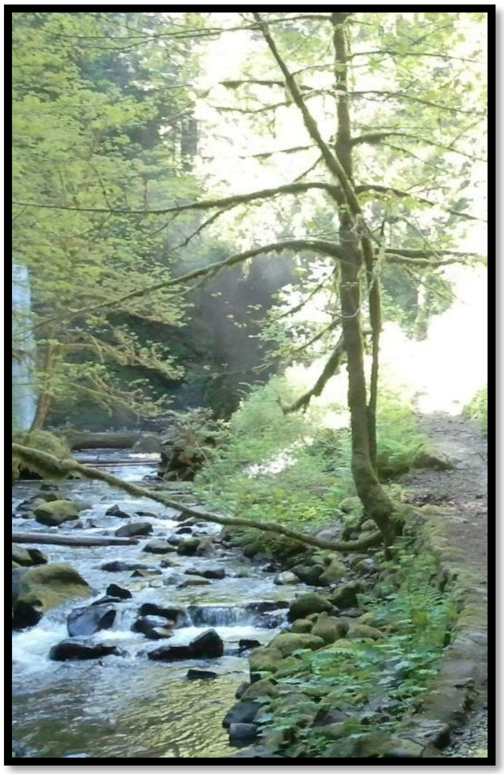
WINDSOR ENGINEERS

PRELIMINARY STORMWATER

TECHNICAL INFORMATION REPORT
JANUARY 17, 2023



Cowlitz Meadows Subdivision.

City of Toledo, Washington

1/12/2023

Revision Log		
0	04-19-2022	Preliminary Plat Application
1	04-27-2022	Preliminary Plat Application - Revision
2	06-20-2022	Response to Incompleteness Determination
3		Response to Engineering & Stormwater Comments

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1.0 CERTIFICATION PAGE

CERTIFICATE OF THE ENGINEER

Title: Preliminary Stormwater Technical Information Report

Project: Cowlitz Meadows Subdivision.

This Technical Information Report (TIR) has been prepared under my supervision and meets the standard of care for similar documents within this community. The TIR includes the required information per the below references and complies with the code. The proposed stormwater design is feasible.

References:

2019 Stormwater Management Manual for Western Washington (The 2019 SWMMWW) – Department of Ecology, State of Washington

Windsor Engineers LLC

01/17/2023

Designed By: Emily Stephens, PE

2.0 REFERENCES

Clean Water Act. (n.d.). Retrieved from https://www.epa.gov/laws-regulations/summary-clean-water-act

Department of Ecology. (n.d.). Western Washington Stormwater Manual (WWSWM). Retrieved from https://www.clark.wa.gov/public-works/stormwater-code-and-manual

DOE Water Quality Permits. (n.d.). Retrieved from https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-quality-permits

Lewis County Code Chapter 15.45 Stormwater Management. (n.d.). Retrieved from https://www.codepublishing.com/WA/LewisCounty/html/LewisCounty15/LewisCounty1545.html

National Pollutant Discharge Elimination System (NPDES). (n.d.). Retrieved from https://www.epa.gov/npdes

Washington Department of Ecology. (n.d.). Construction Stormwater General Permit. Retrieved from https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Construction-stormwater-permit

Washington State Department of Ecology. (n.d.). DOE Stormwater Manuals. Retrieved from https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals

3.0 PROJECT TEAM

Jurisdiction	City of Toledo
Developer	Red Rock Construction Max Halberg PO Box 1724 Battle Ground, WA 98604 (360) 984-1727
Civil Engineer	Windsor Engineers LLC 27300 NE 10th Avenue Ridgefield, WA 98642 360.610.4931 Designed By: Emily Stephens, PE, Civil Engineer estephens@windsorengineers.com

4.0 GENERAL

Purpose and Scope

The purpose of this report is to demonstrate preliminary feasibility of stormwater management associated with the construction of the of the Cowlitz Meadows Subdivision. This report will evaluate and describe the proposed stormwater conveyance, water quality, and water quantity design.

4.1

Project Location

4.2

Address	0 Toledo Vader Rd, Toledo
Parcels	011438001000
Area	36.62 acres
Section-Township-Range	07-11N-01W
Jurisdiction	City of Toledo

Project Description

4.3

The project site is located on a 36.62-acre parcel (011438001000) at Toledo WA, 98632 within the rural area of Lewis County (Figure 1). The developer plans to construct 97 single-family homes. There are currently no existing structures; the land is unused when not being farmed.

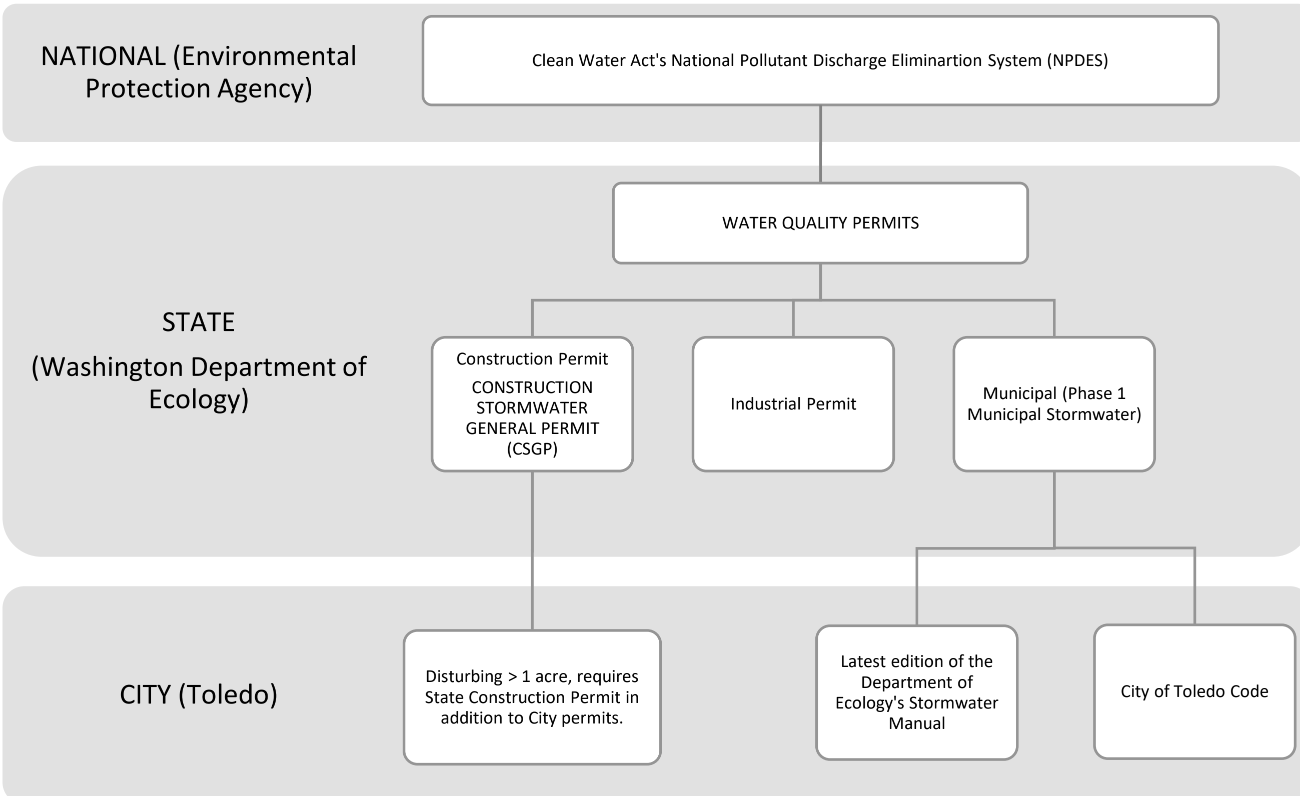
The site topography is generally flat with slopes of 10-15 percent (%). A ridge that is approximately 200-feet wide runs from Toledo Vader, westward across the site with slopes exceeding 15%. The ridge sections the property off into a north and a south portion. The single-family residences will be constructed on the north portion where minimal slopes range from 5-10%. A geotechnical analysis has been completed for the site; and is included in Appendix B. According to the Lewis County Geographic Information System (GIS), soil types near the site are primarily Lacamas Silt Loam, with some hydric soils around the ridge and south of the ridge. Soil data from Web Soil Survey is included in Appendix B. There is an existing wetland on the site that will not be disturbed, south of the ridge, just west of Toledo Vader Road. A critical areas analysis has been completed and can be seen in Appendix E.

For the purposes of this report and stormwater, the project site is defined as the entire 36.62-acre parcel; however, only 20.66 acres will be disturbed for the development. Site grading will be done in a manner that will drain runoff away from the homes. Runoff from the roofs and lots will primarily drain to the street where it will be captured in storm sewer pipes and routed to a wet pond and detention basin. Because of the steep slopes, low infiltration potential, and shallow groundwater, low impact development measures will be taken, and splash blocks will be installed with each home. A stormwater pond, as shown in Appendix A, will treat all impervious surfaces on the site and provide for flow control before the runoff enters the downstream wetland on-site.

Figure 1: Project Location via Lewis County GIS Base Map

4.4 Applicable Codes and Standards

To protect our country's waters, legislature was enacted starting very broadly as the Clean Water Act of 1972, administered by the Environmental Protection Agency (EPA) as the National Pollutant Discharge Elimination System (NPDES) and subsequently delegated to the local (state) authority as a Washington Department of Ecology (DOE) Water Quality Permit, and finally managed as the Construction Stormwater General Permit (CSGP). Washington State implements the CSGP through the Washington DOE Stormwater Manual and municipalities/counties may adopt portions of this manual or an equivalent.



The calculations and stormwater management edition methods in the report are based on the following references:

2019 Stormwater Management Manual for Western Washington (SWMMWW)

4.5 Determination of Applicable Minimum Requirements

The 20.66-acre project will construct 97 single family homes, driveways, a family park, roads, utilities, and stormwater facilities. It is assumed that 20.66 acres will be disturbed.

- Total Site Area: 36.6 acres
- Disturbed Area: 20.66 acres
- Existing Impervious: 0.00 acres
- Proposed Impervious: 11.54 acres.

The project proposes more than 5,000 square feet (SF) of new impervious surfaces. All minimum requirements (MRs) #1-9 will apply to the project sites new and replaced hard surfaces.

Assumptions included in the calculations and MGS Flood modeling described in this report include:

Table 1: Modeling Land Cover and Impervious Assumptions

Lot Impervious Area Calculations				
	Count	**SF Each**	**SF Total**	**AC Total**
Homes *Splash blocks to 50-foot flow path allows for 100% to be modeled as lawn. Avg 4 per home.*	97	2500	242,500	5.57
Driveway	97	750	72,750	1.67
Road Impervious Area Calculations				
Roads	**Length**	**Width**	**SF**	**AC**
ROAD A	850	46	39,100	0.90
ROAD B	750	40	30,000	0.69
ROAD C	875	40	35,000	0.80
ROAD D	825	40	33,000	0.76
ROAD E	727	40	29,080	0.67
Pond Surface Areas				
NWL of Detention/Wet Pond (EL 261)			21460	0.493
Total Impervious.			**502,890**	**11.54**
POND 1 DRAINAGE AREA (MGS Subbasin 1)			**899,949.60**	**20.66**

Abbreviations
AC – acres
EL – elevation
NWL – normal water level
SF – square feet

5.0 MINIMUM REQUIREMENTS

This site triggers minimum requirements (MRs) #1-9 because it will add more than 5,000 SF of impervious surface. The following best management practices (BMP) are proposed to be incorporated into the site and will be discussed with each applicable MR in the sections below:

- Stacked Wet Pond (BMP T10.10) & Detention Pond (BMP D.1)
- Splash Block Dispersion
- Amended Soils on all lawn green space (BMP T5.13)

Typical details for a combined Wet / Detention Pond can be found in **Appendix D;** however, standard details for the stacked combination were not readily available. This will be included with the final engineering plans, and final TIR.

Minimum Requirement #1: Preparation of Stormwater Site Plans

5.1 A site stormwater plan is included in the preliminary engineering plans along with a proposed grading plan. A preliminary stormwater concept has been included in **Appendix A** along with the preliminary stormwater calculations and assumptions to accompany the preliminary plat application.

5.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention

The project results in more than 2,000 SF of new impervious and over one acre of disturbed area; therefore, a Construction Stormwater Pollution Prevention Plan (SWPPP), and National Pollutant Discharge Elimination System (NPDES) Permit are required. The SWPPP is included in the Engineering Plans.

5.3 Should clearing, grading and other soil disturbing activities occur between October 1 through April 30th, additional measures, as needed, will be taken to satisfy the SWMMWW seasonal work limitations.

Minimum Requirement #3: Source Control of Pollution

5.4 The residential site consists of roads, driveways, single family homes, utilities, and a stormwater pond. The driveways and streets are considered pollutant generating hard surfaces (PGHS). All PGHS and non-pollutant generating hard surfaces (NPGHS) within the project site will be routed through a Wet Pond with dead storage for treatment. Roofs, which are considered NPGHS, will be routed through typical splash block dispersion flow paths for flow dispersion to assist with peak flow attenuation, as a low impact development (LID) approach.

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

Mass grading of the site will be performed. The stormwater pond will capture all surface runoff from the developed site and meter it through an outfall to the wetland area that mimics existing drainage conditions of the site.

Minimum Requirement #5: On-site Stormwater Management

The project is within the City of Toledo limits and is more than five acres in size; therefore, based on the SWWMWW, LID standards are required to be met by using "*any Flow Control BMPs desired to achieve the LID Performance Standard, and applying BMP T5.13: Post-Construction Soil Quality and Depth*."
5.5 Due to the groundwater on site prohibiting infiltration for most of the homes, List #2 is proposed for this project. The wet pond and detention basin have been modeled using MGSFlood, to demonstrate compliance with flow control; however, due to proposing list #2 BMPs, the wet pond was not designed to meet the LID Performance standards.

The detention pond (wet pool volume) was sized for flow control with all roof areas modeled as 100% lawn, assuming that splash blocks will be placed at the downspout of all home roof drains with a minimum 50-foot flow path.

See **Appendix C** for MGSFlood model inputs and results.

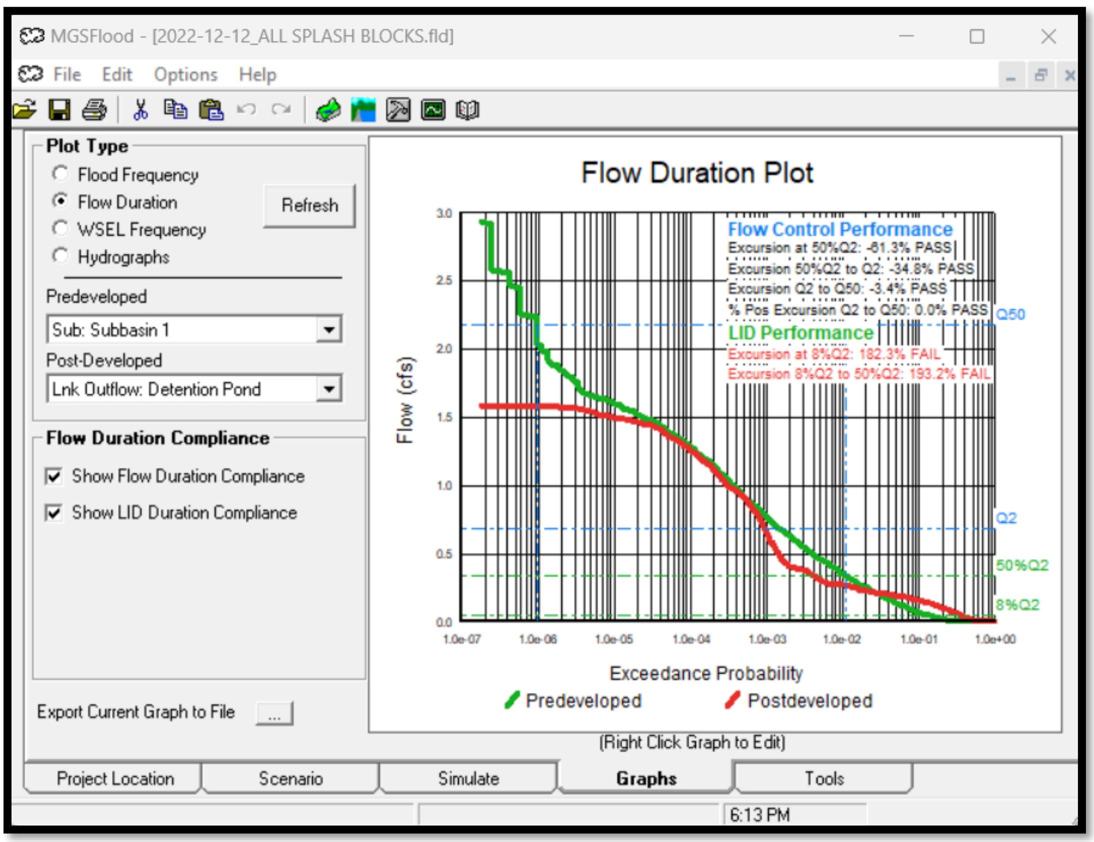


Figure 2: MGSFlood Results Showing for LID and Flow Control Requirements

5.6 Minimum Requirement #6: Runoff Treatment

MR #6 is applicable to threshold discharge areas (TDAs) that have more than 5,000 SF of PGHS. The project proposes approximately 11.54 acres of new impervious surfaces from the roads, roofs and driveways; therefore, MR #6 applies. All new PGHS and NPGHS on the site will be routed to a wet pond for treatment. Roof runoff will first be routed to splash blocks prior to entering the storm sewer conveyance system to the wet pond.

A wet pond can provide treatment of runoff if the dead pool storage is sized large enough for the 91% exceedance water quality treatment volume. Based on the MGS Flood modeling, the required dead pool volume for the proposed site is approximately 61,164 cubic feet (CF). The stormwater facility has been designed to provide dead pool treatment of at least 62,000 CF with a dead pool depth of approximately 5.0 feet.

5.6.1 Modeling

MGS Flood was used to model compliance with the

Model inputs used for the subbasin were as follows:

Table 2: Model Inputs

TREATMENT CALCULATIONS FOR DETENTION POND SIZING			
	SF	ACRES	COVER
Total site	1,595,167	36.62	
Disturbed Area to be modeled	899,950	20.66	
Roofs - Lawn - Splash Block Credits	242,500	5.57	C, LAWN
Lawn - Modified Soils	397,060	9.12	C, PASTURE, MOD
Total Roads	166,180	3.81	ROADS/MOD
Driveways	72,750	1.67	DRIVEWAYS/FLAT
TREATMENT CALCULATIONS FOR WET POND SIZING			
All the same except for:			
Lawn - Splash Block Credits	0	0.00	C, LAWN
Roofs	242,500	5.57	

Abbreviations
C – Soil Type C
MOD – Moderate

This is a single-family residential development; therefore, enhanced treatment is not required.

5.7 Minimum Requirement #7: Flow Control

Developed discharge durations must match pre-developed durations for the range of pre-developed discharge rates from 50% of the 20-year peak flow up to the full 50-year peak flow. The detention basin provides adequate flow control at the outlet, which has been set as the point of compliance. See Figure 2 above, and **Appendix C** for MGSFlood results that demonstrate flow control provided with the proposed pond.

5.8 Minimum Requirement #8: Wetlands Protection

There is an existing wetland on the south, lowland portion of the site. The project design anticipates that it will discharge treated stormwater runoff from the stormwater pond at a location upstream of the wetland. MR #8 will apply in this scenario and MR #8 will be further refined with future engineering submittals as more design details become available. A preliminary flow chart has been included in Appendix E, demonstrating that the following levels of wetland protection will be required:

- General Protection
- Protection from Pollutants
- Wetland Hydroperiod Protection

The above items will be provided with future engineering submittals.

5.9 Minimum Requirement #9: Operation and Maintenance

The stormwater system will be privately owned, operated, and maintained. See Volume V of the SWMMWW. Should the City of Toledo take over the roads for public maintenance, the stormwater system at that time may become City-owned.

6.0 CONVEYANCE SYSTEMS ANALYSIS AND DESIGN

All stormwater piping shall meet the minimum requirements of the Toledo City Code. All storm sewer conveyance calculations will be completed with the final stormwater TIR and managed following the 2019 SWMMWW, making the potential impact on the downstream properties and conveyances systems minimal.

7.0 ADDITIONAL REQUIREMENTS

Offsite Analysis

No offsite analysis has been complete at this stage.

Closed Depression Analysis

7.1 This site is not classified as a closed depression; therefore, this section does not apply.

7.2 Other Permits

A NPDES permit will be required due to more than one acre of disturbance and will be applied for prior
7.3 to construction.

Approval Conditions Summary

7.4 All conditions noted in the pre-application conference final report will be addressed.

Special Reports and Studies

7.5 The following analysis have been, or will be completed:

- Critical Areas – See Appendix E
- Geotechnical – See Appendix B
- Traffic Impact Analysis – To be Completed

.

8.0 APPENDICES

Appendix A – Stormwater Calculation Assumptions and Stormwater Concept

Appendix B – Geotechnical Information

Appendix C – MGS Flood Modeling Results

Appendix D – BMP Details

Appendix E – Critical Areas Report & Wetlands Protection Flow Chart

APPENDIX A

Proposed Drainage Exhibit and Calculations

1 GRADING AND EROSION CONTROL PLAN

Scale: 1" = 60'

POND 1			
Home Surface Areas			
	SF Each	**SF Total**	**AC Total**
Homes *Splast blocks to 50-foot flow path allows for 100% to be modeled as lawn*	2500	242500	5.57
Driveway	750	72750	1.67
Road Surface Areas			
Roads	**Width**	**SF**	**AC**
ROAD A	46	39100	0.90
ROAD B	40	30000	0.69
ROAD C	40	35000	0.80
ROAD D	40	33000	0.76
ROAD E	40	29080	0.67
Pond Surface Areas			
NWL of Detention/Wet Pond (EL 261)		21460	0.493
	Total Imperv	**502,890**	**11.54**
OND 1 DRAINAGE AREA (MGS Subbasin 1)		**899,949.60**	**20.66**

TREATMENT CALCULATIONS FOR DETENTION POND SIZING			
	SF	**AC**	**MGS Model Surface**
Total site	1,595,167	36.62	
Disturbed Area to be modeled	899,950	20.66	
Lawn - Splash Block Credits	242,500	5.57	C, LAWN
Lawn - Modified Soils	397,060	9.12	C, PASTURE, MOD
Total Roads	166,180	3.81	ROADS/MOD
Driveways	72,750	1.67	DRIVEWAYS/FLAT

811 Know what's **below.** **Call** before you dig.
CALL 2 BUSINESS DAYS BEFORE YOU DIG.
CAUTION UTILITY INFORMATION IS APPROXIMATE.
VERIFY ALL UTILITIES PRIOR TO CONSTRUCTION.

Revisions:

LINE IS 1" ON FULL SCALE DRAWING

WINDSOR ENGINEERS
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Project No: 21217

TRAVIS TORMANEN · STATE OF WASHINGTON · 34472 · REGISTERED PROFESSIONAL ENGINEER · PRELIMINARY

COWLITZ MEADOWS
TOLEDO, WA

ENGINEERING SET
Issue Date: 2022-10-x

Project Manager ES
Drawn by CKJ
Checked by TS

PRELIMINARY STORMWATER CALCULATIONS AND DESIGN NOTES

TIR - APPENDIX A

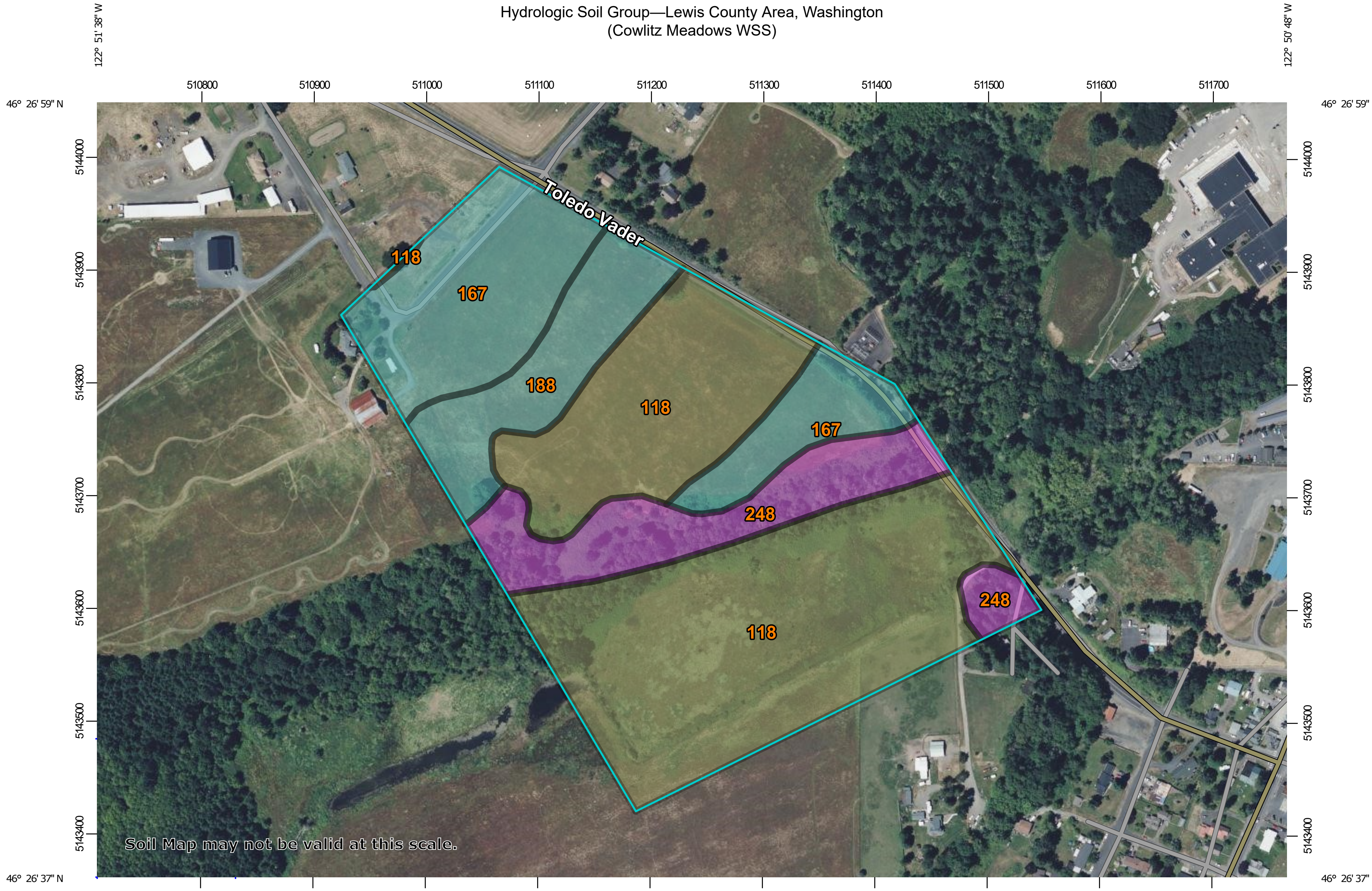
APPENDIX B

Geotechnical Information

APPENDIX B-1

Web Soil Survey Data

Hydrologic Soil Group—Lewis County Area, Washington
(Cowlitz Meadows WSS)



Map Scale: 1:4,840 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lewis County Area, Washington
Survey Area Data: Version 21, Aug 31, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 21, 2021—Nov 22, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
118	Lacamas silt loam, 0 to 3 percent slopes	C/D	25.2	54.9%
167	Prather silty clay loam, 0 to 5 percent slopes	C	9.8	21.3%
188	Salkum silty clay loam, 5 to 15 percent slopes	C	4.7	10.2%
248	Xerorthents, steep	A	6.3	13.6%
Totals for Area of Interest			**45.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX B-2

Geotechnical Report by Strata

GEOTECHNICAL REPORT (REVISED)

COWLITZ MEADOWS
PROPOSED 37-ACRE SUBDIVISION (PARCEL 011438001000)
TOLEDO-VADER ROAD, TOLEDO, WASHINGTON

Prepared for:

Windsor Engineers
Attn: Emily Stephens

March 2, 2022 (Revised June 15, 2022)

STRATA Project No. 22-0628

Co-Prepared By:

Alex Baumann, PE
Senior Engineer

Reviewed By:

Randall S. Goode, PE
Principal

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TABLE OF CONTENTS

1.0 INTRODUCTION

This report presents our geotechnical site evaluation for the proposed new 37-acre subdivision construction within the site located at Parcel 011438001000 adjacent to Toledo-Vader Road in Toledo, Washington. This report is a revision to our March 2, 2022 report to include considerations for the proposed stormwater pond in the southwest corner of the site, which we understand will be lined to prevent infiltration. This report summarizes the work accomplished and provides our conclusions and recommendations for site development. This report has been prepared in accordance with Strata Design's (STRATA) Proposal for Geotechnical Services for the project, dated December 31, 2021. The location of the site is shown on Figure 1 (Vicinity Map). A preliminary lot layout and grading plan, dated April 26, 2022, provided to us by the project team is shown on Figure 2 (Site Exploration Plan).

As detailed in this report, the site is mantled with silt and clay soils, and near-surface groundwater conditions were encountered at variable depths. Below-grade fat clay is present at the site, exhibiting a moderate to high risk of shrink/swell (expansive soil) based site geologic history and soil index properties. Laboratory swell testing was outside our scope of work for the project, but may be recommended depending on the proposed final grading plan. STRATA should be notified once final grading plans for the project are available.

2.0 PROJECT AND SITE DESCRIPTION

The site is located adjacent to Toledo-Vader Road, southeast of Plomondon Road in Toledo, Washington and encompasses the proposed subdivision within Parcel 011438001000, shown as the "site" in the Site Vicinity Map, Figure 1. The site is bordered to the northwest by Plomondon Road, to the northeast by Toledo-Vader Road, to the southeast and southwest by existing residences and farm land. The southeast third of the site appears to consist of unmapped wetland areas, including a densely wooded area separating the upper and middle terraces of the site from lower terrace (unmapped wetland area). We understand the project is in the preliminary design and planning stage, thus limited plans have been made available. From our review of the preliminary layout document provided by the project team, the site could be developed with about 95 lots. Elevations listed in this report reference the National Average Datum of 1983 (NAD 83).

3.0 SLOPE OBSERVATIONS AND REGIONAL MAPPING

Figure 3 (attached) displays the site contour lines based on bare-earth contours as generated in ArcGIS using LiDAR survey obtained from Washington Department of Natural Resources (DNR) GIS data resources. The site topography essentially consists of three relatively flat terraces separated by gentle to steep slopes. The site generally slopes downward to the southeast. The upper terrace (northwest end of the site) ranges in elevation from about 298 to 305 feet, the middle terrace ranges in elevation from about 270 to 278 feet, and the lower terrace (southeast end of site in the unmapped wetland area) ranges in elevation from about 212 to 220 feet. The highest (northwest) terrace and the middle terrace are separated by a southeast facing slope approximately between elevations 278 and 298 feet with grades ranging from about 8 to 20 percent. The middle and the lowest (southeast) terrace are separated by a heavily wooded and relatively steep slope approximately between elevations 220 and 270 feet with grades ranging from about 15 to 75 percent.

We completed an on-site reconnaissance of the property at the time of our subsurface exploration on January 11, 2022. Our field observations were performed during wet conditions at the time of our subsurface exploration. We traversed the property to assess the general features and conditions of the surrounding slopes for evidence of hazards in the form of broken ground, obvious slope movements, or disturbances. From review of historical aerial photographs, it is estimated that the upper two terraces at the site have undergone farming activities, and possibly relatively minor grading changes. From our site reconnaissance and review of the LiDAR image, we can observe the occasional presence of shallow slumps and sloughing within the lower slopes (between the lowest and middle terraces at the site). We did not observe any immediate signs of deeper seated slope failure present along the property slopes. Review of the geologic mapping and DNR GIS maps did not indicate there to be previously identified landslide form or character at or nearer than 5 miles to the study site.

Standing water was observed in several locations at the ground surface in the middle and lower terraces. Within the majority of the lower (southeast) terrace, native wetland plant species were observed. The sloping ground that separates the middle and lower terraces is heavily wooded with shrubs, coniferous, and deciduous trees, indicating a possible east-west trending natural drainage area.

4.0 SITE GEOLOGY

According to published geologic mapping[1], the site is underlain by Outwash deposits (pre-Fraser glaciation). Starting approximately 2.6 million years ago, the Cordilleran ice sheet advanced and retreated across British Columbia and into the northwestern parts of the United States. The Fraser glaciation was one of the last glacial advances into northwestern United States and was succeeded by the Vashon glaciation. Much of the Puget sounds was carved by this glacial activity. The glacial meltwater carried sediment of all sizes from clay to boulders beyond the southern extent of the ice sheet, where alpine and continental glacial deposits are mapped today. Due to controversy over the number of glaciations in this area, geologic mapping often references pre-Fraser glaciation and during Fraser glaciation to simplify age constraints of the geologic units.

The pre-Fraser glaciation Outwash deposits (Qapo) mapped at the site are characterized by outwash sand and gravel with minor silt and clay. This unit also locally includes part of Logan Hill, Weatherwax and Wedekind Creek formations and Hayden Creek, Kittitas and Wingate Hill and Humptulips drifts. These undifferentiated deposits include till, moraine, advance and recessional drift and glacial outwash[2].

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[1] *Walsh, T.J., Korosec, M.A., Phillips, W.M., Logan, R.L., and Schasse, H.W., 1987, Geologic map of Washington--Southwest quadrant: Washington Division of Geology and Earth Resources, Geologic Map GM-34, scale 1:250,000.*

[2] *Lasmanis, R. and Hall, T., 1985, A Geologic Feasibility Study for the Superconducting Super Collider: Washington Division of Geology and Earth Resources, Open-File Report 85-3.*

During our site exploration on January 11, 2022, we encountered excavator practical refusal on very dense gravel/cobbles/boulders at depths between 10 and 12 feet below ground surface (bgs) within two of our test pits. To further assess ground conditions below our exploration depths, we referred to water well logs completed within a 1-mile radius of the site. The logs indicated similar lithology to drilled depths of up to 100 feet bgs. The majority of the online water well logs indicated clay with sand seams. Occasional gravel and cobbles are noted to 38 feet bgs.

As described below in the Subsurface Conditions section of this report, we encountered high-plasticity clay soil within the glacial deposits. It should be expected that the clay layer is highly variable throughout the site, and is likely primarily present within the middle and lower terraces within the southeast two-thirds of the site. A discussion of expansive soils found in glaciated portions of the State (DNR – Galster, Bekey[3]) suggests the potential for expansive (shrink/swell) soils at the site. The recommendations provided in this report consider the risk associated with shrink/swell soils.

5.0 SUBSURFACE CONDITIONS

5.1 Field Explorations

Subsurface explorations were carried out by STRATA on January 11, 2022 by excavating five test pits, designated TP-1 through TP-5, and by advancing one Dynamic Cone Penetrometer test, designated DCP-1. The approximate locations of the explorations are shown on Figure 2. Logs of the explorations are provided in the attached Appendix A.

STRATA has summarized the subsurface units as follows:

SILT (Topsoil)	Silt topsoil was encountered at the ground surface and extends to a depth of about 1 foot in all test pit explorations. The silt topsoil is typically dark brown and contains up to trace clay and fine-grained sand and occasional organics and roots. Based on our observations of the test pit excavation and advancement of DCP-1, the relative consistency of the topsoil is very soft. A 6-inch-thick heavily rooted zone was encountered at the ground surface in all test pits.
SILT	Silt containing up to trace fine-grained sand and some clay was encountered below the topsoil and extends to a depth of about 36 feet in test pit TP-1, to depths of about 3 to 4 feet in test pits TP-2, TP-4, and TP-5, and to a depth of about 11 feet in test pit TP-3. The silt is typically brown or brown mottled rust and black. Based on observations during excavation of the test pits, as well as the recorded penetration blow counts during advancement of DCP-1, the relative consistency of the silt is typically soft, with the exception of the silt

[3] *Galster, Richard W., Bekey, Thomas J., 1989, Engineering Geology in Washington, Volume 1, Washington Division of Geology and Earth Resources, Bulletin 78, pg 137.*

encountered in test pit TP-3, appeared soft to a depth of about 6 feet and medium stiff to stiff below this depth. The silt below a depth of about 3 feet in test pit TP-3.

CLAY

Clay was encountered below the silt in test pits TP-3 through TP-5. Test pit TP-3 was terminated in the clay at a depth of about 13 feet. The clay extends to depths of about 7 to 7.5 feet in test pits TP-4 and TP-5. The clay is typically light gray mottled rust and contains variable percentages of silt ranging from some silt to silty, as well as occasional rounded gravel and cobbles. Based on observations during excavation of the test pits, the relative consistency of the clay is typically medium stiff to stiff. The actual depth to the clay unit, as well as thickness of the clay unit, throughout the site may be highly variable.

Atterberg Limits testing was completed on a sample of the clay at a depth of 5 feet in test pit TP-5. The results of the Atterberg Limits testing indicates high plasticity, with a liquid limit (LL) of 57% and a plasticity index (PI) of 37%.

As discussed in other sections of this report, the clay at the site has a moderate to high risk of shrink/swell potential, based on our review of available geologic and mapping information, laboratory testing, and engineering judgement.

GRAVEL and COBBLES

Gravel and cobbles in a matrix of sand, silt, and clay was encountered below the silt in test pits TP-1 and TP-2, and below the clay in test pits TP-4 and TP-5. These test pits were terminated at depths ranging from about 7 to 11 feet in the gravel and cobbles unit. The matrix of sand, silt, and clay within the gravel and cobbles unit is typically brown or gray to light gray mottled rust. The sand within the matrix is typically fine to coarse grained and the gravel and cobbles are typically subangular to subrounded. The gravel and cobbles unit encountered in test pit TP-4 contains fragments of decomposed rock. Although not encountered in the test pits advanced, the gravel and cobbles unit may contain boulders.

5.2 Groundwater

Seepage and relatively shallow groundwater conditions were encountered in all test pits advanced at the site. Standing water was observed at the ground surface in portions of the middle and lower terraces at the site (southeast two-thirds of site). In general, groundwater elevations appeared to be highly variable. The rate of seepage along the side walls of the test pits varied widely across the site. Moderate to heavy seepage rates were observed in test pits TP-1, TP-3, and TP-5, and very light to moderate seepage rates were observed in test pits TP-2 and TP-4. The depth of seepage zones in the test pits ranged from about 2.5 to 6 feet. It should be noted that groundwater levels can fluctuate during the year depending on climate, irrigation season, extended periods of precipitation, drought, and other factors. Shallow perched-groundwater conditions may develop in the near-surface silt and clay soils and are likely to approach the ground surface during periods of prolonged precipitation or flooding.

6.0 CONCLUSIONS AND RECOMMENDATIONS

It is our opinion that the site can be developed as proposed with the inclusion of appropriate foundation systems and proper drainage that reduce the risk of damage from shrink/swell of the clay deposits on the site. Additionally, the presence of a near-surface groundwater table could be a significant design and construction consideration. The subsurface sand/gravel/cobbles (and potential boulders) should be below anticipated finish elevations of grading, however, this stratum could still be encountered in utility trenching or if final grading plans should be different than we assume. Our specific recommendations for site development are provided in the following paragraphs.

Based on our review of available geologic mapping, expansive soil mapping, the results of laboratory Atterberg Limits testing, and engineering judgement, it is our opinion the clay soils encountered in our subsurface investigation have a moderate to high risk of shrinking or swelling from fluctuations in moisture content over time.

6.1 General Construction Considerations

The site is mantled at the ground surface with relatively soft and moisture-sensitive silt soils, which are susceptible to disturbance from construction equipment activity. The silt or clay at the site are generally underlain by glacial deposits of gravel and cobbles, which may contain boulders. As noted previously, the presence of cobbles and boulders at the site may be significant considerations for the contractor during excavation and when selecting shoring or dewatering methods.

On-site soil conditions are favorable for earthwork in dry weather conditions. Fine-grained soils on the site easily lose strength when disturbed by construction traffic and activities during wet weather. We recommend earthwork take place during the typically dry months of the year when groundwater levels and perched groundwater conditions are likely to be the lowest. It can be expected that extra costs will accrue if earthwork is planned for the wet winter and spring months. If not carefully executed, site preparation, utility trench work, and excavation can create extensive soft areas and significant repair costs can result. Earthwork should be planned and executed to minimize subgrade disturbance.

When planned, or when it is necessary to construct driveways suitable for support of emergency vehicle traffic, including firetrucks, the base rock thickness for project streets, as described below in the section titled "Asphalt Pavement", are intended to support post construction design traffic loads. The base rock thickness determined for post construction traffic will not support construction traffic or pavement construction when the subgrade soils are wet. Accordingly, if construction is planned for periods when the subgrade soils are not dry and firm, then an increased thickness of base rock or other methods to support construction traffic could be required.

To prevent disturbance and softening of the silty subgrade soils during wet weather or ground conditions in areas outside existing paved surfaces, movement of construction traffic should be limited to granular haul roads and work pads in these areas. In general, a minimum of 18 to 24 in. of relatively clean, granular material is required to support concentrated construction traffic, such as dump trucks and concrete trucks, and protect the subgrade. A 12-in.-thick granular work pad should be sufficient to support occasional light-truck traffic and low-volume construction operations. If wet-weather construction is anticipated, a woven geotextile separation fabric may be placed on the exposed subgrade prior to placement and compaction of the granular work pad to improve the performance of work pads and haul roads. The imported granular material should be placed in one lift over the prepared or undisturbed subgrade and compacted using a smooth drum, non-vibratory roller. Alternatively, cement-treated base (CTB) can be used to stabilize the subgrade for repeated construction traffic and generally provides an increased resilient modulus for pavement and base rock sections. Additional recommendations for CTB design and construction can be provided upon request, but were outside the current scope of this report.

Geotextile fabric used in construction should have a minimum Mullen burst strength of 250 pounds per square inch (psi) for puncture resistance and an apparent opening size between the U.S. Standard No. 70 and No. 100 Sieve to minimize migration of fines into the imported granular material.

6.2 Site Preparation

Areas of proposed development should be stripped of existing vegetation, surface organics, and loose or soft surface soils. We estimate stripping will generally be necessary to a depth of about 6 inches. Stripping may need to extend into non-organic soils in areas where significant roots are present. Depending on the methods used, considerable disturbance and loosening of the subgrade could occur during stripping. Strippings should be removed from the site or stockpiled for use in landscaped areas. Following the removal of organic soils and roots, the area should be evaluated by STRATA for the presence of soft, yielding soils. Where encountered, these soils should be removed to expose competent, native soils. We recommend excavations and subgrade preparation be completed with smooth-edged buckets equipped to hydraulic excavators to minimize disturbance to subgrade. Over-excavations should be backfilled with structural fill.

Any existing building footings, floor slabs, septic tanks and drain fields and other structural elements should be removed from the site. Existing utilities underlying new footings, structural fill, or other structural elements should be abandoned by removing the conduit and backfilling with granular structural fill. Openings in existing utilities that underly landscape areas and daylight into excavations should be capped or grouted to avoid loss of excavation backfill or subgrade soils into voids. Soil disturbed during building demolition and grubbing operations should be removed to expose firm undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

We recommend proof rolling the subgrade with a fully loaded dump truck or similar size, rubber-tire construction equipment after stripping and required site cutting have been completed. The proof rolling should be observed by STRATA to identify areas of excessive yielding. Areas of excessive yielding should be excavated and replaced with compacted materials recommended for structural fill. Areas that appear to be too wet and soft to support proof rolling equipment should be prepared in accordance with the recommendations for wet weather construction presented in the following section of this report.

Additionally, it should be noted that existing pavement may not be designed for use with repeated heavy construction traffic, and thus may become distressed during construction and some repair may be required. All construction traffic should adhere to the setback requirements from the steep sloping ground near the southeast third of the site.

Grades should be developed and maintained to drain surface and roof runoff away from structures and other site improvements, and no on-site disposal of stormwater should be allowed due to relatively high groundwater conditions and presence of potentially expansive soils. Permanent cut and fill slopes should be planned no steeper than 2H:1V (Horizontal to Vertical).

6.3 Temporary Excavations, Shoring, and Groundwater Management

6.3.1 General

Based on our preliminary understanding of the project, we assume the maximum depth of temporary excavations at the site will be on the order of about 5 feet and that basements will not be constructed. STRATA should be notified once final plans are made available so additional recommendations can be provided if necessary, especially if partial or full basements are planned for the residences or deep excavations are required. As discussed in the Subsurface Conditions section of this report, we anticipate seasonal groundwater levels at the site are within the planned depths of temporary excavation throughout much of the year. More-shallow groundwater levels and perched-groundwater conditions can be expected during the wet winter and spring months or during periods of prolonged rainfall. Considering this, temporary excavation dewatering and/or groundwater management will be significant considerations during construction of the project, depending on the time of year construction is to proceed and the depth of planned excavations. We recommend earthwork activities take place during the dry months of the year. Additionally, boulders may be present within the planned depth of excavation in various portions of the site, and the contractor should expect significant excavation effort if boulders are encountered.

Temporary shoring systems may be required for excavation support for trenches, depending onactual soil conditions during the time of construction; however, open-cut excavations could also be considered where site access allows. The method of excavation and design of temporary excavation support and dewatering systems are the responsibilities of the contractor and are subject to applicable local, state, and federal safety regulations, including the current Washington Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. The means, methods, and sequencing of construction operations and site safety are also the responsibilities of the contractor. The information provided below is for the use of our client and should not be interpreted to imply we are assuming responsibility for the contractor's temporary excavation and dewatering design, actions, or site safety.

It should be understood that unsupported cut slopes may exhibit distress in the form of localized sloughing or raveling, particularly if seepage develops in portions of the slopes with higher sand content. The on-site soil, if groundwater or seepage is not present, is classified as "Soil Type C". For planning purposes, temporary cut slopes in this type of soil should be made at 1.5H:1V (Horizontal:Vertical) or flatter. If significant seepage, running-soil conditions, or slope instability are observed during excavation, flatter slopes may be necessary. Some minor amounts of sloughing, slumping, or running of temporary slopes should be anticipated during and shortly after excavation. Open-cut excavations should be completed and backfilled in the shortest practical sequence. In our opinion, the short-term global stability of temporary slopes will be adequate if surcharge loads due to construction traffic, vehicle parking, material laydown, foundations for existing nearby structures, etc., are maintained a horizontal distance equal to the height of the slope away from the top of the excavation and if the excavations are made above groundwater. However, smaller horizontal offsets may be appropriate for surcharge loads that act over smaller areas, such as point loads and foundation loads of limited areal extent.

If shoring systems are selected instead of slope layback, these are typically designed by a specialty shoring contractor, who should also have a proven record of successful shoring installation in similar materials. Shoring systems can be either cantilevered or braced using internal bracing. Cantilevered systems are generally designed for maximum exposed wall heights of about 15 feet; however, greater heights may be possible depending on tolerable shoring movements and potential settlement in the surrounding areas. We recommend including a minimum vertical surcharge pressure of 250 pounds per square foot (psf) in the design of the shoring system.

6.3.2 Groundwater Management

Based on our observations during our subsurface exploration, groundwater may be encountered within planned depths of excavations. Selection of groundwater management methods is the responsibility of the contractor. If groundwater is encountered, groundwater levels should be maintained at a minimum depth of 2 feet below the base of the excavation, or as required, to maintain base stability. We anticipate groundwater inflow, if encountered, can generally be managed by pumping from sumps within the excavations in conjunction with a granular drainage/stabilization layer. However, depending on actual groundwater levels at the time of construction, positive control of groundwater using external dewatering wells or well point systems may be required.

It should be expected that groundwater management will be a significant consideration during excavating in the middle and lower terraces and wetland areas, especially in areas that were observed to have standing surface water and shallow or perched groundwater. Our subsurface exploration test pits encountered highly variable seepage rates and relatively high groundwater conditions. If groundwater is encountered in the excavations, it will typically be necessary to overexcavate the base of the excavation and install a granular drainage/stabilization layer to facilitate groundwater management and provide a firm working surface for construction. The actual required depth of overexcavation and thickness of granular drainage/stabilization layer will depend on the conditions exposed in the excavation and the effectiveness of the contractor's groundwater management or dewatering efforts, and must be evaluated based on actual observations during construction. Discharge from groundwater management should not be disposed of onsite, and no stormwater disposal should be allowed onsite.

6.3.3 Utilities

Trench construction and maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. The method of excavation and design of temporary excavation support and dewatering systems are the responsibilities of the contractor and are subject to applicable local, state, and federal safety regulations, including the current Washington Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. Temporary excavations should either be shored or sloped in accordance with applicable regulations. Excavation spoils and material-laydown areas should be set back at least 10 feet from the edge of excavations and the existing steep slope south of the middle terrace.

All utility trenches that will be underlying new pavements, walkways, buildings, or new structural fill should be backfilled with structural fill. Trench backfill should consist of well-graded imported granular material (see Structural Fill section below) with a maximum particle size of ¾-inch and less than 8 percent by weight passing the U.S. Standard No. 200 Sieve. The material should be free of roots, organic matter, and other unsuitable materials.

Trench backfill in the bedding zone and pipe zone should be placed and compacted in maximum lifts of 6 inches. Trench backfill above the pipe zone should be placed and compacted in 8-in. (loose) lifts. A minimum cover of 3 feet over the top of the pipe should be placed before compacting with a hydraulic plate compactor (hoe-pack). The granular backfill should be compacted to at least 95% of the maximum dry density determined by ASTM D698. Flooding or jetting the backfilled trenches with water to achieve the recommended compaction should not be permitted.

6.4 Utility Connections

Utilities resting on or within expansive soils are subject to soil movements. Utility connections should account for such movement potential, such as by using flexible connections. Rigid utilities should be suspended above the soils in suspended floor foundations. Based on review of our subsurface exploration, we anticipate the clay unit to be highly variable throughout the site and may be present at the ground surface. Depth of utilities and proper consideration of shrink/swell potential in construction of the utilities should be considered, especially within the middle and lower terraces at the site (southeast two-thirds of site), and along the crest of the steep slopes in the south half of the site.

6.5 Potential Vertical Rise (PVR) of Shrink/Swell Soil

Based on our review of available geologic and expansive soil mapping and the results of laboratory plasticity testing, we believe the clay soil at the site, when encountered directly or is near to the surface, has a moderate to high risk of swelling when allowed to increase in moisture content and shrinking when allowed to decrease in moisture content. The moisture fluctuations occur due to seasonal wet and dry cycles, but are also influenced after construction by site grading, drainage, landscaping, and groundwater. Some clay soils swell when the overlying load is reduced, such as in the bottom of excavations. Soil movements can occur vertically, affecting foundations, and laterally, affecting retaining walls. Actual soil movement is difficult to predict due to the many variables involved. A formal analysis of Potential Vertical Rise (PVR) or shrink/swell potential to quantify the expansiveness of the native clay is beyond the scope of our current report. Based on our preliminary analyses using the PVR method developed by TxDOT, and considering the results of the Atterberg Limits tests and engineering judgement, we estimate about 1 to 2 inches of PVR. This movement can be up or down, and estimates are approximate. Actual soil movements will depend on the distance from clay stratum and the subsurface moisture fluctuations over the life of the structure. Soil movements may be less than those calculated if moisture variations are reduced after construction. However, significantly larger soil movements than estimated could occur due to grading, poor drainage, ponding of rainfall, and/or leaking utilities. Good drainage is a critical factor in reducing the risk of foundation movements due to expansive soils, and good drainage should be obvious to the casual observer. Floor slabs must be adequately elevated above surrounding ground.

6.6 Preliminary Foundation Support Recommendations

We understand structural loads and final layout of the development is not available at this time; however, we assume the structures will be wood-framed, relatively lightly loaded, and will not include partial or full basements. STRATA should be notified once final plans are made available so additional recommendations can be provided if necessary.

It is our opinion the structures can be supported on shallow foundations. Recommendations provided in this section should not apply to the condition where the expansive clay stratum is exposed or in close proximity to finish grades due to the risk of ground deformations associated with shrink/swell of the clay layer.

6.6.1 Minimum Footing Widths / Design Bearing Pressure

Continuous wall and isolated spread footings widths should be designed minimum to prescribe to residential building code. Footings may be proportioned using a maximum allowable bearing pressure of 1,500 pounds per square foot (psf), provided the footings are established in firm native soils. This is a net bearing pressure, and the weight of the footing and overlying backfill can be disregarded in calculating footing sizes. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads. Allowable bearing pressures may be increased by one-third for seismic and wind loads. Footings will settle in response to column and wall loads. Based on our evaluation of the subsurface conditions and our analysis, we estimate post-construction settlement will be less than 1 inch for the column and perimeter foundation loads, provided subgrade is prepared in accordance with the recommendations provided in this report. These values exclude potential movements associated with shrink/swell of the expansive clay, as we assume structures will not be in contact or near proximity.

6.6.2 Footing Embedment Depths

STRATA recommends that all footings be founded at depths below surrounding adjacent grades as prescribed by residential building code. The footings should be founded below an imaginary line projecting upward at a 1H:1V (horizontal to vertical) slope from the base of any adjacent, parallel utility trenches or deeper excavations.

6.6.3 Footing Preparation

Excavations for footings should be carefully prepared to a neat and undisturbed state. A representative from STRATA should confirm suitable bearing conditions and evaluate all exposed footing subgrades. Observations should also confirm that loose or soft materials have been removed from new footing excavations and concrete slab-on-grade areas. Localized deepening of footing excavations may be required to penetrate loose, wet, or deleterious materials. STRATA recommends a layer of compacted, crushed rock be placed over the footing subgrades to help protect them from disturbance due to foot traffic and the elements. Placement of this rock is the prerogative of the contractor; regardless, the footing subgrade should be in a dense or stiff condition prior to pouring concrete. Based on our experience, about 2 inches of compacted crushed rock will be suitable beneath the footings. However, excessive crushed rock under spread footings in the presence of expansive soils can create undesirable fluctuations in moisture content over time, contributing to greater potential vertical rise in the expanse soils.

6.6.4 Lateral Resistance

Lateral loads can be resisted by passive earth pressure on the sides of footings and grade beams, and by friction at the base of the footings. A passive earth pressure of 250 pounds per cubic foot (pcf) may be used for footings confined by native material and new structural fills. The allowable passive pressure has been reduced by a factor of two to account for the large amount of deformation required to mobilize full passive resistance. Adjacent floor slabs, pavements, or the upper 12-inch depth of adjacent unpaved areas should not be considered when calculating passive resistance. For footings supported on native gravels or new structural fills, we recommend using a coefficient of friction equal to 0.4 when calculating resistance to sliding. These values do not include a factor of safety (FS).

6.7 Slab-on-Grade Floors

Recommendations provided in this section should not apply to the condition where the expansive clay stratum is exposed or in close proximity to finish grades. Where lightly loaded residential building floor slabs are planned, satisfactory subgrade support can be obtained on the undisturbed native soil or on engineered structural fill. A subgrade modulus of 125 pounds per cubic inch may be used to design floor slabs founded on medium stiff or better subgrade, to be evaluated by the geotechnical engineer at the time of subgrade preparation.

A minimum 6-inch-thick layer of free draining fill should be placed and compacted over the prepared subgrade to assist as a capillary break and blanket drain. Open-graded, angular, ¼- to ¾-inch drain rock meeting the requirements of free draining fill in the Structural Fill section of this report is commonly used for this purpose. The free draining fill layer may be capped with a 1- to 2-inch-thick layer of clean ¾ inch minus crushed rock that contains no more than 5 percent fines.

6.8 Site Drainage

Foundation and crawl space drainage should be sloped to drain to a sump or low point drain outlet. Water should not be allowed to pond within crawl spaces.

Roof drains should be connected to a tightline drainpipe leading to storm drain utilities. Pavement surfaces and open space areas should be sloped such that surface water runoff is collected and routed to storm drain utilities. Ground surfaces adjacent to buildings should be sloped to drain away from the buildings. No stormwater should be disposed of on-site.

6.9 Structural Fill

Fill within building, pavement, and sidewalk areas should be placed as compacted structural fill. Structural fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D698/AASHTO T-99, the standard Proctor. In landscaped areas or areas not sensitive to settlement, fill should be compacted to about 90% of the maximum dry density determined by ASTM D698. Flooding or jetting structural fill with water to achieve the recommended compaction should not be permitted.

The earthwork contractor's compactive effort should be evaluated based on field observations. Lift thicknesses should be adjusted to meet compaction requirements. The moisture content for compaction should be within 3 percent of optimum.

Brush, roots, construction debris, and other deleterious material should not be placed in the structural fill. Additional information regarding specific types of fill is provided below.

On-Site Silt: The on-site soil is suitable for use as structural fill provided it can be moisture-conditioned, separated from concentrations of organics, construction debris, and other unsuitable material, and compacted to the specified density. The fill should be placed in lifts with a maximum loose thickness of 8 inches. The on-site silt is considered relatively low-permeability and may be suitable for use as backfill in the removal and replacement of expansive clays underlying new improvements.

Imported Granular Material: Imported granular fill material may include sand, gravel, fragmented rock, or recycled crushed concrete with a maximum size of 4 inches and with not more than about 8 percent passing the No. 200 sieve (washed analysis). Material satisfying these requirements can usually be placed during periods of wet weather. The first lift of granular fill placed over a fine-grained subgrade should be about 18 inches thick and subsequent lifts about 12 inches thick when using medium- to heavy-weight vibratory rollers. Granular structural fill should be limited to a maximum size of about 1-½ inches when compacted with hand-operated equipment. Lift thicknesses should be limited to less than 8 inches when using hand-operated vibratory plate compactors.

Free-Draining Fill: Free-draining material should have less than 2 percent passing the No. 200 sieve (washed analysis). Examples of materials that would satisfy this requirement include open-graded, angular ¾ to ¼ inch, 1½ to ¾ inch, or 3- to 1-inch crushed rock.

6.10 Permanent Slopes

Permanent cut and fill slopes should not exceed a grade of 2H:1V (Horizontal to Vertical). Slopes that will be maintained by mowing should not be constructed steeper than 3H:1V. Structures and paved surfaces should be located at least 15 feet from the crest of the slopes.

The slopes should be planted with vegetation to provide protection against erosion. Surface water runoff should be collected and directed away from slopes steeper than 3H:1V to prevent water from running down the face of the slope.

We understand a stormwater pond is planned in the southwest corner of the planned development, as shown in the preliminary grading plan provided to us by the project team (Figure 2). We understand the sides of the pond will be constructed with permanent cut or fill slopes having a maximum grade of 2H:1V. We recommend structures and paved surfaces maintain a minimum setback of 15 feet behind the crest of the pond slopes. Based on our review of the preliminary grading plan shown in Figure 2 and location of the currently planned stormwater pond, it is our opinion construction of the pond is feasible, provided the pond is lined to prevent infiltration.

6.11 Slope stability

Depending on the actual location of the planned residences, individual lot slope stability may be required once finalized plans are made available. STRATA should be notified once final plans are available so additional recommendations can be provided if necessary. A minimum setback of 25 feet should be adhered to, but may need to be increased based on final slope stability analysis.

6.12 Retaining Walls

6.12.1 Lateral Earth Pressures

The following recommendations assume that site retaining walls (where planned) will be less than 12 feet in height. The parameters stated for retaining wall design assume that backfill is drained and consists of imported granular structural fill (WSDOT specification for retaining walls) and that slopes are graded to drain surface water away from the wall. The following recommendations are not intended to be utilized for embedded basement walls in close proximity to expansive clay, as additional pressures will be applied if expansion of the clay unit occurs.

Backfill for retaining walls should extend a horizontal distance of H/2 from the back of wall, where H is the embedded height, and compacted as recommended for structural fill, except for backfill placed immediately adjacent to walls. To reduce pressure on walls, backfill located within a horizontal distance of 5 feet from retaining walls should be compacted to approximately 95 percent of the maximum dry density, as determined by ASTM D698, and should be compacted in maximum 6- to 8-inch-thick lifts (loose) using hand-operated compaction equipment (such as a jumping jack or vibratory plate compactor). Backfill greater than 5 feet from retaining walls should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D698.

For permanent site retaining walls not restrained from rotation (i.e., walls allowed to yield, should they exist) with a flat backslope, an equivalent fluid pressure (EFP) of 35 pcf may be used for design, and for restrained walls (i.e., embedded basement walls) an EFP of 55 pcf may be used for design. The EFP values provided above assume the grade behind wall is level, or sloping down and away from the wall, for a distance of at least 5 feet, and grade in front of wall is level or sloping up for a distance of at least 5 feet. Additional pressures may need to be accounted for if other surcharges are located within a horizontal distance from the back of a wall equal to twice the height of the wall, as discussed further below. Geotextile drainage products utilized behind the wall should conform to WSDOT Standard Specifications (SS) section 9-33.2. Moisture barrier applied to the concrete face behind the wall may be included at the discretion of the design architect.

The seismic (dynamic) lateral earth pressure increment for retaining walls can be estimated using equivalent fluid unit weights of 11 pcf for yielding walls and 22 pcf for restrained walls, to be added to the static pressures above. Seismic earth pressures for yielding and restrained walls were estimated using the Agusti and Sitar method (2013). The resultant load force may be assumed as acting at a distance of 0.3*H above the base of the wall. According to more recent, widely accepted research material[4], for restrained walls less than 12 feet height and designed to a factor of safety of 1.5 under static condition, the addition of a seismic surcharge load to the calculated static lateral load is unnecessary as applied to embedded (basement) walls.

Additional lateral pressures due to surcharge loading in the backfill area of retaining walls must be added to the above-recommended earth pressures. Additional lateral pressures induced by surcharge loads can be estimated using the guidelines provided on the attached Figure 4. We recommend assuming a minimum-250-psf vertical construction surcharge to account for typical construction equipment and traffic behind walls.

[4] *Reference: Sitar, Mikola and Candia (GeoCongress 2012, "Seismically Induced Lateral Earth Pressures on Retaining Structures and Basement Walls") and by Lew, Sitar, Atik, Pourzanjani.*

6.12.2 Retaining Wall Drainage

Retaining walls should have a minimum-12-inch-wide drainage zone of free-draining meeting the requirements in the Structural Fill section of this report and should be provided with a perforated drainpipe or weepholes at the bottom of the backfill. The drainage backfill should also conform to section 9-03.12(4) (Gravel Backfill for Drains) of WSDOT Standard Specifications (SS). A non-woven geotextile filter fabric, meeting the requirements of section 9-33.2 WSDOT SS for drainage geotextile, should be placed between the drainage blanket and general wall backfill. Section 9-05.2 of the WSDOT SS also provides guidelines for appropriate drainpipe materials and construction.

6.13 Asphalt Pavement

The pavement subgrade should be prepared in accordance with the previously described recommendations described in the "Construction Considerations", and "Structural Fill" sections of this report. Placing pavement base rock and pavement within close proximity to expansive clay stratum soils should be avoided.

We do not have specific information on the frequency and type of vehicles that will use the area; we assume that traffic conditions will be primarily light vehicles and fewer than 10 heavy trucks per day. We assume that subgrade stiffness will be relative soft, conforming to California Bearing Ratio (CBR) equal to 4 and the assumption that construction will be completed during a period of extended dry weather. An increased thickness of granular base course will be required if pavement construction occurs during wet weather conditions.

We recommend an asphalt pavement thickness of at least 3-1/2 inches of Asphalt Concrete (AC) over at least 10 inches of compacted crushed rock base, provided the subgrade is prepared in accordance with our recommendations.

The base aggregate should contain no deleterious materials, meet specifications provided in WSDOT SS 9-03.10 – Aggregate for Gravel Base, and have less than 5 percent (by dry weight) passing the US Standard No. 200 Sieve. The imported granular material should be placed in one lift and compacted to at least 95 percent of the maximum dry density as determined by AASHTO T-99. Aggregate base contaminated with soil during construction should be removed and replaced before paving.

The AC pavement should conform to Section 9-02 of the specifications. We recommend half inch dense graded Hot Mix Asphalt Concrete for Design Level 2 using Performance Grade Asphalt PG-64-22.

6.14 Infiltration Testing

Small-scale pilot infiltration testing (open-pit) was conducted at a depth of about 3.25 feet in test pit TP-2 in the approximate location shown on the Exploration Site Plan, Figure 2. The test was conducted in general conformance with the 2019 Stormwater Management Manual for Western Washington.

Due to groundwater levels near the ground surface and the presence of fine-grained material, we do not recommend on-site stormwater disposal at the project site. The recommended infiltration rate for the site is zero inches per hour.

6.15 Seismic Setting

6.15.1 General

We anticipate the project will likely be designed in accordance with the current International Building Code (IBC). For seismic design, the current IBC references American Society of Civil Engineers (ASCE) document 7-16, titled "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (ASCE 7-16). The current IBC and ASCE 7-16 seismic hazard levels are based on a Risk-Targeted Maximum Considered Earthquake (MCE_R).

Based on our review of the 2018 IBC and soils disclosed by our subsurface explorations, we recommend using Site Class D (Default) to evaluate the seismic design of the structures. The maximum horizontal-direction spectral response accelerations S_S and S_1 were obtained from the USGS Seismic Design Maps for the project coordinates. Site coefficients F_a and F_v were used to develop the Site Class D MCE_R-level spectrum in accordance with Section 11.4 of ASCE 7-16. However, Section 11.4.8 of ASCE 7-16 requires a ground-motion hazard analysis be completed for structures on Site Class D sites to determine the F_v coefficient when the S_1 parameter is greater than or equal to 0.2 g. The code provides an exception that waives the ground-motion hazard analysis if the seismic-response coefficient, C_s, is determined in accordance with Section 11.4.8, Exception 2, of ASCE 7-16. We anticipate the response coefficient will be developed as discussed above; therefore, the code-based, Site Class D, ground-surface MCE_R response spectrum is appropriate for design of the structures. The design-level response spectrum is calculated as two-thirds of the ground-surface MCE_R spectrum.

SEISMIC DESIGN PARAMETERS

2018 IBC/ASCE7-16 CODE BASED RESPONSE SPECTRUM MCE_R GROUND MOTION - 5% DAMPING 1% IN 50 YEARS PROBABILITY OF COLLAPSE			
LAT	46.4472	LON	-122.8535
S_S		1.03G	
S_1		0.45G	
MAPPED MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION PARAMETER (SITE CLASS D)			
F_A		1.2	
F_V		1.85	
S_{MS}		1.23G	
S_{M1}		0.83G*	
DESIGN SPECTRAL RESPONSE ACCELERATION PARAMETER			
S_{DS}		0.82G	
S_{D1}		0.56G*	

*Notes:
1) Exception 2 of Section 11.4.8 should be considered when evaluating base shear calculations in Section 12.8.
2) The S_{D1} value is intended only for calculating T_s

6.15.2 Seismic Hazards

Liquefaction is a phenomenon that occurs when saturated sandy silt, sand, and some gravel deposits lose strength and stiffness during strong seismic shaking. We encountered groundwater in our explorations performed at the site on January 11, 2022 at the ground surface in various portions of the site and at depths ranging from about 2.5 to 5 feet. However, based on the types of soils present at the site and the topography, the potential for earthquake-induced liquefaction and slope instability is low. Review of available geologic literature indicates the nearest mapped fault is located about 1.5 miles southwest of the site. The fault is mapped as inactive. Additional inactive faults are mapped within about 7 to 8 miles east, south, and west of the site. In our opinion, the risk of ground rupture during a design-level earthquake is low unless occurring on a previously unknown or unmapped fault. The risk of tsunami inundation at the site is essentially absent.

7.0 ADDITIONAL SERVICES

Because the future performance and integrity of the structural elements will depend largely on proper site preparation, drainage, excavations, fill placement, and construction procedures, monitoring and testing (geotechnical special inspection) by experienced geotechnical personnel should be considered an integral part of the design and construction process. Consequently, we recommend that STRATA be retained to provide the following post-investigation services:

- Review construction plans and specifications to verify that our design criteria presented in this report have been properly integrated into the design.
- Attend a pre-construction conference with the design team and contractor to discuss geotechnical construction issues, erosion control measures, and maintain slope stability.
- Observe placement of fill and conduct density testing of structural fill.
- Conduct density testing of underground utility backfill.
- Observe proof rolling of pavement and curb line base rock and compaction of asphalt pavement as it is placed.
- Observe footing subgrade before footings are constructed to verify the soil conditions.
- Prepare a post-construction letter-of-compliance summarizing our field observations, inspections, and test results.

8.0 LIMITATIONS

This report has been prepared for the exclusive use of the addressee, and their architects and engineers, for aiding in the design and construction of the proposed development and is not to be relied upon by other parties. It is not to be photographed, photocopied, or similarly reproduced, in total or in part, without the express written consent of the client and STRATA. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials, and contractors to ensure the correct implementation of the recommendations.

The opinions, comments, and conclusions presented in this report are based upon information derived from our literature review, field explorations, laboratory testing, and engineering analyses. It is possible that soil, rock, or groundwater conditions could vary between or beyond the points explored. If soil, rock, or groundwater conditions are encountered during construction that differ from those described herein, the client is responsible for ensuring that STRATA is notified immediately so that we may reevaluate the recommendations of this report.

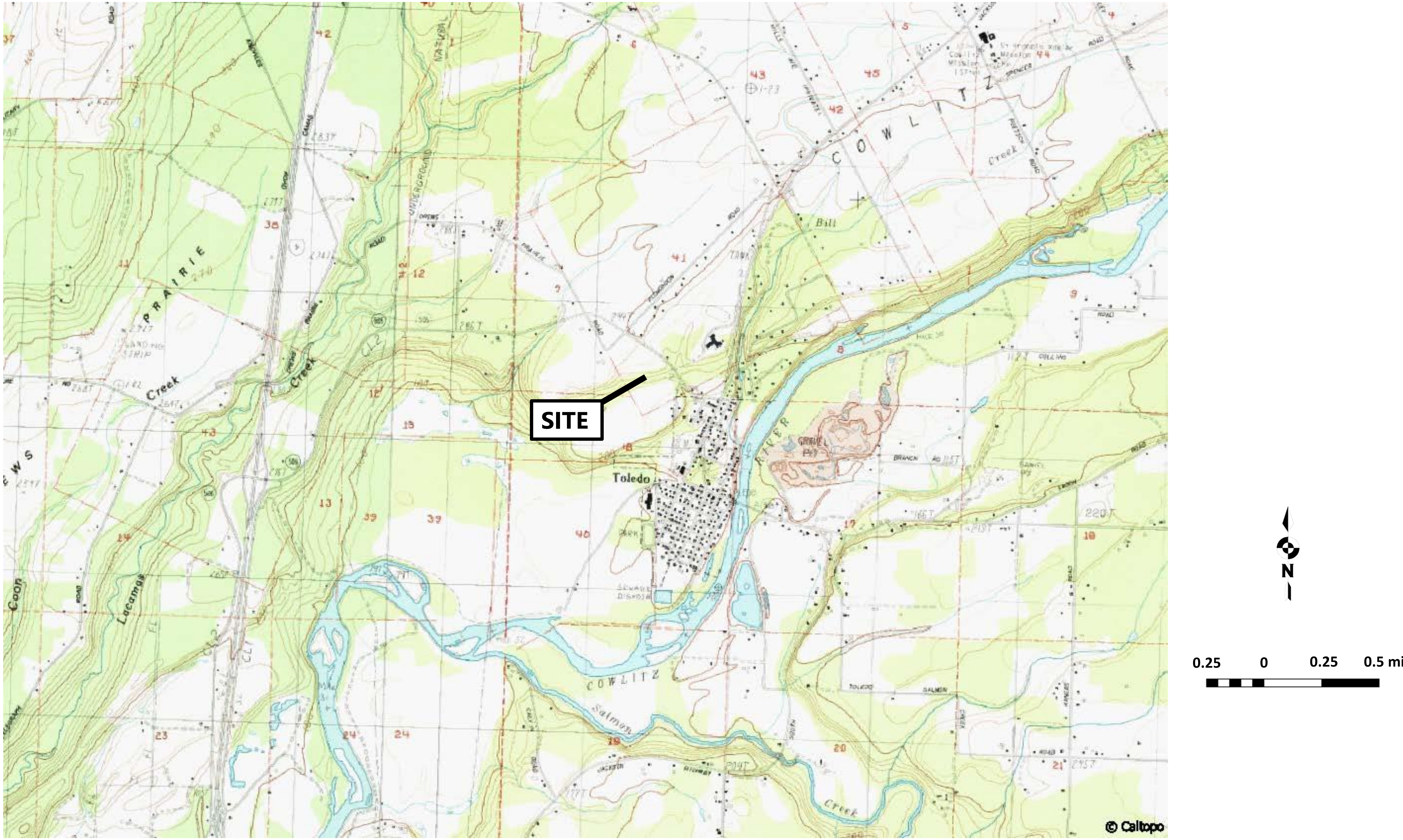
Unanticipated fill, soil, and rock conditions, and seasonal soil moisture and groundwater variations are commonly encountered and cannot be fully determined by merely taking soil samples or completing explorations such as soil borings or test pits. Such variations may result in changes to our recommendations and may require additional funds for expenses to attain a properly constructed project; therefore, we recommend a contingency fund to accommodate such potential extra costs.

The scope of work for this subsurface exploration and geotechnical report did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or groundwater at this site.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, if conditions have changed due to natural causes or construction operations at or adjacent to the site, or if the basic project scheme is significantly modified from that assumed, this report should be reviewed to determine the applicability of the conclusions and recommendations presented herein. Land use, site conditions (both on and off site), or other factors may change over time and could materially affect our findings; therefore, this report should not be relied upon after three years from its issue or if the site conditions change

♦ ♦ ♦

FIGURES



STRATA DESIGN

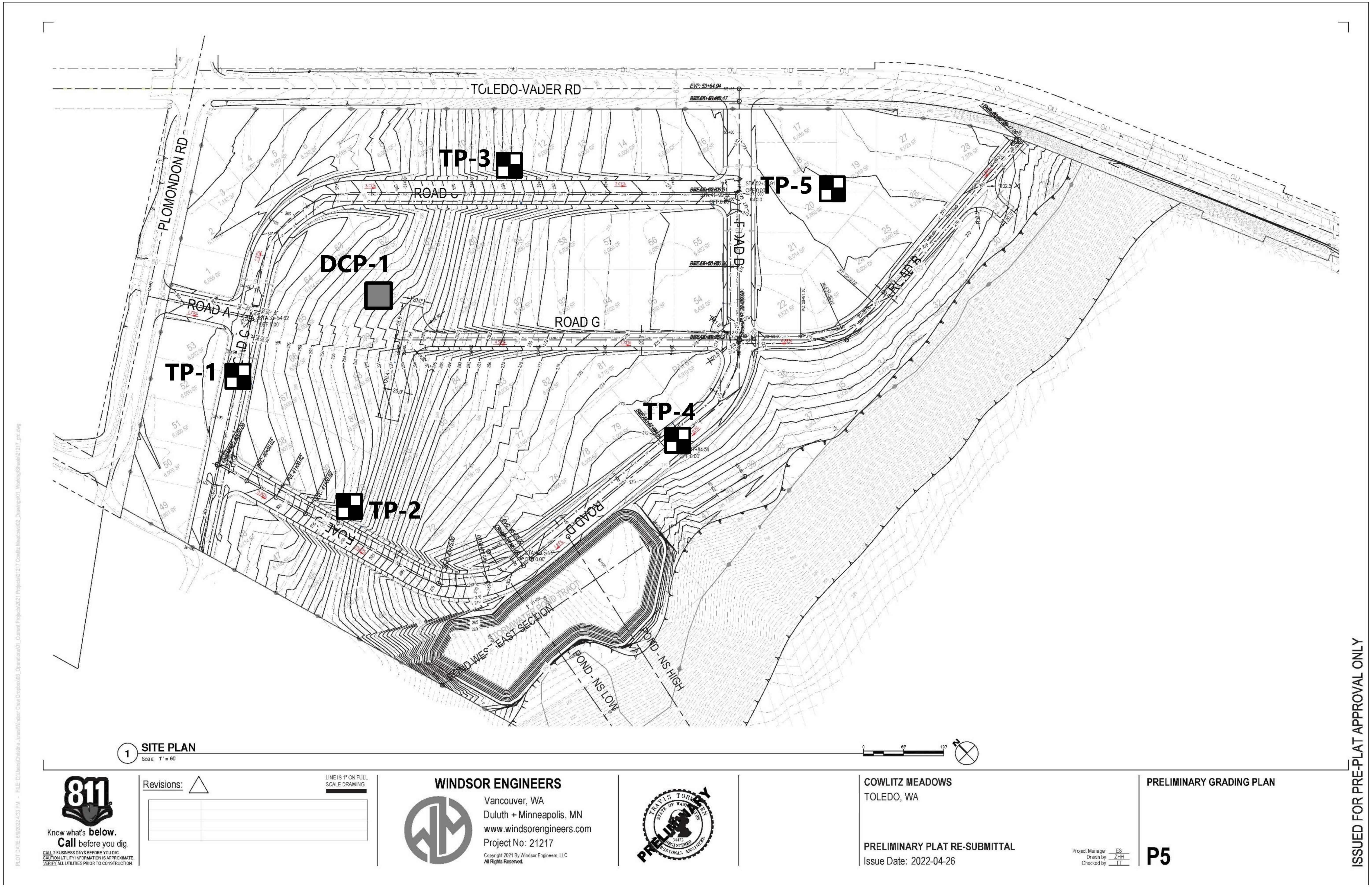
Project No. 22-0628

June 2022

37-Acre Subdivision, 0 Toledo-Vader Road – Vicinity Map

Toledo, Washington

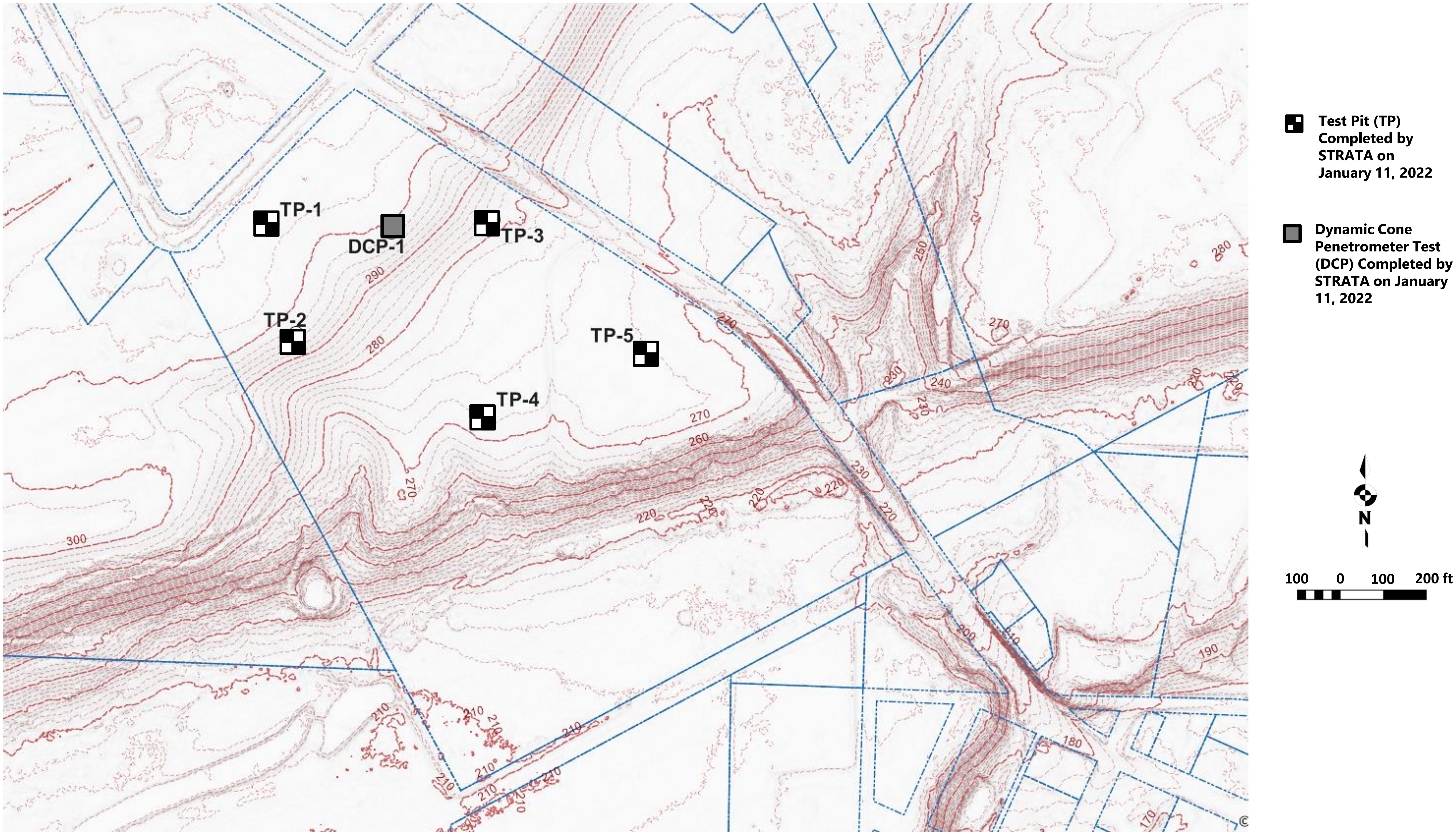
Figure 1



Test Pit (TP) Completed by STRATA on January 11, 2022

Dynamic Cone Penetrometer Test (DCP) Completed by STRATA on January 11, 2022

STRATA DESIGN	Project No. 22-0628 June 2022	**37-Acre Subdivision, 0 Toledo-Vader Road** Toledo, Washington	**Figure 2**



STRATA DESIGN

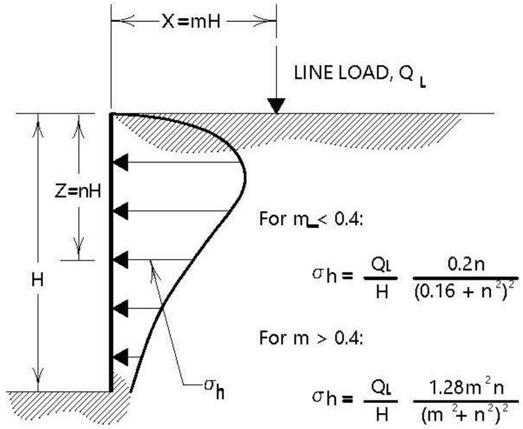
Project No. 22-0628

June 2022

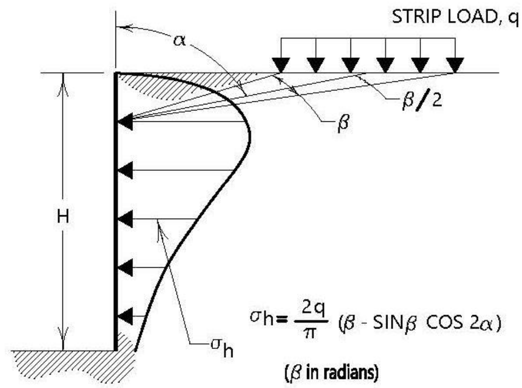
37-Acre Subdivision, 0 Toledo-Vader Road – Site Plan (LiDAR Contours)

Toledo, Washington

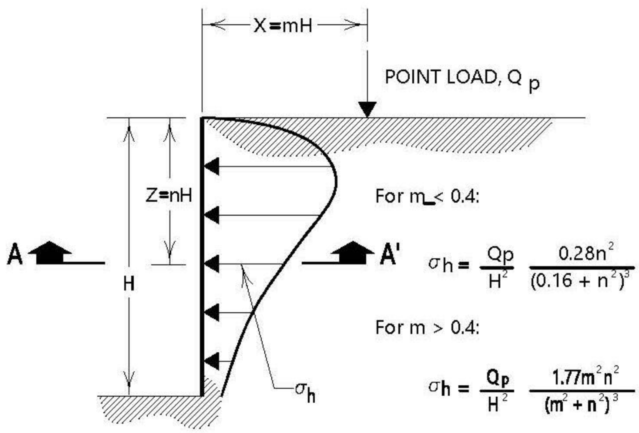
Figure 3

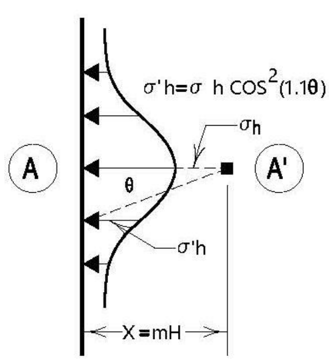


LINE LOAD PARALLEL TO WALL



STRIP LOAD PARALLEL TO WALL





DISTRIBUTION OF HORIZONTAL PRESSURES

VERTICAL POINT LOAD

NOTES:

1. THESE GUIDELINES APPLY TO RIGID WALLS WITH POISSON'S RATIO ASSUMED TO BE 0.5 FOR BACKFILL MATERIALS.

2. LATERAL PRESSURES FROM ANY COMBINATION OF ABOVE LOADS MAY BE DETERMINED BY THE PRINCIPLE OF SUPERPOSITION.

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Proposed 37-Acre Subdivision
Surcharge-Induced Lateral Earth Pressures
Toledo-Vader Road
Toledo, Washington

FIGURE

4

APPENDIX A

Field Explorations and Laboratory Testing

APPENDIX A: FIELD EXPLORATIONS AND LABORATORY TESTING

A1 GENERAL

The site was explored by STRATA on January 11, 2022. The subsurface explorations included advancing five excavated test pits, designated TP-1 through TP-5, to depths ranging from about 7 to 13 feet bgs. The approximate locations of the explorations are shown on the Site Exploration Plan, Figure 2. The procedures used to excavate the test pits, collect samples, and other field techniques are described in detail in the following paragraphs. Unless otherwise noted, all soil sampling and classification procedures followed engineering practices in general accordance with relevant ASTM procedures. "General accordance" means that certain local drilling/excavation and descriptive practices and methodologies have been followed.

A2 EXPLORATIONS AND SAMPLING

A2.1 Test Pit Excavation

The test pit was excavated using a narrow bucket equipped to a mini-trackhoe. The test pit was observed by a member of the STRATA geotechnical staff, who maintained a log of the subsurface conditions and materials encountered during the course of the work.

A2.2 Dynamic Cone Penetrometer (DCP) Testing

One DCP was advanced using the Wildcat DCP. Wildcat© Dynamic Cone Penetrometer (DCP) tests were advanced by STRATA using the DCP equipment. The DCP consists of driving 1.1-inch-diameter, steel rods with a 1.4-inch-diameter, cone tip into the ground using a 35-pound drop hammer with a 15-inch, free-fall height. The number of blows required to drive the steel rods is recorded for each 10 centimeters (3.94 inches) of penetration. The test log for the dynamic cone penetrometer is shown Appendix A.

A2.3 Sampling

Disturbed grab samples were collected from the excavator bucket at selected depth intervals at the time of test pit excavation. The disturbed soil samples were examined by a member of the STRATA geotechnical staff and then sealed in plastic bags for further examination in our laboratory.

A2.4 Test Pit Logs

The test pit logs show the various types of materials that were encountered in the test pits and the depths where the materials and/or characteristics of these materials changed, although the changes may be gradual. Where material types and descriptions changed between samples, the contacts were interpreted. The types of samples taken during excavating, along with their sample identification number, are shown to the left of the classification of materials.

A3 MATERIAL DESCRIPTION

Initially, samples were classified visually in the field. Consistency, color, relative moisture, degree of plasticity, and other distinguishing characteristics of the soil samples were noted. Afterward, the samples were reexamined in the STRATA laboratory and the field classifications were modified where necessary. The terminology used in the soil classifications and other modifiers are defined in Table A-1, Guidelines for Classification of Soil.

A4 LABORATORY TESTING

A4.1 General

Samples obtained during the field explorations were examined in the STRATA laboratory. The physical characteristics of the samples were noted and field classifications were modified where necessary. During the course of examination, representative samples were selected for further testing. The testing program for the soil samples included standard classification tests, which yield certain index properties of the soils important to an evaluation of soil behavior. The testing procedures are described in the following paragraphs. Unless noted otherwise, all test procedures are in general accordance with applicable ASTM standards. "General accordance" means that certain local and common descriptive practices and methodologies have been followed.

A4.2 Visual Classification

The soils were classified in accordance with the Unified Soil Classification System with certain other terminology, such as the relative density or consistency of the soil deposits, in general accordance with engineering practice. In determining the soil type (that is, gravel, sand, silt, or clay) the term that best described the major portion of the sample was used. Modifying terminology to further describe the samples is defined in Table A-1, Guidelines for Classification of Soil, in Appendix A.

A4.3 Moisture (Water) Contents

Natural moisture content determinations were made on samples of the fine-grained soils (that is, silts, clays, and silty sands). The natural moisture content is defined as the ratio of the weight of water to dry weight of soil, expressed as a percentage. The results of the moisture content determinations are presented on the logs of the test pits in Appendix A.

A4.4 Atterberg Limits

Atterberg-limits determinations were completed on a select soil sample in substantial conformance with ASTM D4318. The results of the Atterberg-limits test are presented in Appendix A.

Table 1A

GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values), blows/ft
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values), blows/ft	Torvane or Undrained Shear Strength, tsf
Very Soft	0 - 2	less than 0.125
Soft	2 - 4	0.125 - 0.25
Medium Stiff	4 - 8	0.25 - 0.50
Stiff	8 - 15	0.50 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	over 30	over 2.0

Grain-Size Classification
Boulders: >12 in.
Cobbles: 3-12 in.
Gravel: ¼ - ¾ in. (fine) ¾ - 3 in. (coarse)
Sand: No. 200 - No. 40 sieve (fine) No. 40 - No. 10 sieve (medium) No. 10 - No. 4 sieve (coarse)
Silt/Clay: Pass No. 200 sieve

Modifier for Subclassification		
	Primary Constituent SAND or GRAVEL	Primary Constituent SILT or CLAY
Adjective	Percentage of Other Material (By Weight)	
trace:	5 - 15 (sand, gravel)	5 - 15 (sand, gravel)
some:	15 - 30 (sand, gravel)	15 - 30 (sand, gravel)
sandy, gravelly:	30 - 50 (sand, gravel)	30 - 50 (sand, gravel)
trace:	<5 (silt, clay)	*Relationship of clay and silt determined by plasticity index test*
some:	5 - 12 (silt, clay)	
silty, clayey:	12 - 50 (silt, clay)	

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Test Pit: TP-1

Project:	37-Acre Subdivision, 0 Toledo-Vader Road	Date start:	1/11/2022
Project ID:	22-0628	Date end:	1/11/2022
Location:			
Client	Windsor Engineers	Easting:	
Drilling Co.:		Northing:	
Method of drilling:		Ground Elevation:	
Logged by:	Checked by:	Altitude system:	
Notes:		Scale:	

Depth [ft]	Samples and GWT	Recovery [%]	MC [%]	Number of Blows [BL/12 in]	USCS Classification	Layers description	Drilling Notes
0.00–1.00					ML	Dark brown, SILT, trace clay and fine-grained sand (ML), very soft, (Topsoil), 6-in.-thick heavily rooted zone at ground surface	
1.00–3.00	S-1 (Grab) at 2.00; GWT 2.50				ML	Brown, SILT, some clay, trace fine-grained sand (ML), soft moderate to heavy seepage at 2.5 ft	
3.00–6.00	S-2 (Grab) at 4.50				ML	Brown mottled rust and black, SILT, trace clay (ML), medium stiff to stiff (Residual Soil)	
6.00–10.00	S-3 (Grab) at 7.00; S-4 (Grab) at 9.00				GW-GM	Brown mottled rust and black, gravelly clayey SILT to silty clayey GRAVEL with variable percentages of fine-to-coarse-grained sand (GW-GM), contains subrounded cobbles and boulders, very stiff or medium dense to dense, may contain boulders Hard or dense to very dense below 8 ft Excavator refusal at 10 ft	

Key:

GWT bored — disturbed

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Test Pit: TP-2

Project:	37-Acre Subdivision, 0 Toledo-Vader Road	Date start:	1/11/2022
Project ID:	22-0628	Date end:	1/11/2022
Location:			
Client	Windsor Engineers	Easting:	
Drilling Co.:		Northing:	
Method of drilling:		Ground Elevation:	
Logged by:	Checked by:	Altitude system:	
Notes:		Scale:	

Depth [ft]	Samples and GWT	Recovery [%]	MC [%]	Number of Blows [BL/12 in]	USCS Classification	Graphical log	Layers description	Drilling Notes
0.00 – 1.00					ML		Dark brown, SILT, trace fine-grained sand (ML), very soft (Topsoil), 6-inch-thick heavily rooted zone at ground surface	
1.00 – 3.00	S-1 (Grab) at 2.00				ML		Brown, SILT, trace fine-grained sand (ML), soft	
3.00 – 7.00	S-2 (Grab) at 3.25; GWT 4.00; S-3 (Grab) at 6.50				GW-GM		Brown mottled rust, GRAVEL and COBBLES in a matrix of sand and silt (GW-GM), medium dense to dense, may contain boulders Infiltration Test Completed at 3.25 ft Light seepage at 4 ft	

Depth scale: 0.00, 0.50, 1.00, 1.50, 2.00, 2.50, 3.00, 3.50, 4.00, 4.50, 5.00, 5.50, 6.00, 6.50, 7.00

Key:

GWT bored · disturbed

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Test Pit: TP-3

Project:	37-Acre Subdivision, 0 Toledo-Vader Road	Date start:	1/11/2022
Project ID:	22-0628	Date end:	1/11/2022
Location:			
Client	Windsor Engineers	Easting:	
Drilling Co.:		Northing:	
Method of drilling:		Ground Elevation:	
Logged by:	Checked by:	Altitude system:	
Notes:		Scale:	

Depth [ft]	Samples and GWT	Recovery [%]	MC [%]	Number of Blows [BL/12 in]	USCS Classification	Graphical log	Layers description	Drilling Notes
0.00–1.00					ML		Dark brown, SILT, trace fine-grained sand (ML), very soft (Topsoil), 6-inch-thick heavily rooted zone at ground surface	
1.00–11.00	2.00: S-1 (Grab); 3.50: S-2 (Grab); 4.00: GWT 4.00; 7.00: S-3 (Grab); 11.00: S-4 (Grab)				ML		Brown, SILT, trace fine-grained sand, trace clay (ML), soft, contains occasional subrounded cobbles and fine roots Moderate to heavy seepage at 4 ft Brown mottled rust and black, medium stiff to stiff, roots absent below 6 ft Heavy seepage at 6 feet	
11.00–13.00	12.50: S-5 (Grab)				CH		Light gray mottled rust and yellow, silty CLAY (CH), trace fine-grained sand, stiff, contains occasional rounded gravel and cobbles	

Key:
GWT bored; disturbed

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Test Pit: TP-4

Project:	37-Acre Subdivision, 0 Toledo-Vader Road	Date start:	1/11/2022
Project ID:	22-0628	Date end:	1/11/2022
Location:			
Client	Windsor Engineers	Easting:	
Drilling Co.:		Northing:	
Method of drilling:		Ground Elevation:	
Logged by:	Checked by:	Altitude system:	
Notes:		Scale:	

Depth [ft]	Samples and GWT	Recovery [%]	MC [%]	Number of Blows [BL/12 in]	USCS Classification	Graphical log	Layers description	Drilling Notes
0.00 – 1.00					ML		Dark brown, SILT, trace fine-grained sand (ML), very soft (Topsoil), 6-inch-thick heavily rooted zone at ground surface	
1.00 – 3.00	S-1 (Grab) at 2.00				ML		Brown, SILT, trace fine-grained sand (ML), soft	
3.00 – 7.50	3.00 ▽; S-2 (Grab) at 3.00				CH		Light gray, CLAY, some silt (CH), medium stiff to stiff Very light seepage at 3 feet	
7.50 – 8.50	S-3 (Grab) at 7.50				GW-GM		Light gray mottled rust, GRAVEL and COBBLES in a matrix of sand, silt, and clay (GW-GM), medium dense, contains fragments of decomposed rock, may contain boulders	

Depth scale: 0.00, 0.50, 1.00, 1.50, 2.00, 2.50, 3.00, 3.50, 4.00, 4.50, 5.00, 5.50, 6.00, 6.50, 7.00, 7.50, 8.00, 8.50

Key:

▽ GWT bored   ◩ disturbed

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Test Pit: TP-5

Project:	37-Acre Subdivision, 0 Toledo-Vader Road	Date start:	1/11/2022
Project ID:	22-0628	Date end:	1/11/2022
Location:			
Client	Windsor Engineers	Easting:	
Drilling Co.:		Northing:	
Method of drilling:		Ground Elevation:	
Logged by:	Checked by:	Altitude system:	
Notes:		Scale:	

Depth [ft]	Samples and GWT	Recovery [%]	MC [%]	Number of Blows [BL/12 in]	USCS Classification	Graphical log	Layers description	Drilling Notes
0.00–1.00					ML		Dark brown, SILT, trace fine-grained sand (ML), very soft (Topsoil), 6-inch-thick heavily rooted zone at ground surface	
1.00–4.00	S-1 (Grab) at 2.00				ML		Brown, SILT, trace clay and fine-graned sand (ML), soft, contains occasional fine roots Fine roots absent below 3 ft Moderate seepage at 3 ft	
4.00–7.00	GWT 5.00; S-2 (Grab) at 5.00				CH		Light gray, CLAY, some silt (CH), medium stiff Moderate to heavy seepage below 5 ft	LL=58% PL=20% PI=38%
7.00–11.00	S-3 (Grab) at 7.50; S-4 (Grab) at 11.00				GW-GM		Gray mottled rust, GRAVEL and COBBLES in a matrix of sand and silt (GW-GM), medium dense to dense, subangular to subrounded, may contain boulders Very dense below 11 ft, refusal at 12 ft	

Key:
GWT bored   disturbed

WILDCAT DYNAMIC CONE LOG

PROJECT NUMBER: 22-0628
DATE STARTED: 01-11-2022
DATE COMPLETED: 01-11-2022

HOLE #: DCP-1
CREW: AKB
PROJECT: Proposed 37-Acre Subdivision
ADDRESS:
LOCATION: Toledo, Washington

SURFACE ELEVATION:
WATER ON COMPLETION:
HAMMER WEIGHT: 35 lbs.
CONE AREA: 10 sq. cm

	BLOWS	RESISTANCE	GRAPH OF CONE RESISTANCE		TESTED CONSISTENCY	
DEPTH	PER 10 cm	Kg/cm²	0 50 100 150	N'	NON-COHESIVE	COHESIVE
-	0	0.0		0	VERY LOOSE	VERY SOFT
-	3	13.3	•••	3	VERY LOOSE	SOFT
- 1 ft	3	13.3	•••	3	VERY LOOSE	SOFT
-	3	13.3	•••	3	VERY LOOSE	SOFT
-	3	13.3	•••	3	VERY LOOSE	SOFT
- 2 ft	2	8.9	••	2	VERY LOOSE	SOFT
-	2	8.9	••	2	VERY LOOSE	SOFT
-	3	13.3	•••	3	VERY LOOSE	SOFT
- 3 ft	3	13.3	•••	3	VERY LOOSE	SOFT
- 1 m	3	13.3	•••	3	VERY LOOSE	SOFT
-	2	7.7	••	2	VERY LOOSE	SOFT
- 4 ft	5	19.3	•••••	5	LOOSE	MEDIUM STIFF
-	15	57.9	•••••••••••••••	16	MEDIUM DENSE	VERY STIFF
-	19	73.3	•••••••••••••••••••	20	MEDIUM DENSE	VERY STIFF
- 5 ft	18	69.5	••••••••••••••••••	19	MEDIUM DENSE	VERY STIFF
-	23	88.8	•••••••••••••••••••••••	25	MEDIUM DENSE	VERY STIFF
-	25	96.5	•••••••••••••••••••••••••		MEDIUM DENSE	VERY STIFF
- 6 ft						
-						
- 2 m						
- 7 ft						
-						
-						
- 8 ft						
-						
-						
- 9 ft						
-						
-						
- 3 m 10 ft						
-						
-						
-						
- 11 ft						
-						
-						
- 12 ft						
-						
-						
- 4 m 13 ft						

APPENDIX C

MGSFlood Report

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.58
Program License Number: 202010002
Project Simulation Performed on: 01/17/2023 6:08 PM
Report Generation Date: 01/17/2023 6:25 PM

Input File Name: 2022-12-12_ALL SPLASH BLOCKS.fld
Project Name: Cowlitz Meadows
Analysis Title:
Comments:

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Full Period of Record Available used for Routing

Climatic Region Number: 4
Precipitation Station : 95004405 Puget West 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 951044 Puget West 44 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : Ecology Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********************** WATERSHED DEFINITION ***********************

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	20.660	20.663
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	20.660	20.663

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
C, Forest, Mod	20.660
Subbasin Total	20.660

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
C, Pasture, Mod	9.120
C, Lawn, Mod	5.570
ROADS/MOD	3.810
DRIVEWAYS/FLAT	1.670
POND	0.493
Subbasin Total	20.663

************************* **LINK DATA** *******************************

---------------------SCENARIO: PREDEVELOPED
Number of Links: 0

************************* **LINK DATA** *******************************

---------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: Detention Pond
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 261.00
Riser Crest Elevation (ft) : 268.00
Max Pond Elevation (ft) : 271.00
Storage Depth (ft) : 7.00
Pond Bottom Length (ft) : 146.0
Pond Bottom Width (ft) : 146.0
Pond Side Slopes (ft/ft) : Z1= 3.00 Z2= 3.00 Z3= 3.00 Z4= 3.00
Bottom Area (sq-ft) : 21316.
Area at Riser Crest El (sq-ft) : 35,344.
(acres) : 0.811
Volume at Riser Crest (cu-ft) : 196,252.
(ac-ft) : 4.505
Area at Max Elevation (sq-ft) : 42436.
(acres) : 0.974
Vol at Max Elevation (cu-ft) : 312,760.
(ac-ft) : 7.180

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 6.00
Common Length (ft) : 0.000
Riser Crest Elevation : 268.00 ft

Hydraulic Structure Geometry

Number of Devices: 3

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 261.50
Diameter (in) : 2.00
Orientation : Vertical
Elbow : No

---Device Number 2 ---
Device Type : Circular Orifice
Control Elevation (ft) : 266.50
Diameter (in) : 1.00
Orientation : Vertical
Elbow : No

---Device Number 3 ---
Device Type : Circular Orifice
Control Elevation (ft) : 267.50
Diameter (in) : 2.50
Orientation : Vertical
Elbow : Yes

************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 0

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

********** **Subbasin: Subbasin 1** **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	3.833
5-Year	5.268
10-Year	6.324
25-Year	7.813
50-Year	9.634
100-Year	10.653
200-Year	10.961
500-Year	11.370

********** Link: Detention Pond ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	3.833
5-Year	5.268
10-Year	6.324
25-Year	7.813
50-Year	9.634
100-Year	10.653
200-Year	10.961
500-Year	11.370

********** Link: Detention Pond ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	264.342
1.11-Year	264.672
1.25-Year	265.328
2.00-Year	267.159
3.33-Year	267.949
5-Year	268.152
10-Year	268.508
25-Year	268.998
50-Year	269.408
100-Year	269.475

**************Groundwater Recharge Summary** *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	3858.282
Total:	3858.282

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	2252.492
Link: Detention Pond	0.000
Total:	2252.492

Total Predevelopment Recharge is Greater than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 24.420 ac-ft/year, Post Developed: 14.256 ac-ft/year

***********__Water Quality Facility Data__*************

---------------------SCENARIO: PREDEVELOPED

Number of Links: 0

---------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: Detention Pond **********

Basic Wet Pond Volume (91% Exceedance): 61164. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 91747. cu-ft

2-Year Discharge Rate : 0.273 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 1.16 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.65 cfs

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 6073.21
Inflow Volume Including PPT-Evap (ac-ft): 6073.21
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 6072.80
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

***********__Compliance Point Results__*************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: Detention Pond

*** **Point of Compliance Flow Frequency Data** ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.689	2-Year	0.273
5-Year	1.074	5-Year	0.693
10-Year	1.390	10-Year	1.030
25-Year	1.817	25-Year	1.305
50-Year	2.181	50-Year	1.491
100-Year	2.568	100-Year	1.518
200-Year	2.810	200-Year	1.562
500-Year	3.133	500-Year	1.621

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** **Flow Duration Performance** ****

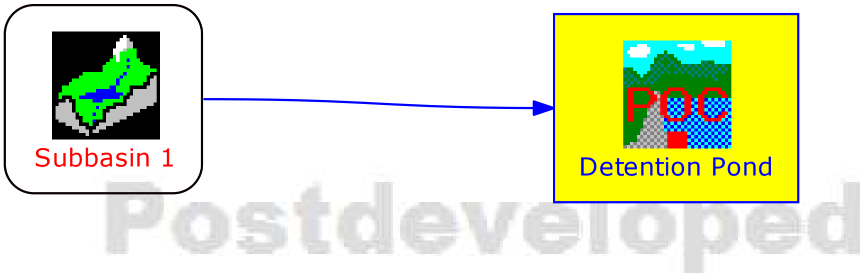
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-61.3%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-34.8%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-3.4%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	182.3%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	193.2%	FAIL

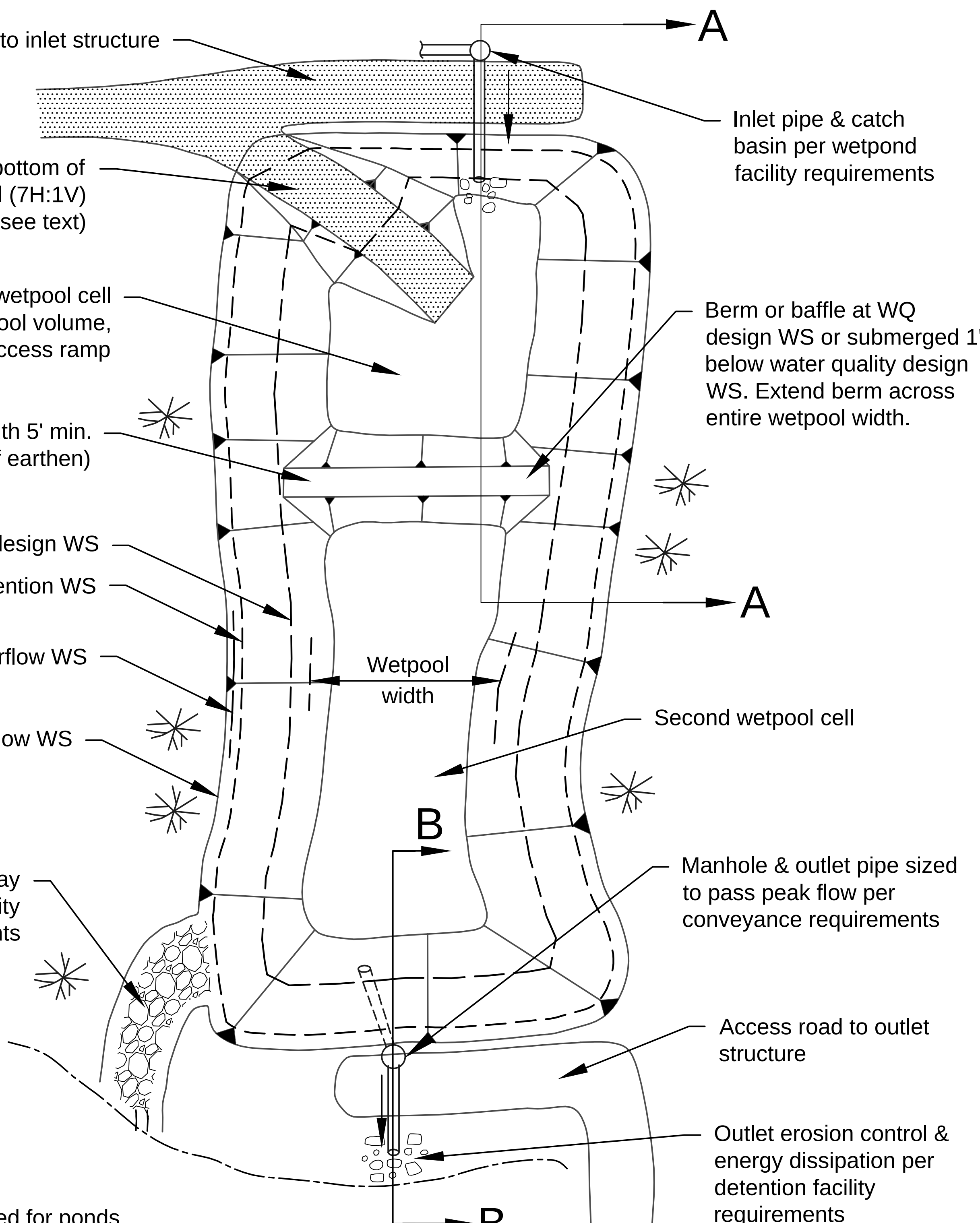
LID DURATION DESIGN CRITERIA: FAIL


Subbasin 1
POC
Detention Pond
Postdeveloped

Predeveloped

APPENDIX D

BMP Details



Note: Berm not required for ponds with length to width ratio ≥ 4:1 or if volume less than 4000c.f.

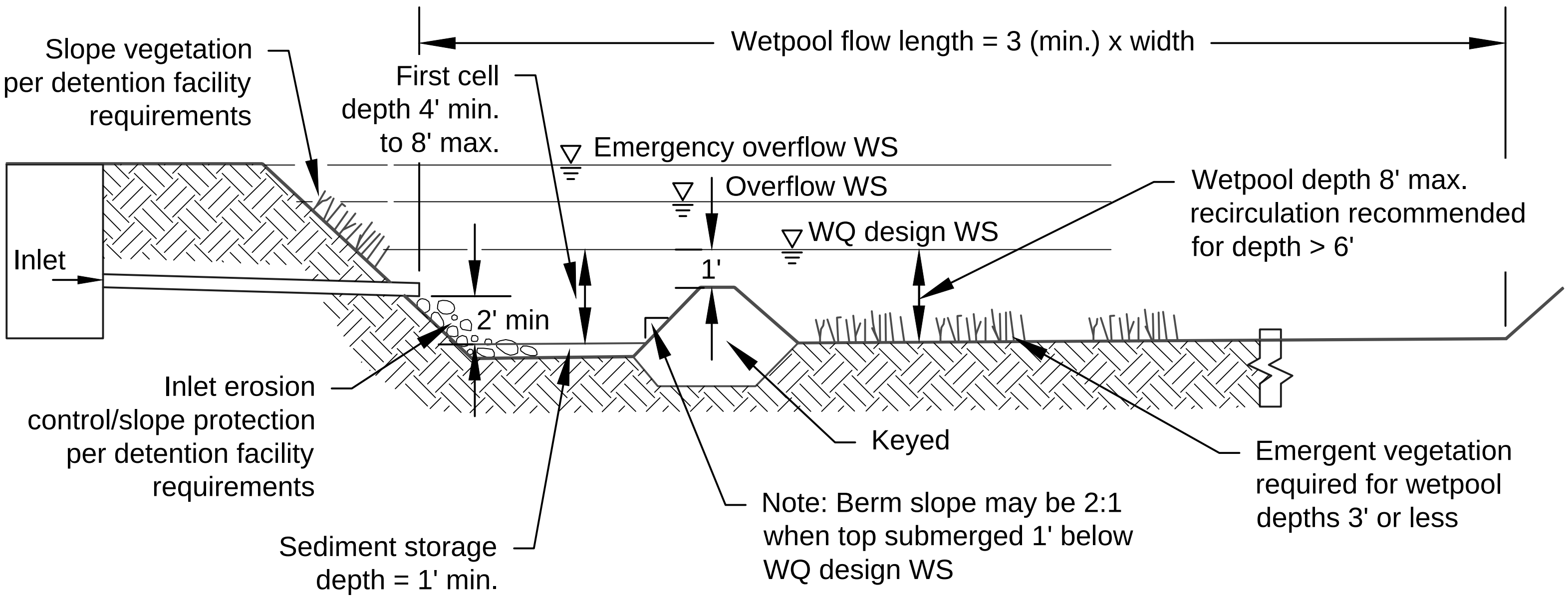
Plan View

NOT TO SCALE

DEPARTMENT OF ECOLOGY
State of Washington

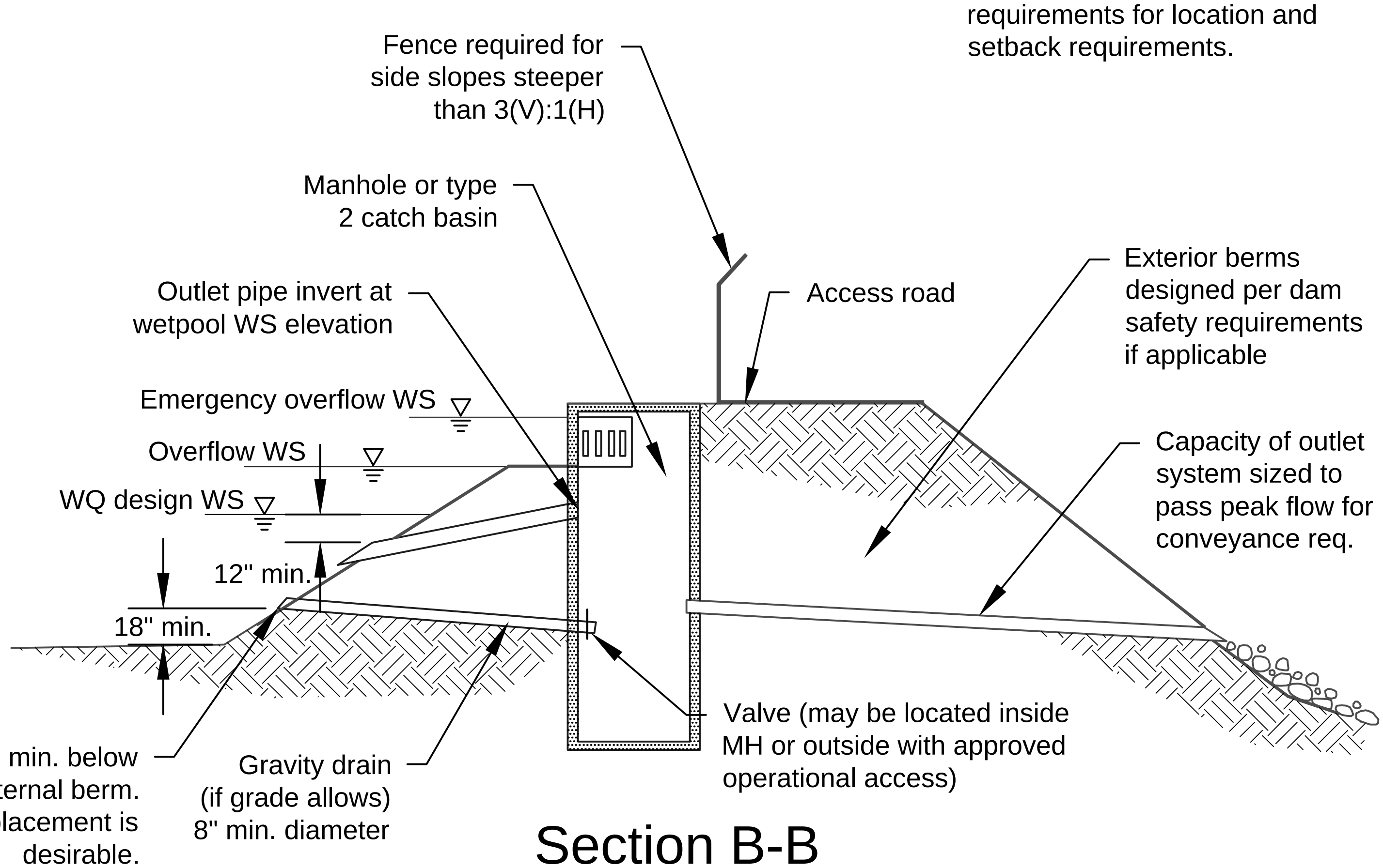
Wetpond (Plan View)

Revised June 2016



Section A-A

Note: See detention facility requirements for location and setback requirements.



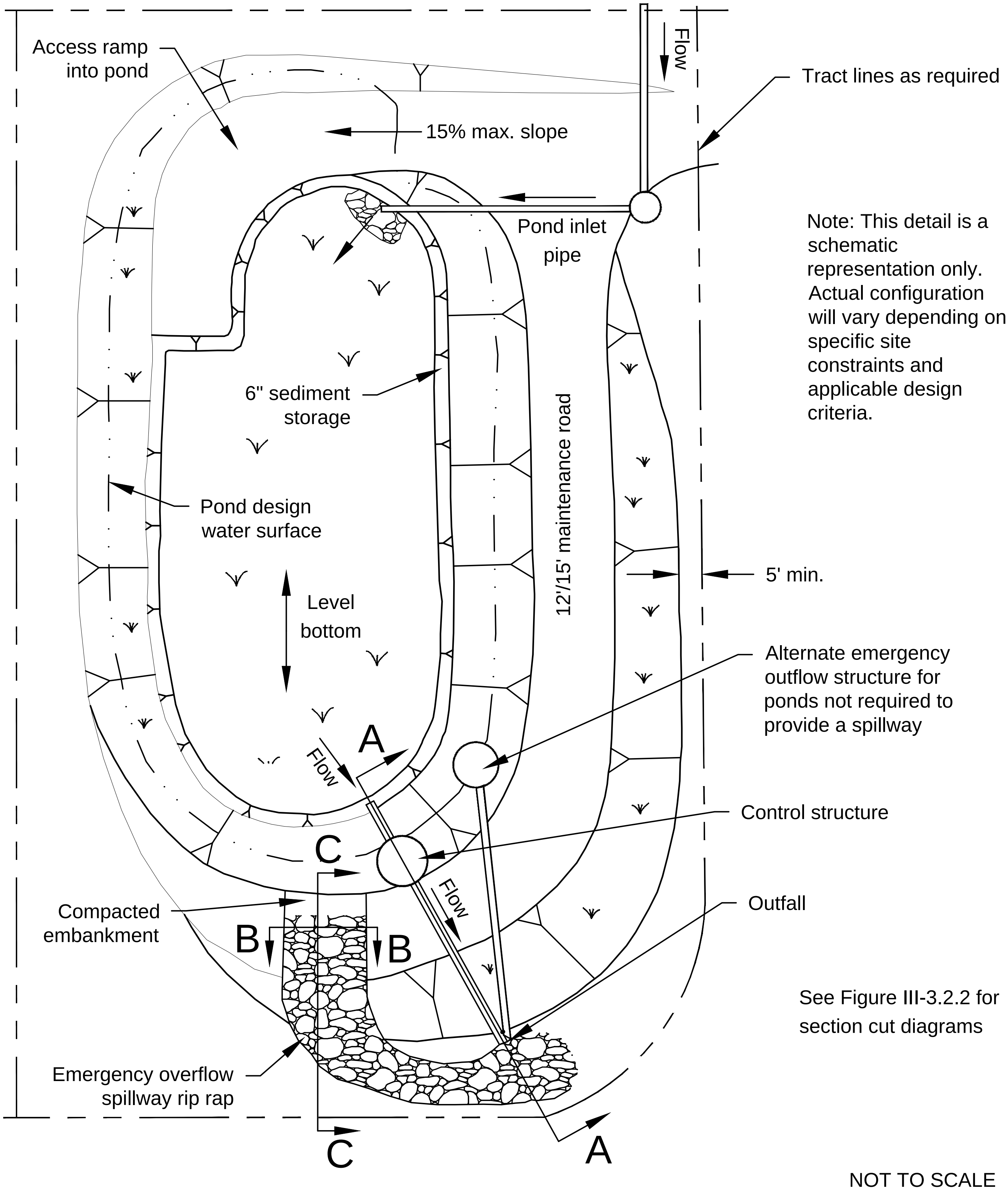
Section B-B

NOT TO SCALE

DEPARTMENT OF ECOLOGY
State of Washington

Wetpond (Section View)

Revised June 2016

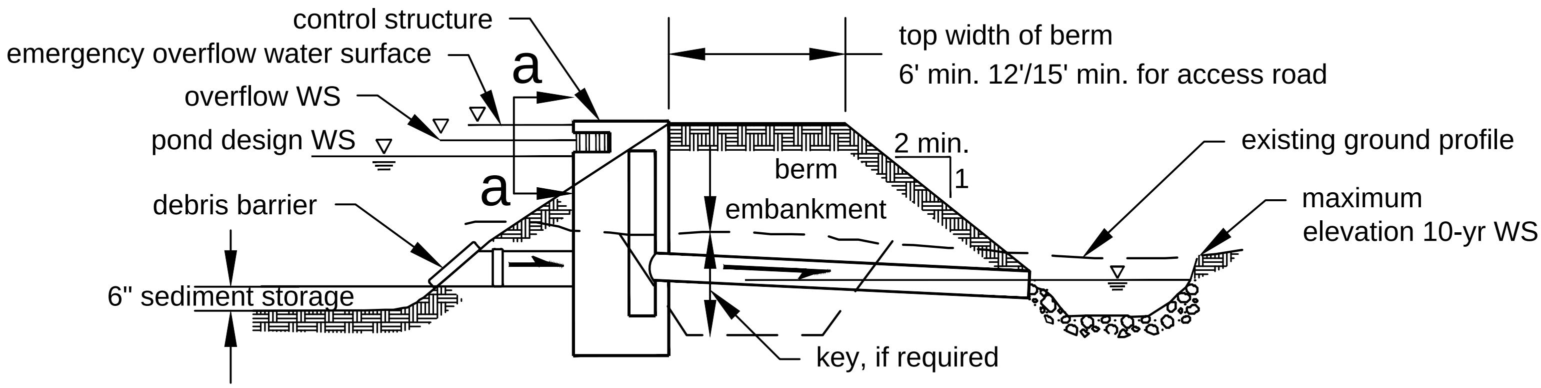


DEPARTMENT OF ECOLOGY

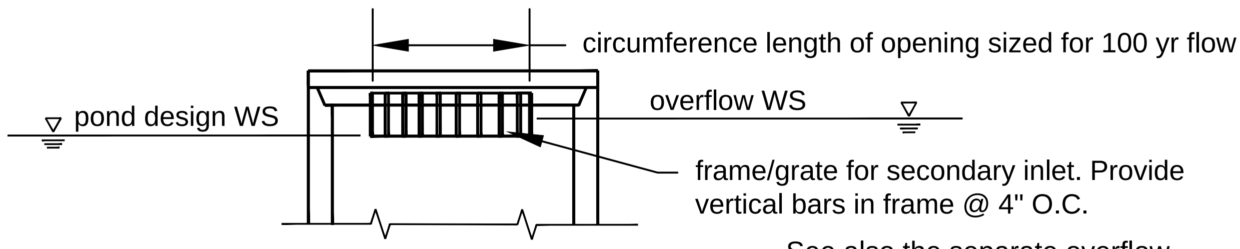
State of Washington

Typical Detention Pond

Revised June 2016

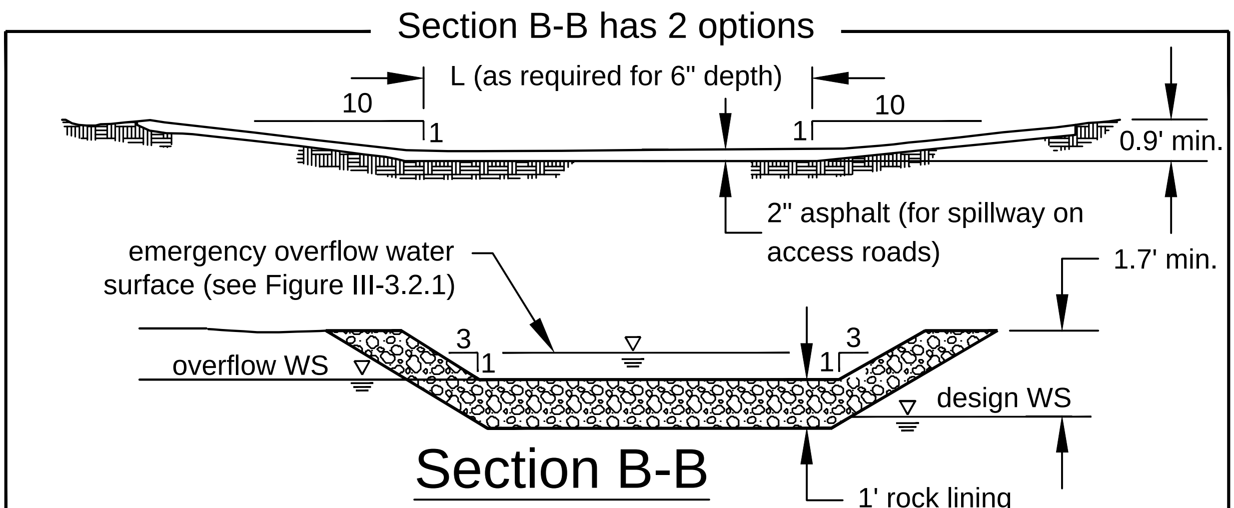


Section A-A



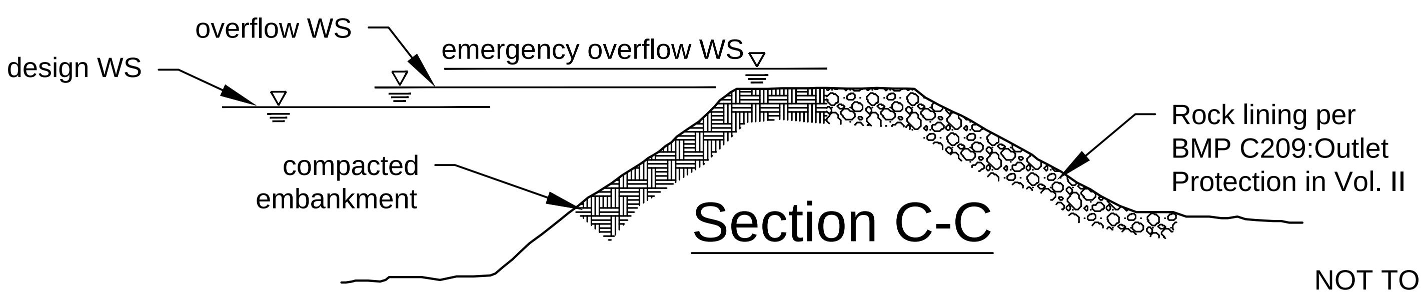
Section a-a

See also the separate overflow structure shown in Figure III-3.2.3



Section B-B

Emergency Overflow Spillway



Section C-C

NOT TO SCALE

DEPARTMENT OF
ECOLOGY
State of Washington

Typical Detention Pond Sections

Revised June 2016

APPENDIX E

Critical Areas Report by Loowit

Wetland Protection Flow Chart

Critical Areas Evaluation
for
XXXX Toledo Vader Road
Toledo, Washington

Prepared for:
Windsor Engineers
12009 NE 99th St, Suite 1460
Vancouver, WA 98682

Project #271.01

Prepared by:
Loowit Consulting Group, LLC
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Castle Rock, WA 98611
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Table of Contents

SIGNATURE PAGE

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned:

Timothy J. Haderly, Principal Scientist/Owner
Loowit Consulting Group, LLC

INTRODUCTION

Purpose and Need

Loowit Consulting Group, LLC (LCG) was retained by Windsor Engineering to complete a critical areas evaluation on an undeveloped parcel located south of Toledo Vader Road in Toledo, Washington (Figures 1 & 2 and Photograph 1). LCG investigated wetland and stream areas and applied jurisdictional buffers according to code requirements adopted by City of Toledo, Washington. Future use of the Subject Site will be a single-family residential lots including access streets, public utilities, and storm water control (Figure 3).

Site Description

The subject area consists of a single parcel totaling 36.62 acres. Subject site specifics include:

Site Address:	XXXX Toledo Vader Road, Toledo, WA
Current Owner:	Red Rock Construction, LLC
Tax Parcel Number:	11438001000
Legal Description:	Section 7, Township 11 North, Range 1 West, W.M.
Property Size:	Approximately 36.62 acres
Jurisdiction:	City of Toledo

The subject site is located south of the intersection of Plomondon Road and Toledo Vader Road in an agricultural area that is within the city limits of Toledo, WA (Figure 1). Topography at the subject site varies from flat to gently sloping to rather steep slopes from the upper field to the lower field. The northwestern two-thirds of the subject site (henceforth referred to as the upper portion of the subject site) has historically been used for hay production (Photograph 1). The southeastern third of the property (henceforth referred to as the lower portion of the subject site) has been used historically as pasture land (Photograph 2). Both the upper and lower portions of the subject site gently slope to the southeast. They are divided from each other by a northeast-to-southwest trending steep wooded slope (Photograph 3) vegetated with hardwood trees, ferns, and other native shrubs. There are a series of manmade ponds/natural wetlands and agricultural ditches along the toe of the steep slope (Photograph 4). These ponds have been excavated to take advantage of the water that seeps from the gravels exposed along the toe of the slope and also to collect water from the minor drainage flowing from the upper field to the lower field (Photograph 5). Water from the ponds have been used for livestock water and irrigation (Photograph 4 and 6). There is no formal vehicular access to the property just an opening in the fence off Plomondon Road. There are no buildings or other improvements to the subject site besides the remains of the old irrigation ponds.

Photograph 1: Upper two-thirds of the subject sight, looking southeast down the northeast property boundary from the intersection of Plomondon Road and Toledo Vader Road. Subject site is to the right and the line of trees in the distance is the top of the break in slope that bisects the subject site.

Photograph 2: Lower pasture area looking west toward Toledo Vader Road just past the tree line in the distance.

Photograph 3: The steep slope that divides the subject site into upper and lower portions. Looking north towards the upper portion of the subject site.

Photograph 4: Wetland/pond along the toe of slope just off-site to the southwest. Subject site is behind and to the right of photographer. Note, the evidence of historic damming to collect water for agricultural use.

Photograph 5: Minor drainage from the upper portion of the subject site to the lower portion of the subject site. Photo taken near the midpoint of the southwestern property boundary looking upslope.

Photograph 6: Remains of old pump system adjacent to the manmade pond located along the southwest property boundary.

Land uses adjacent to the subject site include:

- To the North – Agriculture, commercial, and rural residential
- To the South – Agriculture and rural residential.
- To the East – Forestry, agriculture and rural residential.
- To the West –Agriculture and rural residential.

METHODS

Desktop Review

Prior to visiting the subject site, LCG conducted a desktop review of readily available mapping resources and other pertinent information including:

- Lewis County Web Map (http://ims.lewiscountywa.gov/webmaps/composite2/viewer.htm). This source provided parcel information, aerial photographs, physical attributes, and other information from the Lewis County Assessor.
- Google Earth Pro (https://www.google.com/earth/) This source provided recent and past aerial photographs of the project area.
- US Fish and Wildlife Service National Wetlands Inventory Wetlands Mapper (https://www.fws.gov/wetlands/data/mapper.html). This mapping source depicts wetlands and streams throughout the United States.
- US Department of Agriculture Natural Resources Conservation Service Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). This source depicts mapped soils including hydric soils throughout the United States.
- Washington Department of Natural Resources Forest Practices Application Mapping Tool (https://fpamt.dnr.wa.gov/default.aspx). This mapping source depicts streams and wetlands in Washington State.
- Washington Department of Natural Resources Geologic Information Portal. (https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides#find-mapped-landslides). This site maps known geologic hazard areas in Washington State.
- Washington Department of Fish and Wildlife Salmonscape (http://apps.wdfw.wa.gov/salmonscape/map.html). This mapping source depicts streams and fish distribution in Washington State.
- Washington Department of Fish and Wildlife Priority Habitat and Species (http://apps.wdfw.wa.gov/phsontheweb/). This mapping source depicts priority habitats and species throughout Washington State.

State Regulations

Wetlands are regulated by Washington Department of Ecology (Ecology) under the Water Pollution Control Act and the Shoreline Management Act. The State Environmental Policy Act (SEPA) process is also used to identify potential wetland-related concerns early in the permitting process. All proposed direct and identified indirect impacts to wetlands are reviewed and approved/denied by Ecology using the regulations previously listed.

Streams are regulated by Washington Department of Fish and Wildlife under the State Hydraulic Code, Chapter 77.55 Revised Code of Washington. Projects involving activities within, over, or beneath jurisdictional streams are subject to the Hydraulic Project Approval (HPA) permitting process administered by WDFW.

Federal Regulations

Wetlands are regulated as "waters of the United States" under Section 404 of the Clean Water Act. Section 404 regulations are administered by the US Army Corps of Engineers (USACE).

Local Regulations

Critical Areas are regulated by City of Toledo under *Chapter IV – Critical Areas Protection.*

Field Investigations

On March 12, 2022 LCG collected site information, delineated jurisdictional wetlands, and flagged wetland and stream boundaries with pink survey flagging labeled WETLAND DELINEATION. Conditions at the site were considered normal because vegetation was intact, no recent soil grading was observed, and no recent ditching was observed. Weather conditions at the time of the site investigation consisted of clear skies with a high of 58.2°F and 0.02 inches of rain the previous 24 hours. Recorded climatological history from the Chehalis Airport two weeks prior to visiting the site was characterized with high temperatures ranging from 44.3 to 61.7°F and low temperatures ranging from 25.8 to 51.6°F. Total recorded precipitation two weeks prior to the site visit (February 26 – March 11) was recorded at 4.52 inches (Table 1, Appendix C).

Table 1: Daily Weather Data Summary at Chehalis, Washington.

Date	Minimum Temp (Deg F)	Maximum Temp (Deg F)	Total Precipitation (in)
2/26/2022	26.3	44.3	0.18
2/27/2022	42.1	51.5	0.82
2/28/2022	51.6	55.5	2.78
3/1/2022	47.2	61.7	0.30
3/2/2022	44.7	53.3	0.16
3/3/2022	40.1	50.5	0.02
3/4/2022	37.3	51.5	0.02
3/5/2022	31.5	53.7	0.00
3/6/2022	32.0	53.9	0.01
3/7/2022	31.8	50.2	0.00
3/8/2022	38.6	47.8	0.23
3/9/2022	29.8	49.3	0.00
3/10/2022	25.8	49.7	0.00
3/11/2022	34.0	60.3	0.00
		Total:	4.52
3/12/2022	30.6	58.2	0.02

Data from Agweathernet

Site investigation work tasks included:

- Documentation of current site conditions
- Documentation of adjacent land uses
- Delineation and flagging of wetlands
- Documentation of wetland/upland conditions with Test Plots
- Mapping of streams
- Collection of site photographs

Wetlands were delineated according to methods outlined in the U.S. Army Corps of Engineers, 2010, *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0)*. Data documenting vegetation, soils, and hydrology were collected and used to determine wetland and uplands at the subject area (Appendix A). Wetland boundaries were delineated using documented test plots. All points were subsequently surveyed by LCG using handheld GPS equipment with a sub 1-foot horizontal accuracy.

Vegetation

Vegetation on the upper portion of the subject site is comprised primarily of grasses and low growing forbs, as is the lower portion of the subject site. The steep slope between the upper and lower portions of the site is vegetated with hardwood trees, ferns, and other native shrubs. Table 2 summarizes vegetation observed at the subject site.

Table 2: Vegetation Observed

Scientific Name	Common Name	Wetland Indicator Code
Acer macrophyllum	Big Leaf Maple	FACU
Alnus rubra	Red Alder	FAC
Carex obnupta	Slough Sedge	OBL
Cornus sericea	Red Osier Dogwood	FACW
Equisetum hyemale	Scouring Rush	FACW
Fraxinus latifolia	Oregon Ash	FACW
Juncus effusus	Softrush	FACW
Malus fusca	Pacific Crab Apple	FACW
Oemleria cerasiformis	Indian Plum	FACU
Oenanthe sarmentosa	Pacific Water Parsley	OBL
Phalaris arundinacea	Reed Canary Grass	FACW
Physocarpus capitatus	Pacific Ninebark	FACW
Polystichum munitum	Sword Fern	FACU
Prunus emarginata	Bitter Cherry	FACU
Pseudotsuga menziesii	Douglas Fir	FACU
Quercus garryana	Garry Oak	FACU
Rosa nutkana	Nootka Rose	FAC

Rubus armeniacus	Himalayan Blackberry	FAC
Rubus spectabilis	Salmonberry	FAC
Rubus ursinus	Trailing Blackberry	FACU
Schedonorus arundinaceus	Tall Fescue	FAC
Symphoricarpos albus	Snowberry	FACU
Thuja plicata	Western Red Cedar	FAC
Typha latifolia	Cattail	OBL
Thuja plicata	Western Red Cedar	FAC

Wetland Indicator Code
OBL = Obligate (Almost always occur in wetlands)
FACW = Facultative Wetland (usually occur in wetlands, but may occur in non-wetlands)
FAC = Facultative (Occur in wetlands and non-wetlands)
FACU = Facultative Upland (Usually occur in non-wetlands, but may occur in wetlands)
UPL = Obligate Upland (Almost never occur wetlands)

Soils

According to the Web Soil Survey for Lewis County, the subject site can be divided into three distinct portions. A gently southeast sloping section in the northwest, a steeply sloped section (which bisects the site into northwest and southeast portions), and a southeast portion which is essentially flat. According to the US Department of Agriculture Natural Resources Conservation Service (NRCS), approximately 60 percent of the subject site is Lacamas silt loam. It occurs in the middle of the northwest portion, and is the entirety of the southeast portion of the site. The Prather silty clay loam and Salkum silty clay loam are also present in the northwest portion of the site. These are all soils common to floodplains and terraces in the local area. The steep slope which bisects the site is comprised of Xerorthents, common to mountain slopes in the area. Onsite soils are summarized in Table 3 and mapped in Figure 4.

Table 3: Soil Summary.

Soil #	Soil Name	Slope %	Hydric %
118	Lacamas silt loam	0-3	97
167	Prather silty clay loam	0-5	7
188	Salkum silty clay loam	5-15	5
248	Xerorthents	Steep	0

Historic land disturbance activities including general grading may have historically altered natural soil conditions at the site resulting in soils that may be somewhat different than those mapped by NRCS.

Hydrology

The subject area is situated on two historic terraces, both of which gently slope to the southeast. The two terraces are bisected by a steep gravel based slope which trends northeast to southwest. According to the U.S. Fish and Wildlife National Wetlands Inventory Map (Figure 5), there are no wetlands on the subject site, but there are several wetlands, both Freshwater

Emergent and Freshwater Forested/Shrub, north and northeast of the subject site, on the other side of Toledo Vader Road.

According to the Washington Department of Natural Resources Forest Practices Application Mapping Tool, there are no mapped streams on the subject site (Figure 6). There are two unnamed Type Ns tributaries of the Cowlitz River proximal to, but not on, the subject site. Stream A, the closest one, flows through a culvert under Toledo Vader Road, and emerges near the easternmost corner of the subject site along Toledo Vader Road, from there it bends away from the subject site before flowing southwest again where it eventually discharges into Cowlitz River. The second Type Ns creek located southwest of the subject site, is fed from agricultural ditches on either side of the lower field. After leaving the subject site, this stream joins the first stream that eventually discharges to the Cowlitz River. A third drainage along the southwestern portion of the site was mapped as a wetland due to numerous springs/seeps, feeds the off-site irrigation pond.

Mapping

Wetland boundary flagging, roads, property boundaries, and other site features were derived from public sources and augmented with data collected using handheld GPS equipment with a ±11 foot horizontal accuracy.

RESULTS and DISCUSSION

Wetlands

A single wetland area (Wetland "A") was identified and delineated within the subject area on March 12, 2022 (Figure 3). Wetland areas were delineated using vegetation, soil, and hydrology data gathered from paired plots contained in Appendix A.

<u>Wetland "A"</u>

Wetland "A", a slope wetland dominated by both native and non-native vegetation, is fed by springs/seeps originating from water bearing gravel along the slope separating the two terraces at the site (Figure 3).

Wetland "A" has a low score (5 points) for improving water quality, a moderate score (6 points) for hydrologic, and a moderate score (6 points) for habitat resulting in an overall score of 17; a Category III wetland based on functions (Table 4 & Appendix B).

Table 4: Wetland Summary.

Wetland ID	HGM[A]	Wetland Rating System[B]				Category[B]	Standard Buffer[C] (ft)
		Improving Water Quality	Hydro-logic	Habitat	Total		
Wetland "A"	Slope	5	6	6	17	III	50

[A] *Hydrogeomorphic Classification*

[B] *Washington State Wetland Rating System for Western Washington: 2014 Update*

[C] *City of Toledo: Chapter IV – Critical Areas Protection, Section 13, 12.02.d.2.*

Wetland Buffers

City of Toledo: Chapter IV – Critical Areas Protection, Section 13, 12.02(d)(2) requires buffers on all jurisdictional wetlands according to the category of wetland (Table 4). Wetland "A" requires a minimum 50-foot wide buffer.

CONCLUSIONS

All proposed developments at the subject site are located outside the required 50-foot wide wetland buffer and no indirect or direct impacts to jurisdictional wetlands or buffers are anticipated (Figure 3). It is our opinion that proposed developments within the northwest corner of the subject area will not reduce the functions and values of on-site wetlands and associated buffers.

LIMITATIONS

The findings and conclusions contained in this document were based on information and data available at the time this document was prepared and evaluated using standard Best Professional Judgment. LCG assumes no responsibility for the accuracy of information and data generated by others. Local, State, and Federal regulatory agencies may or may not agree with the findings and conclusions contained in this document.

REFERENCES

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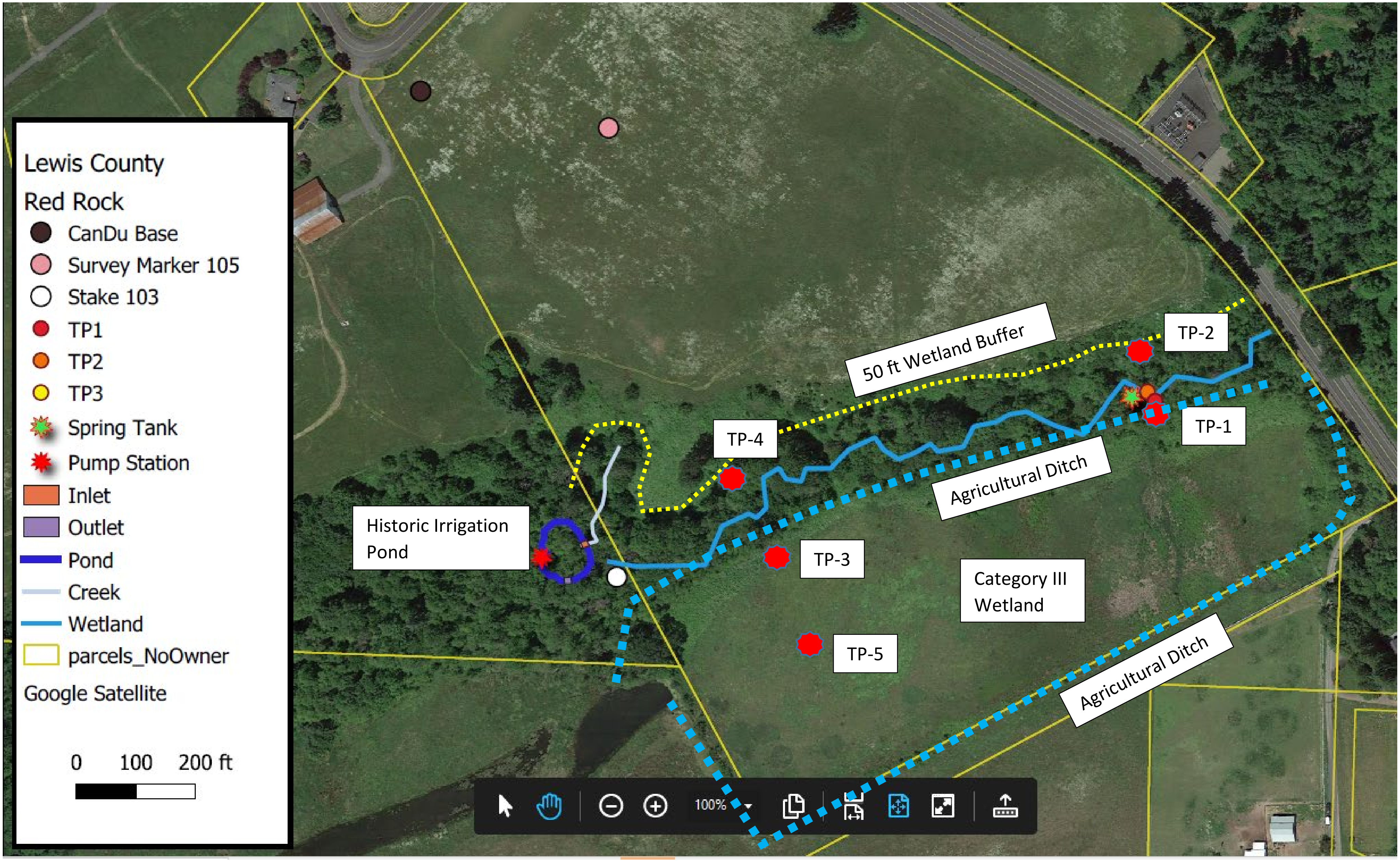
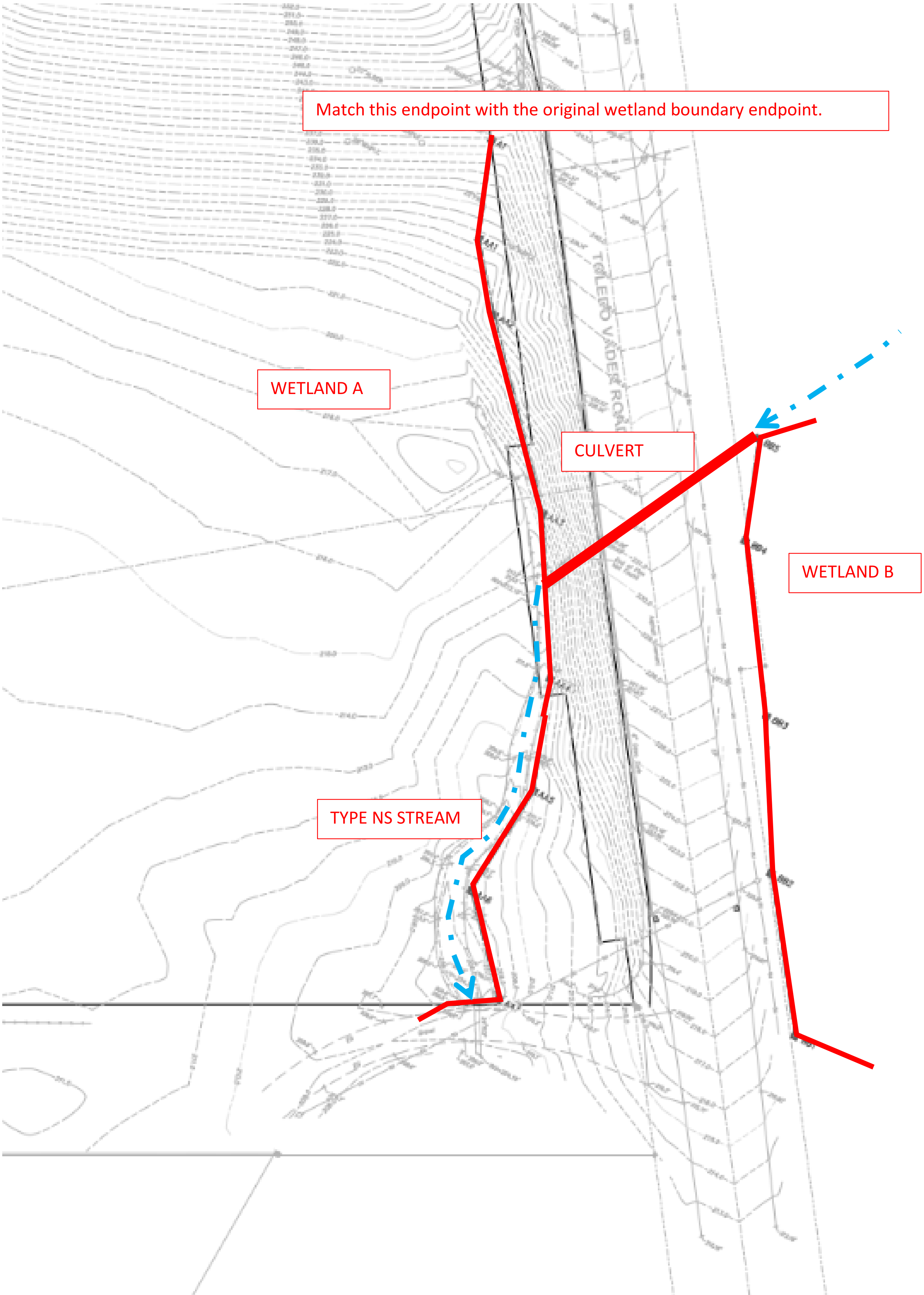
FIGURES


Lewis County
Red Rock
CanDu Base
Survey Marker 105
Stake 103
TP1
TP2
TP3
Spring Tank
Pump Station
Inlet
Outlet
Pond
Creek
Wetland
parcels_NoOwner
Google Satellite
0 100 200 ft
50 ft Wetland Buffer
TP-2
TP-1
TP-4
Agricultural Ditch
Historic Irrigation Pond
TP-3
Category III Wetland
TP-5
Agricultural Ditch
100%

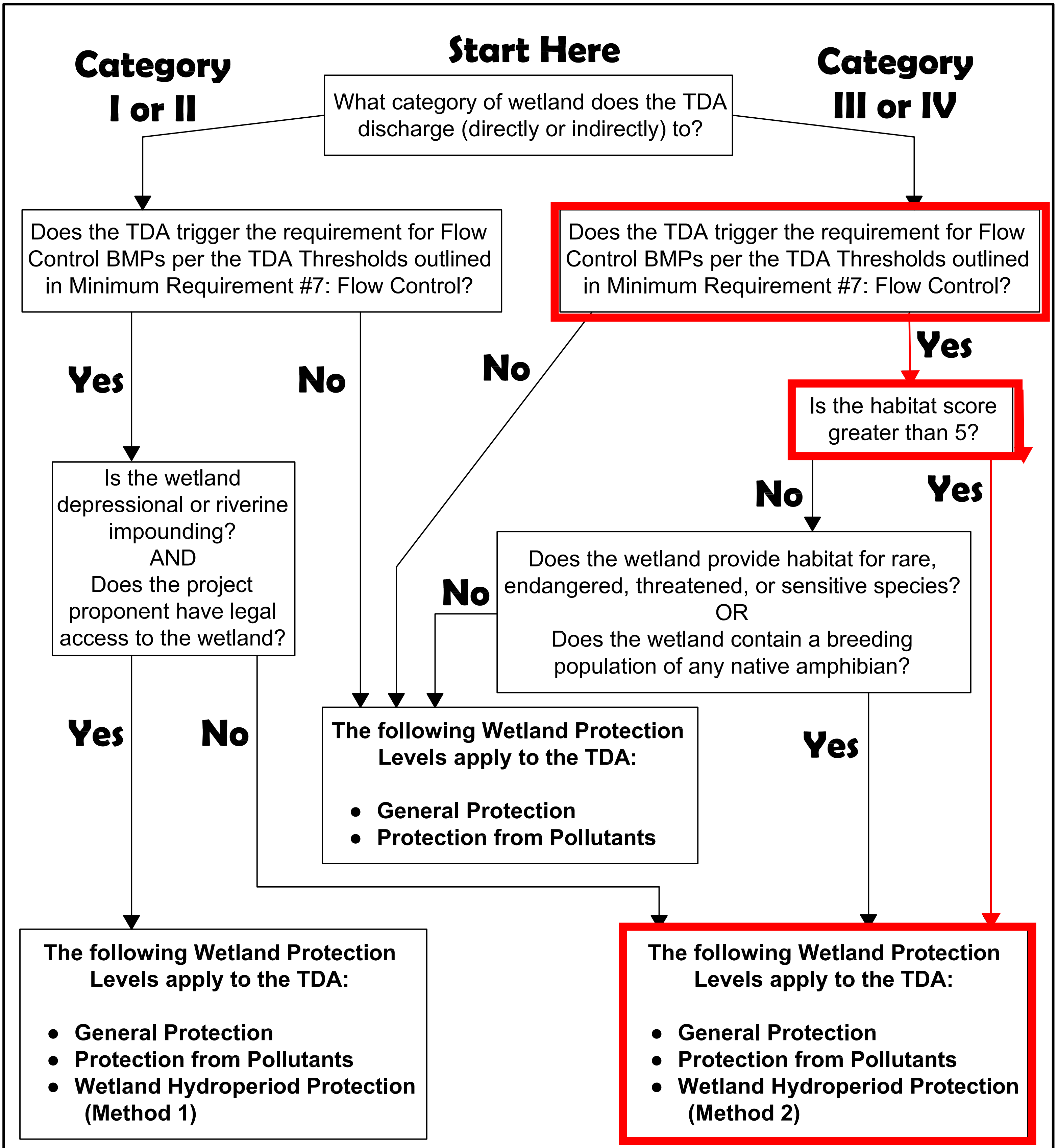


Match this endpoint with the original wetland boundary endpoint.
WETLAND A
CULVERT
WETLAND B
TYPE NS STREAM
TOLEDO VADER ROAD

APPENDIX A - DATA FORMS

APPENDIX B - WETLAND RATING SUMMARY

APPENDIX C - CLIMATOLOGICAL SUMMARIES



DEPARTMENT OF ECOLOGY
State of Washington

Flow Chart for Determining the Wetland Protection Levels Required

Revised May 2019

Appendix V-A: BMP Maintenance Tables

Ecology intends the facility-specific maintenance standards contained in this section to be conditions for determining if maintenance actions are required as identified through inspection. Recognizing that Permittees have limited maintenance funds and time, Ecology does not require that a Permittee perform all these maintenance activities on all their stormwater BMPs. We leave the determination of importance of each maintenance activity and its priority within the stormwater program to the Permittee. We do expect, however, that sufficient maintenance will occur to ensure that the BMPs continue to operate as designed to protect ground and surface waters.

Ecology doesn't intend that these measures identify the facility's required condition at all times between inspections. In other words, exceedance of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the Permittee shall adjust inspection and maintenance schedules to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table V-A.1: Maintenance Standards - Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance and inspection access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g.,rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed engineer in the state of Washington should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.

Table V-A.1: Maintenance Standards - Detention Ponds (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Liner (if Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Ponds Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation If settlement is apparent, measure berm to determine amount of settlement Settling can be an indication of more severe problems with the berm or outlet works. A licensed engineer in the state of Washington should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway and Berms over 4 feet in height	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed engineer in the state of Washington should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/Spillway	Emergency Overflow/Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side Slopes of Pond"	

Table V-A.2: Maintenance Standards - Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Poisonous/Noxious Vegetation	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Contaminants and Pollution	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Rodent Holes	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.

Table V-A.10: Maintenance Standards - Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

Table V-A.11: Maintenance Standards - Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Table V-A.12: Maintenance Standards - Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables	Remove trash and debris from vault.