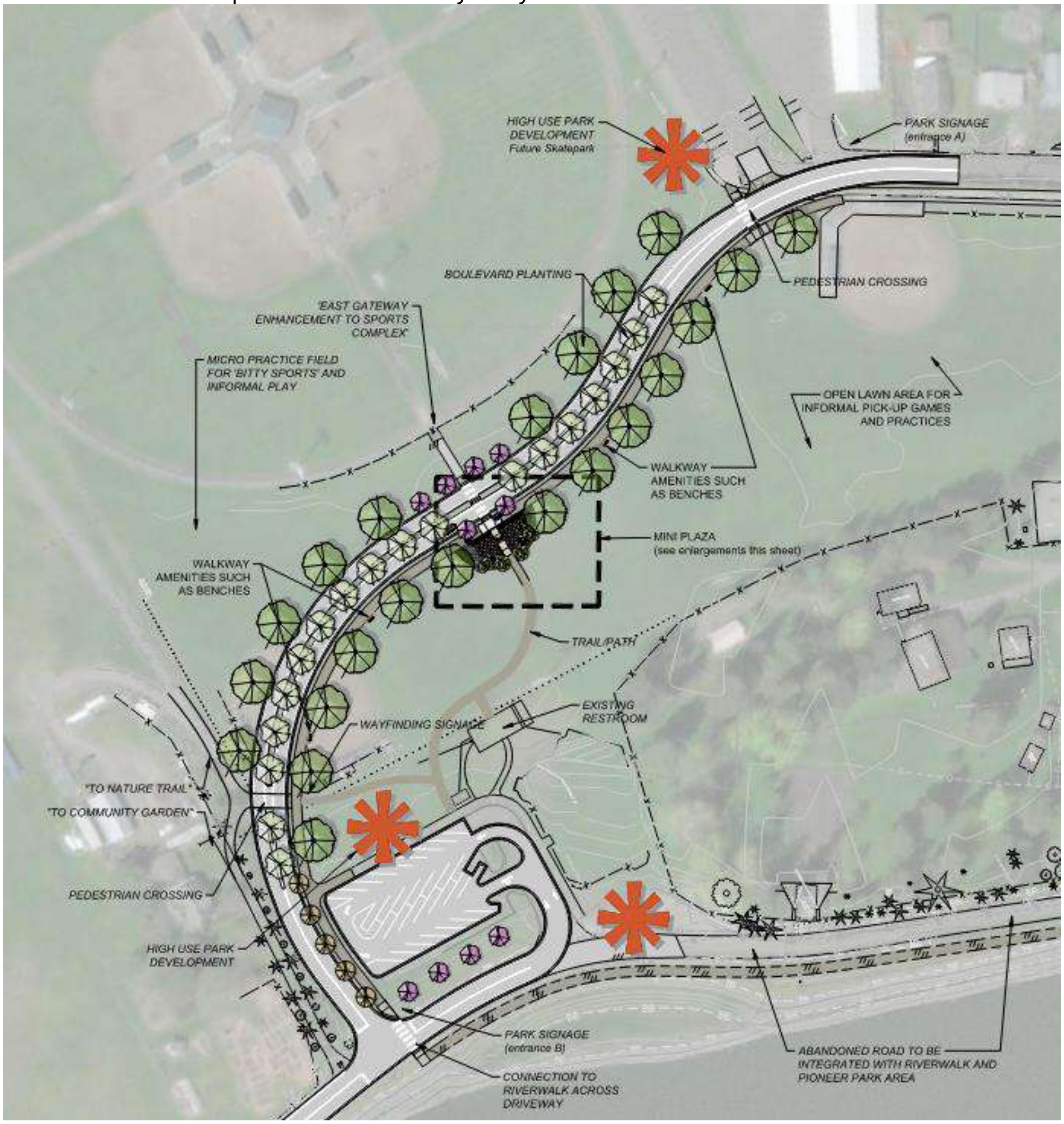
Traffic Analysis

The traffic impact analysis focuses on two major areas of evaluation. The first area is the impact on traffic patterns on study roadways. The second area is the impact on multimodal safety, including walk, bike, and vehicle modes. Traditional capacity or level of service analysis was not performed for the alternatives because traffic volumes are relatively low within the study area even for 2040 conditions.

Traffic pattern impacts refer to how the alternative may or may not change existing travel patterns through the area. This may increase traffic in areas that had little to none previously.

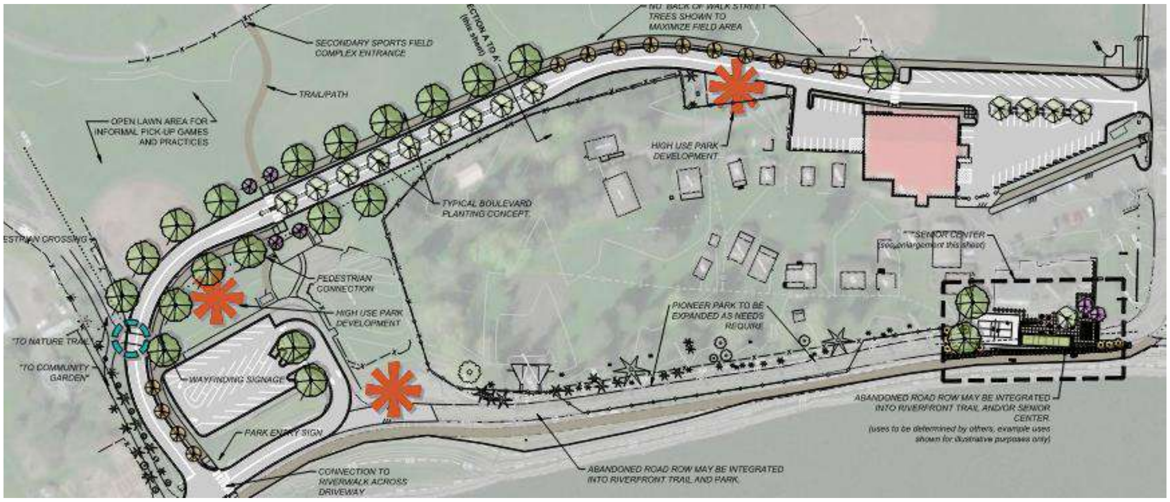
Multimodal safety refers to a qualitative discussion on how the alternatives may or may not change safety risks for pedestrians and bicyclists. Any increased risks for vehicle collisions in general are also noted.

Table 2 shows a comparison of traffic analysis by network alternatives.



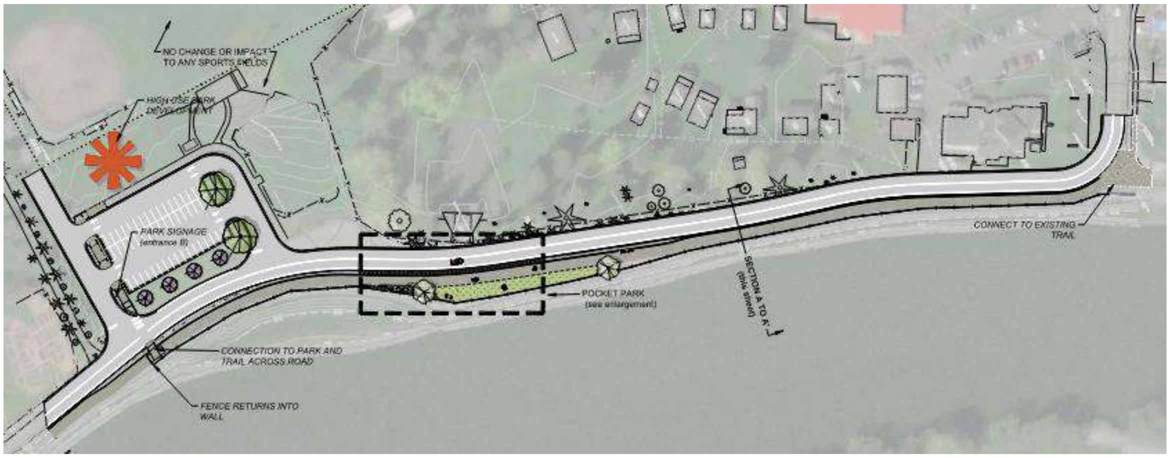
(Source: eccosDesign, 2021)

Figure 3. Network Alternative A – 2nd Avenue Extension



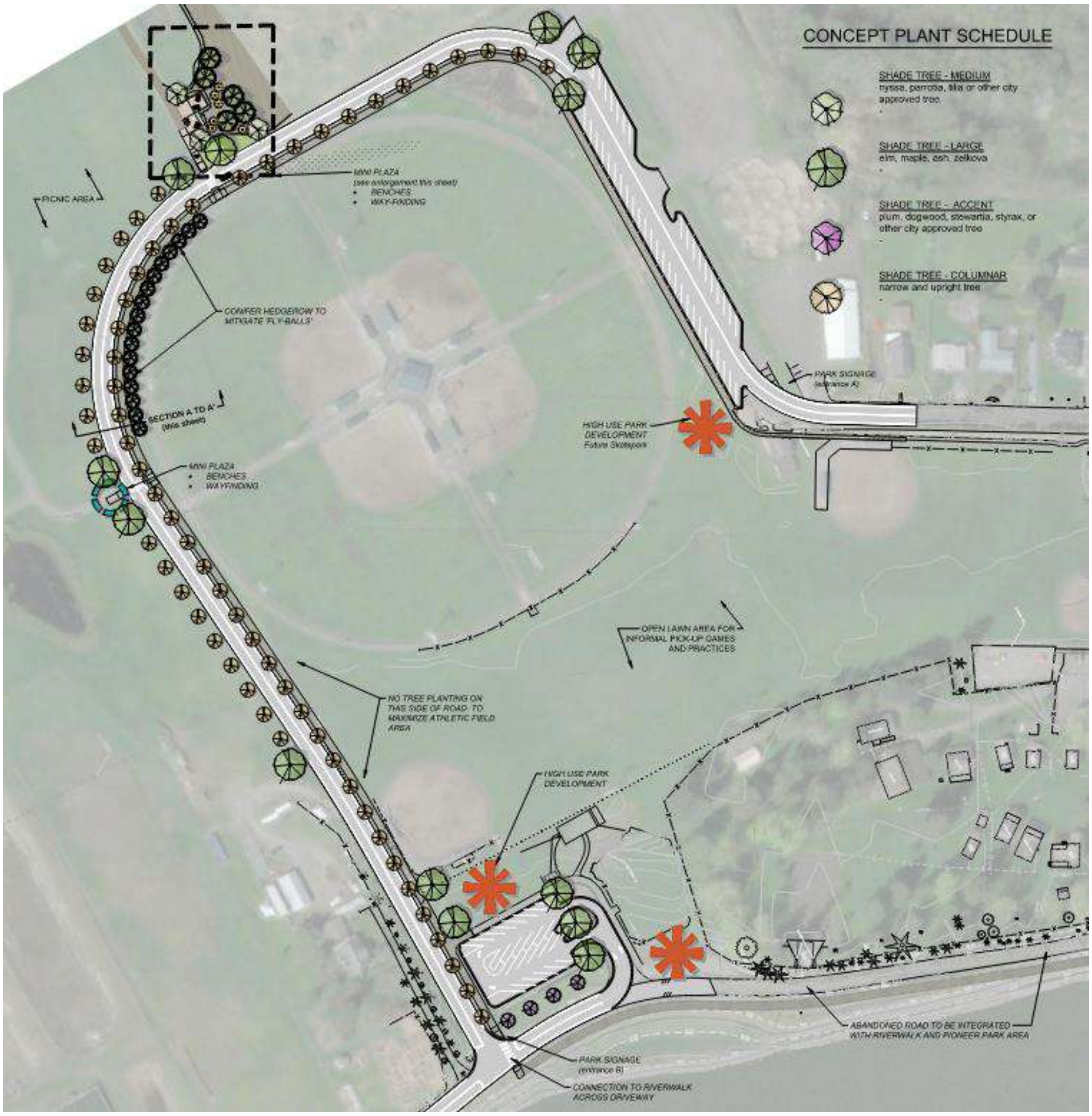
(Source: eccosDesign, 2021)

Figure 4. Network Alternative B – 1st Avenue Extension



(Source: eccosDesign, 2021)

Figure 5. Network Alternative D – Front Avenue Rebuild



(Source: eccosDesign, 2021)

Figure 6. Network Alternative E – 2nd Avenue Extension Western Route

Table 2. Comparison of Alternatives

	Traffic Pattern Impacts	Multimodal Safety Impacts
	Changes in traffic patterns may or may not impact surrounding land uses	Network changes may or may not increase safety risks within the study area
Alternative A **2nd Avenue Extension**	One benefit is that this alternative would create a direct route along 2nd Avenue through the study area. That creates a clear route from a Main Street signal to the recreation areas. Volume impacts would be positive or negative depending on location. Traffic along 1st Avenue and Cherry Street would reduce. All along 2nd Avenue, land uses would see more traffic along their frontage, which may include an occasional truck. At Main Street, likely to see more turning volumes shifting from 1st Avenue to 2nd Avenue (vehicles turning into or out of 1st Avenue shifted to turning into or out of 2nd Avenue). Intersection LOS would not change. Another benefit would be more direct access to the ball diamond parking areas from either direction.	One benefit is that this pulls traffic away from the waterfront. This allows for a low-risk trail experience with no road crossings between Star Park and Main Street. Other benefits include: (1) the new pedestrian amenities along the new extension, such as mixed-use pathway; (2) the new roadway alignment has several broad curves that should keep speeds lower by design, decreasing collision risks. New risks (negative impacts) include bisecting an active park area, so more pedestrians must cross the road between the ball fields and Star Park/Levee Trail.
Alternative B **1st Avenue Extension**	One benefit is that this alternative would create a direct route along 1st Avenue through the study area. That creates a clear route from Main Street to the recreation areas, though without a traffic signal. Volume impacts would be positive or negative depending on location. Traffic along 2nd Avenue and Cherry Street would reduce. All along 1st Avenue, land uses would see more traffic along their frontage, which may include an occasional truck. At Main Street, likely to see more turning volumes shifting from 2nd Avenue to 1st Avenue (mirroring Alternative A) but not enough that would suggest re-installing a traffic signal. Intersection LOS would not change.	This has similar benefits and risks as discussed in Alternative A. The alignment creates some potential new risks (negative impacts). First, the north end of the new alignment appears to traverse the community center parking lot that may present confusion for drivers and hazards for pedestrians. Possible mitigation is discussed below. 1st Avenue is also the location of Central Elementary School parent drop-off/pick-ups. Another negative impact is that the alignment does have more straight sections that may encourage higher speeds. The inclusion of the landscape median would help mitigate that risk.
Alternative D **Front Street Rebuild**	From a traffic pattern perspective, this scenario would largely represent the status quo. No new traffic pattern impacts.	A negative impact is that this alignment continues to have the crossing risk from Star Park to the Levee Trail. A positive benefit is that the proposed wall along the east side of the road would help protect pedestrians and bikes along the trail, and hinder “run off the road” collisions that caused a recent fatality.
Alternative E **2nd Avenue Extension Western Route**	Traffic benefits and impacts would be similar to Alternative A, except that overall traffic volume forecasts for the area may reduce. This alternative is fairly circuitous and discourages overall use by through traffic. While the shifts may be minor, they would likely push more traffic to Imhoff Road. In other words, volume impacts would be positive or negative depending on location but would be very minor.	This is similar to the benefits of Alternative A, but has two major additional risks (negative impacts): (1) This alignment traverses a major parking area north of the ball fields, creating a safety risk for pedestrians; (2) This alignment also has long straight segments that may encourage higher speeds. While this alignment is expected to have fewer pedestrian crossings, the alignment still bisects the southern soccer fields from ball diamonds creating pedestrian conflicts with higher vehicle speeds.

Source: Transpo Group, 2021

Findings

The following are general findings from the Ferndale Levee Improvement Project Traffic Analysis:

- Expected traffic volumes (existing and future) along the Front Avenue/Ferndale Road corridor (and proposed alternatives) are not high enough to be concerned about impacts to capacity or level of service.
- The traffic impact analysis focused on impacts due to traffic pattern changes and impacts due to multimodal safety.
- Alternative D has the least amount of traffic and safety impacts, mostly because it is following the same alignment as existing conditions and added safety design features.
- Alternative A has the next least amount of traffic and safety impacts. Most of the risks come from bisecting the Pioneer Park area.
- Compared to Alternative A, Alternative B has more traffic and safety impacts. These could be mitigated with revised plans for parking at the community center (such as removing on-street parking and provide off-street parking near the Boys & Girls Club or near the Ferndale Senior Center) and Central Elementary parent drop-off/pick up areas. Reinstalling the signal at 1st Avenue/Main Street is not recommended with Alternative B.
- Alternative E has the most traffic and safety impacts, relative to the other alternatives.

Appendix G: Cost Estimates

R&E Reichhardt & Ebe
ENGINEERING INC

423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By: Whatcom County River & Flood
For: FERNDALE LEVEE IMPROVEMENTS - ALTERNATE A
322 N. Commercial St.
Bellingham, WA 98225

PRELIMINARY ENGINEER'S ESTIMATE
By: IH / EV / BLB
Date: April 1, 2022

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
	Schedule A - Roadway and Storm				
1	Mobilization	1	LS	$ 110,000.00	$ 110,000.00
2	SPCC Plan	1	LS	$ 500.00	$ 500.00
3	Project Temporary Traffic Control	1	LS	$ 25,000.00	$ 25,000.00
4	Clearing and Grubbing	1	LS	$ 25,000.00	$ 25,000.00
5	Removal of Structures and Obstructions	1	LS	$ 15,000.00	$ 15,000.00
6	Sawcut ACP	660	LF-IN	$ 1.00	$ 660.00
7	Sawcut PCC	100	LF-IN	$ 1.75	$ 175.00
8	Roadway Excavation Incl. Haul	4,860	CY	$ 15.00	$ 72,900.00
9	Gravel Borrow Incl. Haul	6,600	TON	$ 15.00	$ 99,000.00
10	Water	100	M GAL.	$ 45.00	$ 4,500.00
11	Shoring or Extra Excavation Class B, Incl. Haul	10,760	SF	$ 0.10	$ 1,076.00
12	Crushed Surfacing Top Course	870	TON	$ 35.00	$ 30,450.00
13	HMA Cl. 1/2" PG 58H-22	1,860	TON	$ 110.00	$ 204,600.00
14	Stormwater Treatment Facilities	1	LS	$ 50,000.00	$ 50,000.00
15	Solid Wall PVC Storm Sewer Pipe 8 In. Diam.	235	LF	$ 30.00	$ 7,050.00
16	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	2,160	LF	$ 35.00	$ 75,600.00
17	Catch Basin Type 1	16	EA	$ 1,500.00	$ 24,000.00
18	Catch Basin Type 2 48 In. Diam.	5	EA	$ 3,500.00	$ 17,500.00
19	Adjustments to Finished Grade	1	LS	$ 5,000.00	$ 5,000.00
20	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
21	Topsoil Type A	3,650	SY	$ 11.00	$ 40,150.00
22	Seeded Lawn Installation	3,650	SY	$ 3.50	$ 12,775.00
23	Landscape Restoration	1	LS	$ 193,000.00	$ 193,000.00
24	Cement Conc. Traffic Curb and Gutter	4,115	LF	$ 25.00	$ 102,875.00
25	Cement Conc. Traffic Curb	1,390	LF	$ 30.00	$ 41,700.00
26	Cement Conc. Pedestrian Curb	190	LF	$ 40.00	$ 7,600.00
27	Cement Conc. Driveway Entrance	40	SY	$ 80.00	$ 3,200.00
28	Cement Conc. Sidewalk	1,220	SY	$ 50.00	$ 61,000.00
29	Cement Conc. Curb Ramp Type Combination	2	EA	$ 1,800.00	$ 3,600.00
30	Cement Conc. Curb Ramp Type Single Direction A	4	EA	$ 1,800.00	$ 7,200.00
31	Detectable Warning Surface	175	SF	$ 45.00	$ 7,875.00
32	Street Illumination System	12	EA	$ 7,500.00	$ 90,000.00
33	Conduit Pipe 2 In. Diam.	1,820	LF	$ 25.00	$ 45,500.00
34	Street Light Foundation	12	EA	$ 3,500.00	$ 42,000.00
35	Permanent Signing	1	LS	$ 7,500.00	$ 7,500.00
36	Paint Line	5,350	LF	$ 1.00	$ 5,350.00
37	Plastic Stop Line	36	LF	$ 20.00	$ 720.00
38	Plastic Crosswalk Line	216	SF	$ 10.00	$ 2,160.00
39	Plastic Traffic Arrow	6	EA	$ 250.00	$ 1,500.00
40	Pothole Existing Underground Utility	15	EA	$ 500.00	$ 7,500.00
41	Repair Existing Public and Private Facilities	1	EST	$ 15,000.00	$ 15,000.00
	Total Schedule A				$ 1,476,216.00

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
	Schedule B - Levee and Pedestrian Path				
42	Mobilization	1	LS	$ 75,000.00	$ 75,000.00
43	Clearing and Grubbing	1	LS	$ 10,000.00	$ 10,000.00
44	Removal of Structures and Obstructions	1	LS	$ 15,000.00	$ 15,000.00
45	Sawcut ACP	580	LF-IN	$ 1.00	$ 580.00
46	Roadway Excavation Incl. Haul	12,570	CY	$ 15.00	$ 188,550.00
47	Gravel Borrow Incl. Haul	630	TON	$ 15.00	$ 9,450.00
48	Water	50	M GAL.	$ 45.00	$ 2,250.00
49	Levee Fill Incl. Haul	8,300	TON	$ 12.00	$ 99,600.00
50	Crushed Surfacing Top Course	280	TON	$ 35.00	$ 9,800.00
51	HMA Cl. 1/2" PG 58H-22	150	TON	$ 110.00	$ 16,500.00
52	Pedestrian Railing	1,320	LF	$ 120.00	$ 158,400.00
53	Adjustments to Finished Grade	1	LS	$ 2,500.00	$ 2,500.00
54	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
55	Topsoil Type A	8,650	SY	$ 11.00	$ 95,150.00
56	Seeded Lawn Installation	8,650	SY	$ 3.50	$ 30,275.00
57	Planting Plan Levee and Habitat Bench	1	LS	$ 90,500.00	$ 90,500.00
58	Path Illumination System	9	EA	$ 7,500.00	$ 67,500.00
59	Conduit Pipe 2 In. Diam.	1,315	LF	$ 25.00	$ 32,875.00
60	Street Light Foundation	9	EA	$ 3,500.00	$ 31,500.00
61	Permanent Signing	1	LS	$ 2,500.00	$ 2,500.00
62	Pothole Existing Underground Utility	10	EA	$ 500.00	$ 5,000.00
63	Repair Existing Public and Private Facilities	1	EST	$ 10,000.00	$ 10,000.00
64	Slope Protection	1	LS	$ 750,000.00	$ 750,000.00
	Total Schedule B				$ 1,712,930.00

TOTAL SCHEDULES A AND B	$ 3,189,146.00
Project Escalation (15%)	$ 478,372.00
Construction Management (15%)	$ 478,372.00
Final Design (6%)	$ 191,350.00

ROW Acquisition	52,665	SF	$ 15.00	$ 789,975.00

GRAND TOTAL INCLUDING ROW - ALT A	$ 5,127,215.00

Note:
This estimate was prepared without a complete design and shall therefore be considered preliminary and subject to change due to actual quantities of work incorporated into the project and changes in unit prices over time.

Reichhardt & Ebe
ENGINEERING INC
423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By: Whatcom County River & Flood
For: FERNDALE LEVEE IMPROVEMENTS - ALTERNATE B
322 N. Commercial St.
Bellingham, WA 98225

PRELIMINARY ENGINEER'S ESTIMATE
By: IH / EV / BLB
Date: April 1, 2022

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
	Schedule A - Roadway and Storm				
1	Mobilization	1	LS	$ 145,000.00	$ 145,000.00
2	SPCC Plan	1	LS	$ 500.00	$ 500.00
3	Project Temporary Traffic Control	1	LS	$ 25,000.00	$ 25,000.00
4	Clearing and Grubbing	1	LS	$ 25,000.00	$ 25,000.00
5	Removal of Structures and Obstructions	1	LS	$ 20,000.00	$ 20,000.00
6	Sawcut ACP	2,190	LF-IN	$ 1.00	$ 2,190.00
7	Sawcut PCC	252	LF-IN	$ 1.75	$ 441.00
8	Roadway Excavation Incl. Haul	5,070	CY	$ 15.00	$ 76,050.00
9	Gravel Borrow Incl. Haul	10,540	TON	$ 15.00	$ 158,100.00
10	Water	100	M GAL.	$ 45.00	$ 4,500.00
11	Shoring or Extra Excavation Class B, Incl. Haul	14,330	SF	$ 0.10	$ 1,433.00
12	Crushed Surfacing Top Course	1,420	TON	$ 35.00	$ 49,700.00
13	HMA Cl. 1/2" PG 58H-22	3,030	TON	$ 110.00	$ 333,300.00
14	Stormwater Treatment Facilities	1	LS	$ 70,000.00	$ 70,000.00
15	Solid Wall PVC Storm Sewer Pipe 8 In. Diam.	360	LF	$ 30.00	$ 10,800.00
16	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	2,830	LF	$ 35.00	$ 99,050.00
17	Catch Basin Type 1	28	EA	$ 1,500.00	$ 42,000.00
18	Catch Basin Type 2 48 In. Diam.	10	EA	$ 3,500.00	$ 35,000.00
19	Adjustments to Finished Grade	1	LS	$ 7,500.00	$ 7,500.00
20	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
21	Topsoil Type A	5,800	SY	$ 11.00	$ 63,800.00
22	Seeded Lawn Installation	5,800	SY	$ 3.50	$ 20,300.00
23	Landscape Restoration	1	LS	$ 109,000.00	$ 109,000.00
24	Cement Conc. Traffic Curb and Gutter	5,460	LF	$ 25.00	$ 136,500.00
25	Cement Conc. Traffic Curb	835	LF	$ 30.00	$ 25,050.00
26	Cement Conc. Pedestrian Curb	205	LF	$ 40.00	$ 8,200.00
27	Manufactured Wheel Stop	17	EA	$ 100.00	$ 1,700.00
28	Cement Conc. Sidewalk	2,060	SY	$ 50.00	$ 103,000.00
29	Cement Conc. Curb Ramp Type Parallel A	1	EA	$ 1,800.00	$ 1,800.00
30	Cement Conc. Curb Ramp Type Parallel B	2	EA	$ 1,800.00	$ 3,600.00
31	Cement Conc. Curb Ramp Type Perpendicular A	1	EA	$ 1,800.00	$ 1,800.00
32	Cement Conc. Curb Ramp Type Single Direction A	5	EA	$ 1,800.00	$ 9,000.00
33	Detectable Warning Surface	215	SF	$ 45.00	$ 9,675.00
34	Street Illumination System	18	EA	$ 7,500.00	$ 135,000.00
35	Conduit Pipe 2 In. Diam.	2,525	LF	$ 25.00	$ 63,125.00
36	Street Light Foundation	18	EA	$ 3,500.00	$ 63,000.00
37	Permanent Signing	1	LS	$ 7,500.00	$ 7,500.00
38	Paint Line	8,685	LF	$ 1.00	$ 8,685.00
39	Plastic Stop Line	48	LF	$ 20.00	$ 960.00
40	Plastic Crosswalk Line	216	SF	$ 10.00	$ 2,160.00
41	Plastic Traffic Arrow	6	EA	$ 250.00	$ 1,500.00
42	Pothole Existing Underground Utility	15	EA	$ 500.00	$ 7,500.00
43	Repair Existing Public and Private Facilities	1	EST	$ 15,000.00	$ 15,000.00
	Total Schedule A				$ 1,913,419.00

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
	Schedule B - Levee and Pedestrian Path				
44	Mobilization	1	LS	$ 75,000.00	$ 75,000.00
45	Clearing and Grubbing	1	LS	$ 10,000.00	$ 10,000.00
46	Removal of Structures and Obstructions	1	LS	$ 15,000.00	$ 15,000.00
47	Sawcut ACP	580	LF-IN	$ 1.00	$ 580.00
48	Roadway Excavation Incl. Haul	12,570	CY	$ 15.00	$ 188,550.00
49	Gravel Borrow Incl. Haul	630	TON	$ 15.00	$ 9,450.00
50	Water	50	M GAL.	$ 45.00	$ 2,250.00
51	Levee Fill Incl. Haul	8,300	TON	$ 12.00	$ 99,600.00
52	Crushed Surfacing Top Course	280	TON	$ 35.00	$ 9,800.00
53	HMA Cl. 1/2" PG 58H-22	150	TON	$ 110.00	$ 16,500.00
54	Pedestrian Railing	1,320	LF	$ 120.00	$ 158,400.00
55	Adjustments to Finished Grade	1	LS	$ 2,500.00	$ 2,500.00
56	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
57	Topsoil Type A	8,650	SY	$ 11.00	$ 95,150.00
58	Seeded Lawn Installation	8,650	SY	$ 3.50	$ 30,275.00
59	Planting Plan Levee and Habitat Bench	1	LS	$ 90,500.00	$ 90,500.00
60	Path Illumination System	9	EA	$ 7,500.00	$ 67,500.00
61	Conduit Pipe 2 In. Diam.	1,315	LF	$ 25.00	$ 32,875.00
62	Street Light Foundation	9	EA	$ 3,500.00	$ 31,500.00
63	Permanent Signing	1	LS	$ 2,500.00	$ 2,500.00
64	Pothole Existing Underground Utility	10	EA	$ 500.00	$ 5,000.00
65	Repair Existing Public and Private Facilities	1	EST	$ 10,000.00	$ 10,000.00
66	Slope Protection	1	LS	$ 750,000.00	$ 750,000.00
	Total Schedule B				$ 1,712,930.00

TOTAL SCHEDULES A AND B	$ 3,626,349.00
Project Escalation (15%)	$ 543,954.00
Construction Management (15%)	$ 543,954.00
Final Design (6%)	$ 217,582.00

ROW Acquisition	102,600	SF	$ 15.00	$ 1,539,000.00

GRAND TOTAL INCLUDING ROW - ALT B	$ 6,470,839.00

Note:

This estimate was prepared without a complete design and shall therefore be considered preliminary and subject to change due to actual quantities of work incorporated into the project and changes in unit prices over time.

Reichhardt & Ebe
ENGINEERING INC

423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By: For:	Whatcom County River & Flood FERNDALE LEVEE IMPROVEMENTS - ALTERNATE D 322 N. Commercial St. Bellingham, WA 98225
	PRELIMINARY ENGINEER'S ESTIMATE
By: Date:	IH / EV / BLB April 1, 2022

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
1	Mobilization	1	LS	$ 355,000.00	$ 355,000.00
2	SPCC Plan	1	LS	$ 500.00	$ 500.00
3	Project Temporary Traffic Control	1	LS	$ 50,000.00	$ 50,000.00
4	Clearing and Grubbing	1	LS	$ 20,000.00	$ 20,000.00
5	Removal of Structures and Obstructions	1	LS	$ 15,000.00	$ 15,000.00
6	Sawcut ACP	415	LF-IN	$ 1.00	$ 415.00
7	Sawcut PCC	166	LF-IN	$ 1.75	$ 290.50
8	Roadway Excavation Incl. Haul	7,180	CY	$ 15.00	$ 107,700.00
9	Gravel Borrow Incl. Haul	7,700	TON	$ 15.00	$ 115,500.00
10	Embankment Compaction	1,100	CY	$ 10.00	$ 11,000.00
11	Water	150	M GAL.	$ 45.00	$ 6,750.00
12	Structure Excavation Class A Incl. Haul	200	CY	$ 50.00	$ 10,000.00
13	Shoring or Extra Excavation Cl. A	1	LS	$ 10,000.00	$ 10,000.00
14	Shoring or Extra Excavation Class B	11,715	SF	$ 0.10	$ 1,171.50
15	Crushed Surfacing Top Course	1,210	TON	$ 35.00	$ 42,350.00
16	HMA Cl. 1/2" PG 58H-22	2,180	TON	$ 110.00	$ 239,800.00
17	Conc. Class 3000 for Wall	550	CY	$ 750.00	$ 412,500.00
18	Stop Log Assemblies Including Aluminum Stop Logs	1	LS	$ 128,000.00	$ 128,000.00
19	Steel Sheet Piles Furnishing and Driving	30,800	SF	$ 45.00	$ 1,386,000.00
20	Pedestrian Railing	1,440	LF	$ 120.00	$ 172,800.00
21	St. Reinf. Bar for Wall	61,600	LB	$ 2.00	$ 123,200.00
22	Stormwater Treatment Facilities	1	LS	$ 50,000.00	$ 50,000.00
23	Solid Wall PVC Storm Sewer Pipe 8 In. Diam.	260	LF	$ 30.00	$ 7,800.00
24	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	2,345	LF	$ 35.00	$ 82,075.00
25	Catch Basin Type 1	22	EA	$ 1,500.00	$ 33,000.00
26	Catch Basin Type 2 48 In. Diam.	7	EA	$ 3,500.00	$ 24,500.00
27	Adjustments to Finished Grade	1	LS	$ 7,500.00	$ 7,500.00
28	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
29	Topsoil Type A	5,700	SY	$ 11.00	$ 62,700.00
30	Seeded Lawn Installation	5,700	SY	$ 3.50	$ 19,950.00
31	Landscape Restoration	1	LS	$ 55,000.00	$ 55,000.00
32	Planting Plan Levee	1	LS	$ 72,400.00	$ 72,400.00
33	Cement Conc. Traffic Curb and Gutter	4,085	LF	$ 25.00	$ 102,125.00
34	Cement Conc. Pedestrian Curb	160	LF	$ 40.00	$ 6,400.00
35	Cement Conc. Sidewalk	340	SY	$ 50.00	$ 17,000.00
36	Cement Conc. Curb Ramp Type Combination	1	EA	$ 1,800.00	$ 1,800.00
37	Cement Conc. Curb Ramp Type Parallel B	1	EA	$ 1,800.00	$ 1,800.00
38	Cement Conc. Curb Ramp Type Perpendicular B	3	EA	$ 1,800.00	$ 5,400.00
39	Cement Conc. Curb Ramp Type Single Direction A	1	EA	$ 1,800.00	$ 1,800.00
40	Street and Path Illumination System	13	EA	$ 7,500.00	$ 97,500.00
41	Conduit Pipe 2 In. Diam.	2,015	LF	$ 25.00	$ 50,375.00
42	Street Light Foundation	13	EA	$ 3,500.00	$ 45,500.00
43	Permanent Signing	1	LS	$ 7,500.00	$ 7,500.00
44	Paint Line	5,260	LF	$ 1.00	$ 5,260.00
45	Plastic Stop Line	24	LF	$ 20.00	$ 480.00
46	Plastic Crosswalk Line	96	SF	$ 10.00	$ 960.00

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
47	Plastic Traffic Arrow	8	EA	$ 250.00	$ 2,000.00
48	Pothole Existing Underground Utility	15	EA	$ 500.00	$ 7,500.00
49	Repair Existing Public and Private Facilities	1	EST	$ 15,000.00	$ 15,000.00
50	Slope Protection	1	LS	$ 750,000.00	$ 750,000.00
	Subtotal				$ 4,751,302.00
	Project Escalation (15%)				$ 712,696.00
	Construction Management (15%)				$ 712,696.00
	Final Design (6%)				$ 285,080.00
	GRAND TOTAL - ALT D				$ 6,461,774.00

Note:
This estimate was prepared without a complete design and shall therefore be considered preliminary and subject to change due to actual quantities of work incorporated into the project and changes in unit prices over time.

Reichhardt & Ebe
ENGINEERING INC
423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By: Whatcom County River & Flood
For: FERNDALE LEVEE IMPROVEMENTS - ALTERNATE E
322 N. Commercial St.
Bellingham, WA 98225

PRELIMINARY ENGINEER'S ESTIMATE

By: IH / EV / BLB
Date: April 1, 2022

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
	Schedule A - Roadway and Storm				
1	Mobilization	1	LS	$ 195,000.00	$ 195,000.00
2	SPCC Plan	1	LS	$ 500.00	$ 500.00
3	Project Temporary Traffic Control	1	LS	$ 25,000.00	$ 25,000.00
4	Clearing and Grubbing	1	LS	$ 30,000.00	$ 30,000.00
5	Removal of Structures and Obstructions	1	LS	$ 20,000.00	$ 20,000.00
6	Sawcut ACP	510	LF-IN	$ 1.00	$ 510.00
7	Sawcut PCC	38	LF-IN	$ 1.75	$ 66.50
8	Roadway Excavation Incl. Haul	5,450	CY	$ 15.00	$ 81,750.00
9	Gravel Borrow Incl. Haul	11,400	TON	$ 15.00	$ 171,000.00
10	Water	100	M GAL.	$ 45.00	$ 4,500.00
11	Shoring or Extra Excavation Class B, Incl. Haul	17,205	SF	$ 0.10	$ 1,720.50
12	Crushed Surfacing Top Course	1,530	TON	$ 35.00	$ 53,550.00
13	HMA Cl. 1/2" PG 58H-22	3,270	TON	$ 110.00	$ 359,700.00
14	Stormwater Treatment Facilities	1	LS	$ 75,000.00	$ 75,000.00
15	Solid Wall PVC Storm Sewer Pipe 8 In. Diam.	495	LF	$ 30.00	$ 14,850.00
16	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	3,330	LF	$ 35.00	$ 116,550.00
17	Catch Basin Type 1	32	EA	$ 1,500.00	$ 48,000.00
18	Catch Basin Type 2 48 In. Diam.	9	EA	$ 3,500.00	$ 31,500.00
19	Adjustments to Finished Grade	1	LS	$ 7,500.00	$ 7,500.00
20	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
21	Topsoil Type A	6,800	SY	$ 11.00	$ 74,800.00
22	Seeded Lawn Installation	6,800	SY	$ 3.50	$ 23,800.00
23	Landscape Restoration	1	LS	$ 211,000.00	$ 211,000.00
24	Cement Conc. Traffic Curb and Gutter	7,050	LF	$ 25.00	$ 176,250.00
25	Cement Conc. Pedestrian Curb	230	LF	$ 40.00	$ 9,200.00
26	Cement Conc. Sidewalk	2,730	SY	$ 50.00	$ 136,500.00
27	Cement Conc. Curb Ramp Type Combination	3	EA	$ 1,800.00	$ 5,400.00
28	Cement Conc. Curb Ramp Type Single Direction A	3	EA	$ 1,800.00	$ 5,400.00
29	Cement Conc. Curb Ramp Type Parallel A	1	EA	$ 1,800.00	$ 1,800.00
30	Detectable Warning Surface	135	SF	$ 45.00	$ 6,075.00
31	Street Illumination System	22	EA	$ 7,500.00	$ 165,000.00
32	Conduit Pipe 2 In. Diam.	3,345	LF	$ 25.00	$ 83,625.00
33	Street Light Foundation	22	EA	$ 3,500.00	$ 77,000.00
34	Permanent Signing	1	LS	$ 7,500.00	$ 7,500.00
35	Paint Line	10,305	LF	$ 1.00	$ 10,305.00
36	Plastic Stop Line	36	LF	$ 20.00	$ 720.00
37	Plastic Crosswalk Line	248	SF	$ 10.00	$ 2,480.00
38	Plastic Traffic Arrow	6	EA	$ 250.00	$ 1,500.00
39	Pothole Existing Underground Utility	15	EA	$ 500.00	$ 7,500.00
40	Repair Existing Public and Private Facilities	1	EST	$ 15,000.00	$ 15,000.00
41	Wetland Mitigation	1.05	AC	$ 330,000.00	$ 346,500.00
	Total Schedule A				$ 2,614,052.00

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
	Schedule B - Levee and Pedestrian Path				
42	Mobilization	1	LS	$ 75,000.00	$ 75,000.00
42	Clearing and Grubbing	1	LS	$ 10,000.00	$ 10,000.00
43	Removal of Structures and Obstructions	1	LS	$ 15,000.00	$ 15,000.00
44	Sawcut ACP	580	LF-IN	$ 1.00	$ 580.00
45	Roadway Excavation Incl. Haul	12,570	CY	$ 15.00	$ 188,550.00
46	Gravel Borrow Incl. Haul	630	TON	$ 15.00	$ 9,450.00
47	Water	50	M GAL.	$ 45.00	$ 2,250.00
48	Levee Fill Incl. Haul	8,300	TON	$ 12.00	$ 99,600.00
49	Crushed Surfacing Top Course	280	TON	$ 35.00	$ 9,800.00
50	HMA Cl. 1/2" PG 58H-22	150	TON	$ 110.00	$ 16,500.00
51	Pedestrian Railing	1,320	LF	$ 120.00	$ 158,400.00
52	Adjustments to Finished Grade	1	LS	$ 2,500.00	$ 2,500.00
53	Erosion Control and Water Pollution Prevention	1	LS	$ 10,000.00	$ 10,000.00
54	Topsoil Type A	8,650	SY	$ 11.00	$ 95,150.00
55	Seeded Lawn Installation	8,650	SY	$ 3.50	$ 30,275.00
56	Planting Plan Levee and Habitat Bench	1	LS	$ 90,500.00	$ 90,500.00
57	Path Illumination System	9	EA	$ 7,500.00	$ 67,500.00
58	Conduit Pipe 2 In. Diam.	1,315	LF	$ 25.00	$ 32,875.00
59	Street Light Foundation	9	EA	$ 3,500.00	$ 31,500.00
60	Permanent Signing	1	LS	$ 2,500.00	$ 2,500.00
61	Pothole Existing Underground Utility	10	EA	$ 500.00	$ 5,000.00
62	Repair Existing Public and Private Facilities	1	EST	$ 10,000.00	$ 10,000.00
63	Slope Protection	1	LS	$ 750,000.00	$ 750,000.00
	Total Schedule B				$ 1,712,930.00

TOTAL SCHEDULES A AND B	$ 4,326,982.00
Project Escalation (15%)	$ 649,048.00
Construction Management (15%)	$ 649,048.00
Final Design (6%)	$ 259,620.00

ROW Acquisition	160,500	SF	$ 15.00	$ 2,407,500.00

GRAND TOTAL INCLUDING ROW - ALT E	$ 8,292,198.00

Note:
This estimate was prepared without a complete design and shall therefore be considered preliminary and subject to change due to actual quantities of work incorporated into the project and changes in unit prices over time.

Reichhardt & Ebe
ENGINEERING INC

423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By: Whatcom County River & Flood
For: FERNDALE LEVEE IMPROVEMENTS - FERNDALE ROAD SOUTH OF STAR PARK
322 N. Commercial St.
Bellingham, WA 98225

PRELIMINARY ENGINEER'S ESTIMATE

By: IH / EV
Date: November 24, 2021

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
1	Mobilization	1	LS	$ 590,000.00	$ 590,000.00
2	SPCC Plan	1	LS	$ 500.00	$ 500.00
3	Flaggers	3,600	HR	$ 65.00	$ 234,000.00
4	Other Traffic Control Labor	360	HR	$ 65.00	$ 23,400.00
5	Other Temporary Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
6	Clearing and Grubbing	1	LS	$ 15,000.00	$ 15,000.00
7	Removal of Structures and Obstructions	1	LS	$ 15,000.00	$ 15,000.00
8	Sawcut ACP	510	LF-IN	$ 1.00	$ 510.00
9	Roadway Excavation Incl. Haul	5,325	CY	$ 15.00	$ 79,875.00
10	Gravel Borrow Incl. Haul	20,300	TON	$ 15.00	$ 304,500.00
11	Water	100	M GAL.	$ 45.00	$ 4,500.00
12	Shoring or Extra Excavation Class B	16,100	SF	$ 0.10	$ 1,610.00
13	Levee Fill Incl. Haul	63,900	TON	$ 12.00	$ 766,800.00
14	Crushed Surfacing Top Course	3,100	TON	$ 35.00	$ 108,500.00
15	HMA Cl. 1/2" PG 58H-22	5,300	TON	$ 110.00	$ 583,000.00
16	Furnishing and Driving Steel Sheet Piles	35,000	SF	$ 52.00	$ 1,820,000.00
17	Structural Earth Wall	14,200	SF	$ 60.00	$ 852,000.00
18	Stormwater Treatment Facilities	1	LS	$ 150,000.00	$ 150,000.00
19	Solid Wall PVC Storm Sewer Pipe 8 In. Diam.	660	LF	$ 30.00	$ 19,800.00
20	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	2,910	LF	$ 35.00	$ 101,850.00
21	Catch Basin Type 1	40	EA	$ 1,500.00	$ 60,000.00
22	Catch Basin Type 2 48 In. Diam.	10	EA	$ 3,500.00	$ 35,000.00
23	Adjustments to Finished Grade	1	LS	$ 5,000.00	$ 5,000.00
24	Erosion Control and Water Pollution Prevention	1	LS	$ 20,000.00	$ 20,000.00
25	Topsoil Type A	27,810	SY	$ 12.00	$ 333,720.00
26	Seeding and Mulching	5.00	AC	$ 3,000.00	$ 15,000.00
27	Landscape Restoration	1	EST	$ 5,000.00	$ 5,000.00
28	Cement Conc. Traffic Curb and Gutter	5,855	LF	$ 25.00	$ 146,375.00
29	Beam Guardrail Type 31	285	LF	$ 40.00	$ 11,400.00
30	Beam Guardrail Type 31 Non-Flared Terminal	4	EA	$ 4,500.00	$ 18,000.00
31	Conduit Pipe 2 In. Diam.	1,600	LF	$ 25.00	$ 40,000.00
32	Street Light Foundation	11	EA	$ 3,500.00	$ 38,500.00
33	Permanent Signing	1	LS	$ 2,500.00	$ 2,500.00
34	Paint Line	17,055	LF	$ 1.00	$ 17,055.00
35	Plastic Stop Line	12	LF	$ 20.00	$ 240.00
36	Pothole Existing Underground Utility	5	EA	$ 500.00	$ 2,500.00
37	Repair Existing Public and Private Facilities	1	EST	$ 15,000.00	$ 15,000.00
38	Slope Protection	1	LS	$ 3,750,000.00	$ 3,750,000.00
	Subtotal				$ 10,196,135.00
	Project Escalation (15%)				$ 1,529,422.00
	Construction Management (15%)				$ 1,529,422.00
	Final Design (6%)				$ 611,770.00
	ROW Acquisition	168,200	SF	$ 2.00	$ 336,400.00
	GRAND TOTAL INCLUDING ROW - SOUTH OF STAR PARK				$ 14,203,149.00

Note:
This estimate was prepared without a complete design and shall therefore be considered preliminary and subject to change due to actual quantities of work incorporated into the project and changes in unit prices over time.

Appendix H: Stakeholder Workshop Agenda and Sign-in Sheet

Whatcom County – Ferndale Levee Improvements

Ferndale Road Alignment Alternative Selection Workshop

Location – Ferndale Library

When – 4/19/2022, 9:00 AM to 2:00 PM

Attendees –

Project Team

Owner

- River and Flood Manager................................ Paula Harris
- Project Manager... Daniel Goger
- Project Engineer... Gary Goodall

Design Team Present

- R&E – Project Manager/Principal.................... Nathan Zylstra
- R&E – Lead Civil Engineer .... Ian Hinton
- R&E – Project Engineer................................... Eric Vavra
- NHC – Project Manager/Hydraulic Engineer ... Jaron Brown
- NHC – Principal/Hydraulic Engineer .... Vaughn Collins

Primary Stakeholders

City of Ferndale Public Works

- Public Works Director..................................... Kevin Renz
- Surface/Stormwater Manager .... Paul Knippel
- City of Ferndale .... Jori Burnett
- City of Ferndale .... Michael Cerbone

Whatcom County PUD No. 1

- Director of Utility Operations .... Duane Holden

Washington Department of Fish and Wildlife

- Habitat Biologist... Joel Ingram

Lummi Nation

- Deputy Water Resources Manager .... Kara D. Kuhlman
- Natural Resources Specialist........................... Frank Lawrence III

Nooksack Indian Tribe

- Fisheries and Resource Protection Manager ... Ned Currence
- Forest and Fish Specialist, Geomorphologist... Mike Maudlin

Schedule –

9:15a – Introductions (County)

- Purpose of this meeting/workshop
- Project Team
- Primary Stakeholders

9:30a – Levee History and Background (County)

- Ferndale Levees Overview
- History
- Condition Inspections
- Nooksack River SWIF

9:40a – Project Purpose and Need (County)

- Background and Location
- Purpose and Need

9:45a – Road Alignment Alternatives Overview (R&E)

- Conceptual Roadway Alternatives Memo – late Nov. 2020
    - Looked at 5 concepts
    - Narrowed the field to 4 after Alternative C
- Design Assumptions
- Existing Alignment Alternative
    - Alternative D – Ferndale Rd. (Existing Alignment)
- New Alignment Alternatives
    - Alternative A – 2nd Ave Extension
    - Alternative B – 1st Ave Extension
    - Alternative E – 2nd Ave Routed West

10:05a – Q&A

10:15a – Start Evaluation Criteria and Weighting Exercise (R&E)

- Review Criteria
- Introduce Weighting Process
- Weighting Exercise

12:00p – Lunch (~0.5 hr)

12:30p – Finish Evaluation Criteria Weighting Exercise

1:15p – Scoring and Ranking Exercise (R&E)

- Scoring Exercise
- Rank and Select Preferred Alternative
- Next Steps

2:00p – Meeting End

Sign - In Sheet

Ferndale Levee Improvement Project

Stakeholder Meeting

Whatcom County Public Works - River & Flood Division

April 19, 2022

Name	Company	Phone	Email
Kara Kuhlman	Lummi Nation	(360)312-2128	Karak@lummi-nsn.gov
Joel Ingram	WDFW	360 584-6339	Joel.Ingram@dfw.wa.gov
Paul Knippel	City of Ferndale	360-685-2357	paulknippel@cityofferndale.org
Duane Holden	Whatcom PUD	360-305-9806	DuaneHolden@Pudwhatcom.org
KEVIN RENZ	CITY OF FERNDALE	360-685-2376	KEVINRENZ@CITYOFFERNDALE.ORG
Mike Cerbone	City of Ferndale	360 685-2315	michaelcerbone@ "
JAROD BROWN	Northwest Hydraulic Consultants	206 241 6000	jbrown@nhcweb.com
VAUGHN COLLINS	" "	" "	vcollins@nhcweb.com
Danny Goger	Whatcom County	(360) 389-8304	~~dgoger@g~~ dgoger@co.whatcom.wa.us
Ned Currence	Nooksack Tribe	360 592 5140 ext 3157	NCurrence@Nooksack-nsn.gov
Paula Harris	WCPW	360 778 6285	pharris@co.whatcom.wa.us
JOHN N. THOMPSON	WCPW	360. 778. 6295	jnthomps@co.whatcom.wa.us
IAN HINTON	R+E	360 354 3687	ihinton@recivil.com
ERIC VAVRA	R&E		
Nathan Zylstra	R&E	360 354-3687	nathanz@recivil.com