DRAFT REPORT | NOVEMBER 2022

City of Rainier
Fox Creek Culvert Feasibility Study Report

PREPARED FOR

City of Rainier

PREPARED BY

WEST YOST
Water. Engineered.

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City of Rainier

West Yost Project No. 962-30-22-04

Project Engineer: Preston Van Meter, PE
Date

QA/QC Review: [Name]
Date

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Annual Chance of Exceedance
CEP	Continuous exceedance probability
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
EL, Elev	Elevation
ft/s	Feet per Second
H&H	Hydrology and Hydraulics
LCFRB	Lower Columbia Fisheries Recovery Board
LF	Linear Feet
mgd	Million Gallons Per Day
NAVD88	North American Vertical Datum of 1988
NMFS	National Oceanographic and Aeronautic Association's Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OWRD	Oregon Water Resources Department
O&M	Operation and Maintenance
SPT	Standard Penetration Test
USGS	United States Geological Survey

1.0 INTRODUCTION AND BACKGROUND

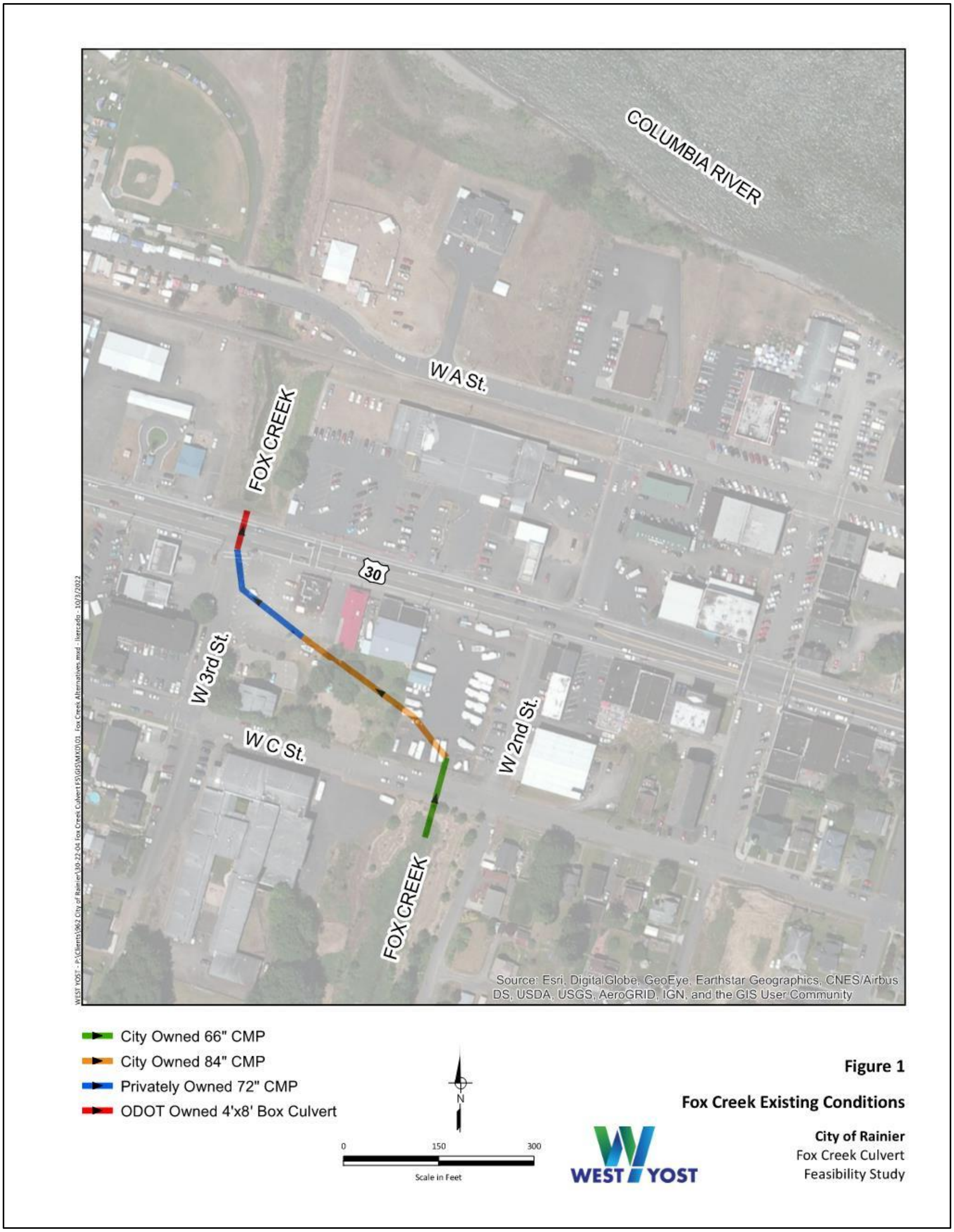
Fox Creek is an open channel from its headwaters at the southern City of Rainier (City) City limits to West C Street in the center of town, flowing south to north. From West C Street, Fox Creek flows through a series of culverts, approximately 650 feet long, terminating at the Columbia River. There are at least three different owners of the series of culverts that contain Fox Creek. The City owns the upstream 66-inch corrugated metal pipe (CMP). Following is the 72-inch CMP owned by a private landowner, then into an 84-inch CMP (reportedly owned by the City, but not confirmed). Next it flows into an 8-foot by 4-foot box culvert owned by Oregon Department of Transportation (ODOT) and finally through the restored stream segment and into the Columbia River. The ground area between the culvert inlet and outlet is lower in elevation causing a low point on private property.

During heavy rain events in early December 2015, the culvert was overwhelmed with debris and material accumulating within the culvert and creating clogged points. As a result, major flooding occurred on Highway 30 and a sink hole developed in the area of the private property in the middle of the culvert threatening the three adjacent businesses.

In response to the formation of the sinkhole, a large portion of the culvert was replaced in 2017, and local drains were connected to the new culvert. In 2019, another large rain event, approximately a 10-year storm event, occurred that caused significant flooding on West C Street and Highway 30 and collapse of the culvert. When repairing the culvert, state regulatory agencies brought to light that this series of culverts is a fish passage barrier for migratory fish species found in Fox Creek, and this barrier should be remedied. In 2020 a hydraulic evaluation of the Fox Creek was performed and it was concluded that the culvert is undersized. Based on this hydraulic analysis, the City hired West Yost to conduct a Feasibility Study to analyze structure sizes and alternatives to amend flooding and fish passage. The findings are presented in this report. Feasible fish passage options that comply with state and federal regulations were a significant component in determining the various structure alternatives.

1.1 Project Area

The project area Fox Creek Culvert (Project) is located in the City of Rainier, Oregon in Columbia County. The culvert runs under West C Street, an RV service center, a private vacant lot, a restaurant parking lot, and Highway 30 before discharging to an open channel which then confluences with the Columbia River (Figure 1). The Columbia River is approximately 900 feet north of the Project.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure 1. Fox Creek Existing Conditions

1.2 Project Phasing

The Project will be divided into two phases. Phase 1 will include upgrading the series of culverts leading up to the ODOT owned box culvert that passes under Highway 30. Phase 2 will include upgrading ODOT's segment of the Project. Phasing of the Project is necessary due to ODOT having different funding resources and a list of project prioritization throughout the state. A transition joint will be placed between the improved sections and the existing ODOT owned box culvert in order to make constructability simpler when ODOT can rehabilitate their segment. ODOT will oversee removing the transition piece.

1.3 Geotechnical Analysis

The project location is near the northern extent of the Portland Basin, a structurally controlled lowlands where the Columbia River passes through. Based on the Geotechnical Technical Memorandum TM prepared by McMillen Jacobs Associates (see Appendix A), the footprint of the existing culvert system did not have significant depressions at the ground surface or cracking within the asphalt. Additionally, erosion at the culvert inlet and discharge point was not observed. However, there are steep sloping embankments downstream of the box culvert beneath Highway 30 that are covered with vegetation that was considered to be at-risk of erosion, particularly during heavy rain events.

To evaluate the subsurface conditions of the project area, a soil boring was completed on May 19, 2022 and was advanced to approximately 26.5 feet below the asphalt pavement surface on West 3rd Street. Groundwater was observed at 16 feet below the top of the asphalt. A Standard Penetration Test (SPT) was also completed on May 19, 2022. Details on the subsurface findings can be found in Appendix A. Background data investigation also revealed that two borings were completed in 2016 following the collapse of the culvert. Each of these historical borings was drilled to a depth of 36.5 feet below ground surface and the logs indicated that boulders were encountered at various depths.

The boring log revealed that soils in the project area are very loose to loose sandy soils down to a depth of approximately 22.5 feet, followed by a layer of sandy fat clay. These sandy soils are susceptible to liquefaction and lateral spread, and necessary measures, such as ground improvements, should be considered to mitigate these hazards. In the TM, only the soil bearing capacity for static conditions were provided. However, the design recommendation for the alternative analysis will be based on mitigating seismic hazards; therefore, excavating to a non-liquifiable layer (the clay layer at approximately 22.5 feet below ground surface) and backfilling approximately 8 feet with imported material to stabilize the ground conditions under the proposed structures will be required. Due to the loose sandy soils, trenching methods such as trench shoring or shielding will likely be the necessary during excavation. It is recommended that the subgrade be stabilized, and dewatering methods be utilized when preparing the subgrade in order to achieve the recommended bearing capacities. Further information can be found in the TM (Appendix A).

Potential flowing soils conditions due to the presence of groundwater and sandy soils may create ground surface subsidence, such as sinkholes. Imported crushed rock, approximately ¾-inch minus, should be used to backfill voids between the trench wall and the outside face of the shoring up to 2 feet above the groundwater level when trenching surpasses the groundwater level. The trench box can be backfilled with the onsite sandy soils from 1 foot above the groundwater level to the ground surface.

2.0 STREAM AND HABITAT ASSESSMENT

Wolf Water Resources (W2r) engineering staff, contracted by the City, walked Fox Creek on March 9, 2022 to survey the creek and assess its general hydraulic and geomorphic conditions. W2r found the culvert inlet is small relative to the creek channel width. The debris barrier (trash rack) at the inlet of the culvert at West C Street does appear to function, but debris accumulation at the barrier causes sediment to deposit at the inlet and upstream. Sedimentation and blockage was estimated at 50 percent of inlet capacity on the day of the site visit. Fish passage is impaired at low flows at the inlet due to a steep stream profile (where flow cascades over racked debris and deposits sediment) and inlet constriction causing high velocity. Passage is also impaired at higher flows due to velocity as the culvert is undersized.

In the vicinity of the culvert and immediately upstream of West C Street, the stream is a generally uniform U-shaped channel with steep banks. Instream habitat is simplified with few pools, riffles, or instream wood. Riparian and floodplain vegetation is sparse and poorly established, likely due to the incised channel and associated poor stream-floodplain connectivity and low groundwater levels. According to W2r, this general condition is due largely to the backwater effect of the undersized culvert at West C Street which prevents high flows from engaging the floodplain, but does not elevate low flow water surface elevations sufficiently to keep the water table high and promote healthy floodplain vegetation.

Fox Creek in the vicinity of the culvert (Figure 2) has three distinct sub-reaches: a reference reach, a backwater reach, and a downstream reach. Each of the sub-reaches are characterized below, with basic parameters summarized in Table 1. Flow in Fox Creek was measured during W2r's site visit and calculated as approximately 5 cubic feet per second (cfs). This flow could be considered a common winter (non-storm or low-receding limb) flow.

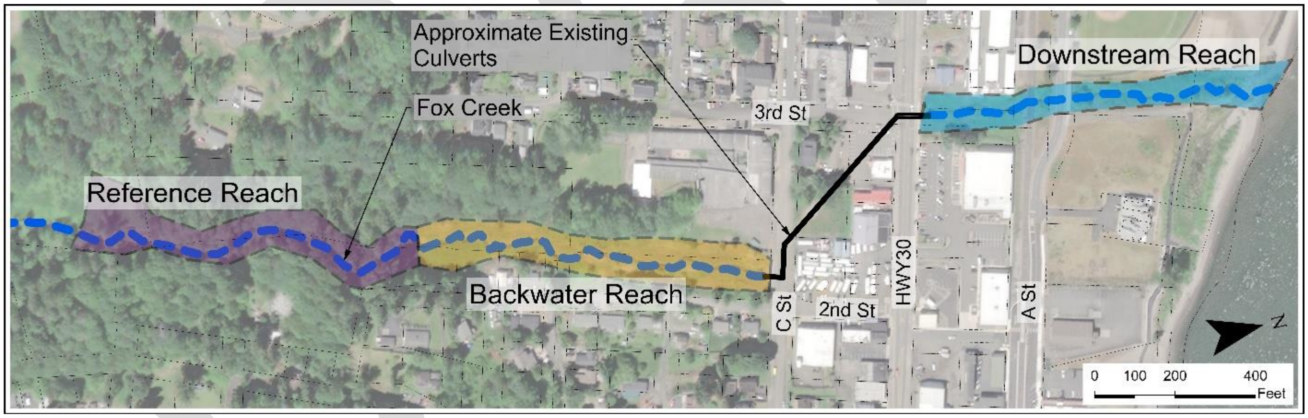


Figure 2. Fox Creek Characteristic Reaches

Table 1. Fox Creek Characteristic Reach Parameters

Reach Name	Bank Height, feet	Active Channel Width, feet	Average Slope	Substrate
Reference	1 – 3	18 – 23	~1.0%	Naturally varying armored cobble (up to ~4") bed with sand and gravel deposition throughout
Backwater	3 – 5	10 – 16[(a)]	~0.6%	Depositional bars of sand and gravel (up to ~1")
Downstream	2 - 5	15 – 20*	~0.8%	Sand and gravels, large (4" to 24") angular rock grade control at crossings

(a) Active channel within the backwater and downstream reaches are not geomorphically representative of Fox Creek due to infrastructure constraints and backwater conditions upstream of the culvert.

2.1.1 Reference Reach

The Reference Reach is characterized by a channel with a low bank height, relatively good in-channel and floodplain habitat structure, and meandering planform that makes contact with both valley margins over its length. The general active (bankfull) channel width is considered 20 feet, with the range of values shown in Table 1. This reach has naturally-occurring large wood which was observed to result in:

- Sorted gravels and other bed material size classes
- Progressive stream planform changes
- Pool and bar habitat
- Good floodplain connectivity
- Hydraulic diversity

2.1.2 Backwater Reach

The Backwater Reach is characterized by a U-shaped channel set into a high floodplain with sand and gravel deposition in the channel that are not consistent with the entrenchment of the channel. The backwater effects of the West C Street culvert extend significantly upstream (more than 1,000 feet) south of the road. The backwater condition appears to keep velocities low at higher flows and allows otherwise highly transportable material to settle out in the confined channel and the floodplain. Three constructed log weirs in the channel appear to be limiting continued vertical incision and causing small stream profile discontinuities, though they also show signs of rotting and flanking of flows (bank erosion around the weir).

This reach will become higher energy following a culvert retrofit, so an eventual culvert replacement design should consider channel adjustments in this reach to limit excessive adjustments that could lead to fish passage issues at the weirs or other locations.

2.1.3 Downstream Reach

The Downstream Reach located north of the Hwy 30 culvert is characterized by significant confinement between high banks that are vegetated with willow, dogwood, and other tree, shrub, and grass species. The creek is constrained here by the crossings and adjacent development and infrastructure. Just downstream of Highway 30, an old sewer crossing is armored with rock (with sill at approximate elevation of 12.3 feet NAVD88) which backwaters the culvert outlet (elev. 8.4 feet NAVD88) and inlet (elev. 10.9 feet NAVD88).

This may contribute to the backwater morphological effects noted in the upstream reach. The armoring at the pipe is not causing an observable profile break that would constitute a fish passage barrier.

Active channel width measurements and other parameters for the reference reach are documented in greater detail in Appendix B – Fox Creek Field Data Summary.

3.0 FISH PASSAGE AND DESIGN CRITERIA

The culverts conveying Fox Creek through the City are a known priority fish passage barrier. The Oregon Department of Fish and Wildlife (ODFW) fish passage database shows a partial fish passage barrier at the Highway 30 crossing location (ID 3,242, assessment revised in 2019). It is unclear if the West C Street culvert is included in assessment for ODFW Crossing ID 3242, or if the field assessment includes only Highway 30.

Design of culverts for passage of aquatic species is required and enforced by both the ODFW and potentially the National Oceanographic and Aeronautic Association's Marine Fisheries Service (NMFS) depending on project funding, land ownership, and other factors. It is unclear if there will be a federal trigger for the Fox Creek crossing structure, so both ODFW and NMFS criteria are considered in this report.

Fish passage design requirements consider the species and life stages present in the system over time. ODFW has the Fox Creek basin listed as habitat for Coho Salmon and Winter Steelhead (Figure 3).

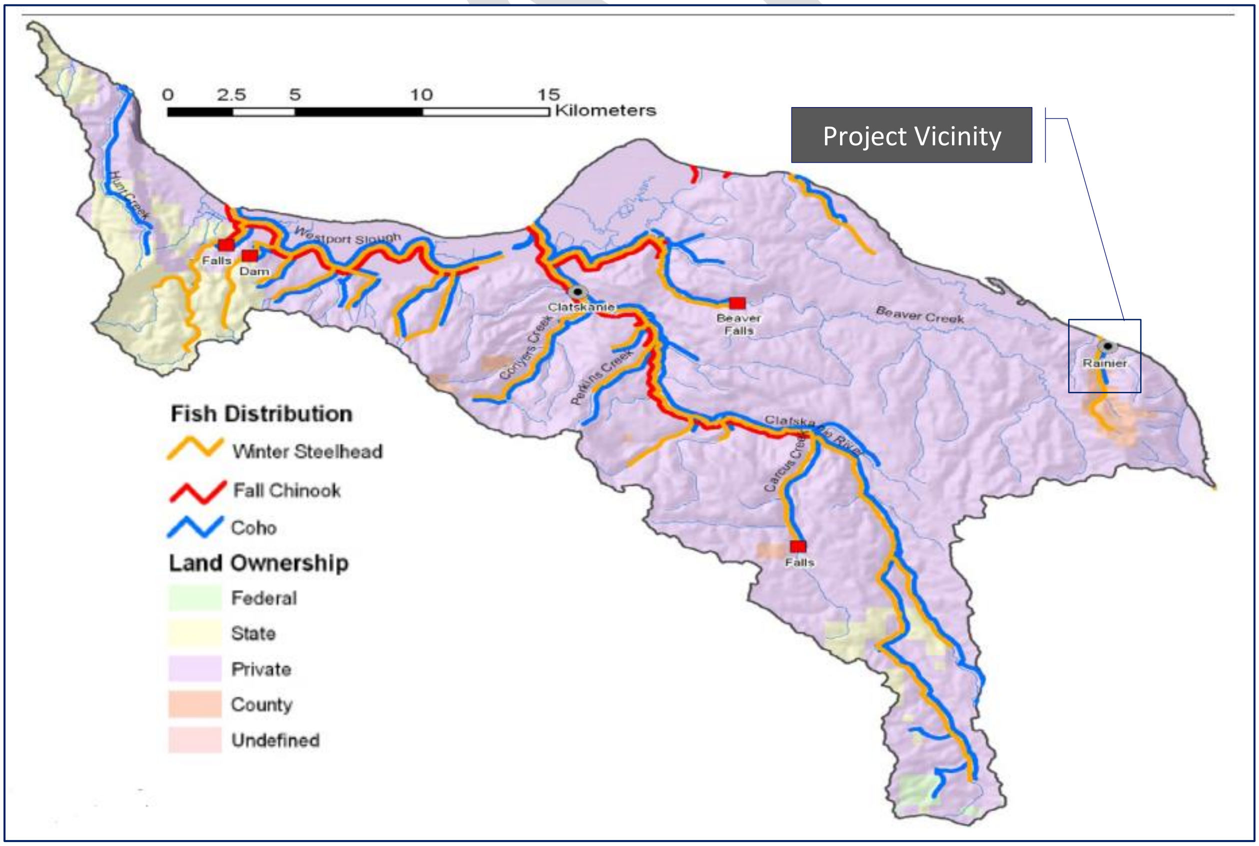
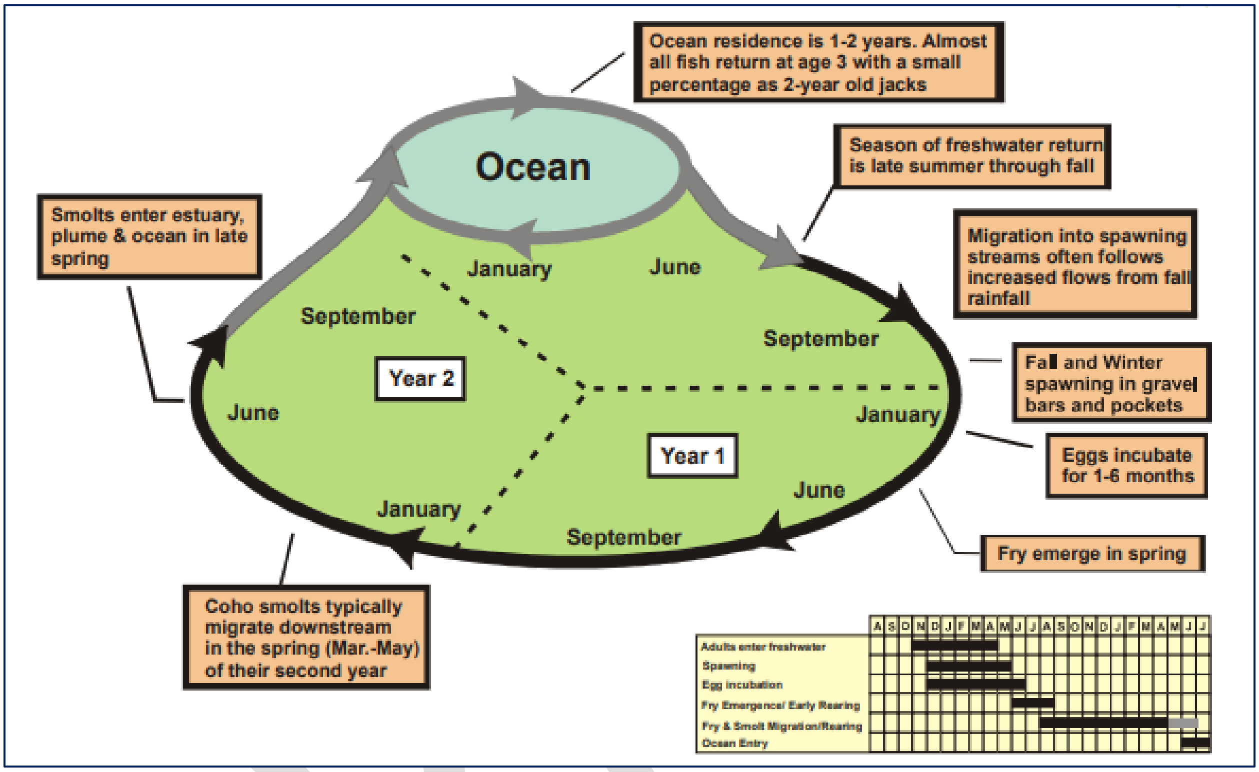


Figure 3. Fish Distribution in the Clatskanie Population Range of the Lower Columbia Management Unit (ODFW, 2011). Fox Creek (at right in rainier) Supports both Winter Steelhead & Coho Salmon

Life history and seasonal timing of fish presence has been summarized (Figure 4 and 5) by species by the Lower Columbia Fisheries Recovery Board (LCFRB) in the Lower Columbia Fisheries Recovery Plan (recovery plan). These figures illustrate typical periods over which the stages of the salmonid lifecycle occur (Spawning, Emergence, Outmigration, Estuarine Rearing, and Ocean Rearing). Both Winter Steelhead and Coho are typically entering freshwater and spawning between November and May.



Ocean residence is 1-2 years. Almost all fish return at age 3 with a small percentage as 2-year old jacks

Season of freshwater return is late summer through fall

Migration into spawning streams often follows increased flows from fall rainfall

Fall and Winter spawning in gravel bars and pockets

Eggs incubate for 1-6 months

Fry emerge in spring

Coho smolts typically migrate downstream in the spring (Mar.-May) of their second year

Smolts enter estuary, plume & ocean in late spring

Figure 4. Life Cycle of Lower Columbia River Coho Salmon (LCFRB, 2010)

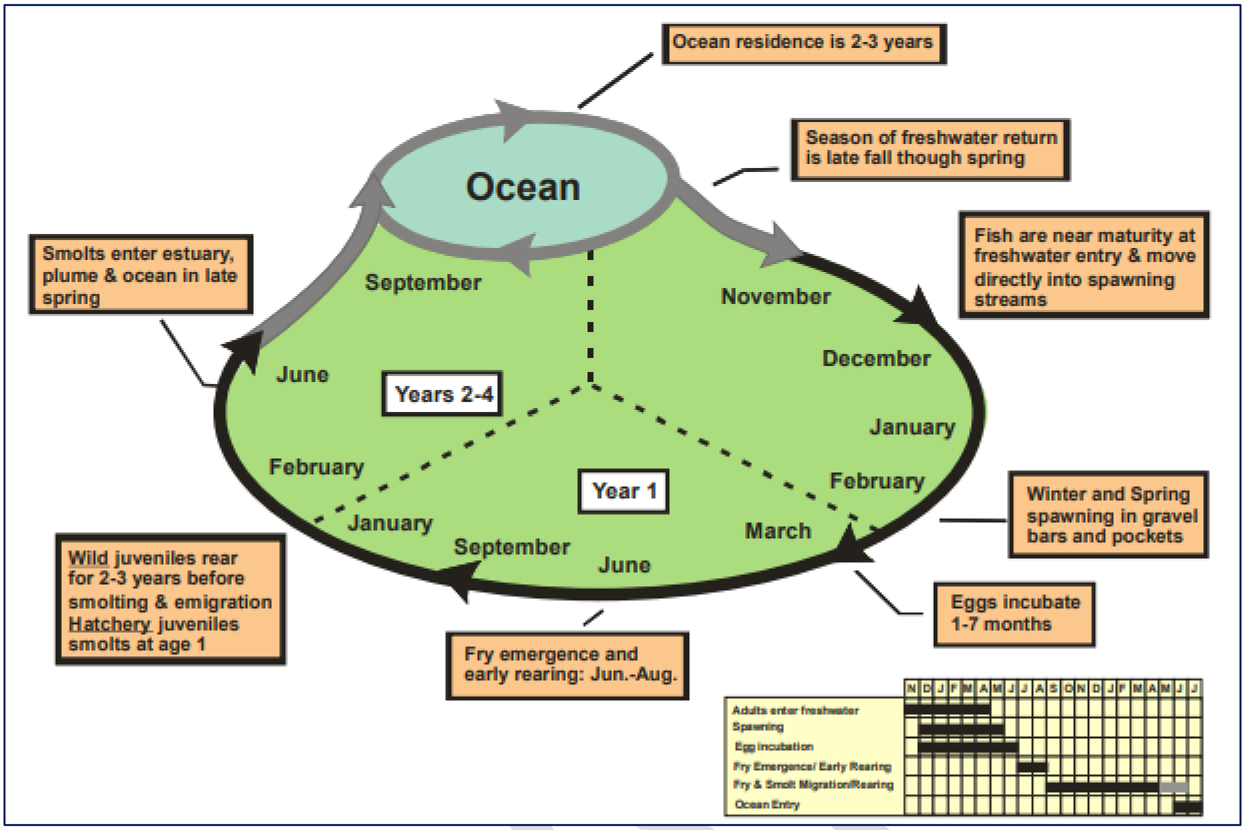


Figure 5. Life cycle of Lower Columbia River Winter Steelhead (LCFRB, 2010)

Due to the diversity in downstream travel time to the Columbia River Estuary from spawning grounds in the basin and complex life history of many salmonids, there are juveniles present in the lower estuary and seeking margin habitat refuge (as can be found in Fox Creek) throughout the entire year (Figure 6). Coho typically spend at least one year after hatching in fresh water before entering the ocean.

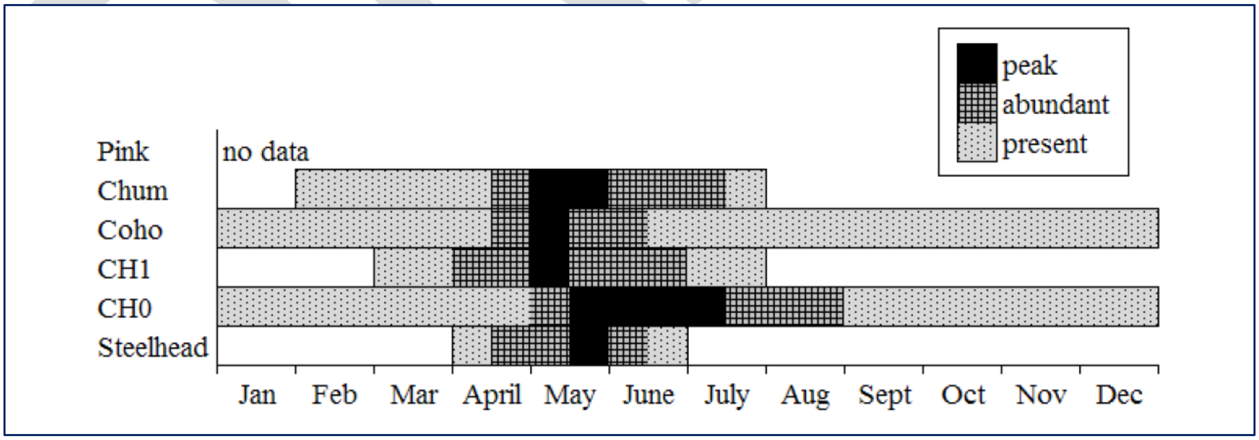


Figure 6. Presence and Abundance of Juvenile Salmonids in the Lower Columbia Estuary at and Downstream of Jones Beach (PNNL, 2009)

Fish passage design can be based on different approaches. For Fox Creek, two potential approaches for approval of the culvert replacement are the hydraulic design and stream simulation design. The hydraulic design approach requires detailed hydraulic modeling and identification of specific hydraulic criteria for high and low design flows to design the minimum structure size. In contract, the stream simulation design approach uses appropriate channel and floodplain characteristics upstream and/or downstream to guide the design of the new stream crossing structure. Each design approach is further described below.

3.1 Hydraulic Design Approach

The first design approach considered was the Hydraulic Design due to the periods of time when each salmonid species and life stage of interest is present can be used to develop high and low fish passage flow criteria for a project. For low and high fish passage flows, hydraulic assessment must demonstrate that minimum flow depth and maximum velocity thresholds are met with the proposed culvert. The velocity thresholds are defined by the species, life stage, and crossing length (Table 2).

Table 2. Maximum Allowable Average Velocity for Fish by Species and Lifestage (NMFS, 2011)

	Maximum Average Velocity (ft/s)		
Culvert Length, feet	Chinook, Steelhead, Sockeye, and Coho Adults	Pink and Chum Adults	Juvenile Salmonids
<60	6.0	5.0	1.01
60-100	5.0	4.0	1.0
100-200	4.0	3.0	1.0
200-300	3.0	2.0	1.0
>300	2.0	2.0	1.0

Depth criteria for Coho and Steelhead are:

- Adult salmonid minimum depth is one foot
- Juvenile salmonid minimum depth is six inches

3.2 Stream Simulation Design Approach

A second stream crossing structure design approach, the Stream Simulation Approach, was considered because it is the approach preferred by state and federal agencies. Instead of meeting specific hydraulic parameters, the stream simulation approach attempts to match natural conditions in the reach upstream and downstream of the crossing in terms of slope, substrate, channel width, and other parameters. Stream simulation design accounts for the long-term sediment dynamics in a system and improves both fish passage and long-term stability of the crossing by avoiding scour that might undermine a structure foundation or cause a break in the stream profile and supporting accumulation of woody material that occludes the crossing and restricts flood conveyance.

ODFW's stream simulation approach currently requires a structure span to be equal to or greater than the active channel width (ODFW, 2022), although this minimum is likely to be increased within the timeline of this Project. NMFS requires a minimum structure span to be 1.5 times the active channel width (NMFS, 2022), and this criterion is used in this analysis. Using the active channel width of the reference reach, the resulting minimum structure span is estimated to be 1.5 x 20 feet, or 30 feet.

Additional stream simulation design parameters include:

- Approximately matching upstream and downstream slopes
- Sufficient clearance to allow maintenance debris removal as needed (minimum 6 feet)
- Sufficient embedment to allow for intermittent scour of the substrate
    - Minimum 3 feet
    - Between 30 percent and 50 percent of the structure height
- Streambed materials should be similar in composition to those found naturally upstream and downstream
    - Erosion resistant materials may be incorporated for hydraulic roughness to avoid simplification to a plane-bedded morphology

3.3 Culvert Length and Lighting Considerations

The existing culvert is 650 feet long which is longer than a typical roadway crossing culvert. This introduces specific challenges for fish passage, including lack of lighting (natural or artificial). Fish prefer ambient natural lighting and are less likely to enter a dark culvert. One method of improving lighting conditions is to shorten the culvert by daylighting a section of the creek. However, other methods of appropriately lighting the culvert should be considered in greater detail during design and could include increasing interior clearance in the culvert, adding skylights, adding artificial lighting, among others.

4.0 HYDROLOGY & HYDRAULICS

To appropriately size a passage structure/culvert using the hydraulic design approach, velocity and depth in the culvert under specific hydrologic conditions are checked against the requirements for the species and life stages present in the system.

Continuous exceedance probability (CEP) flows and peak flows are summarized in Table 3. CEP percentages refer to the expected portion of a given calendar year when the listed discharge is equaled or exceeded. Peak flows are referred to by the Annual Chance of Exceedance (ACE) for the listed discharge.

Table 3. Discharge Summary

Recurrence Interval (or Flow Frequency)	Flow Estimate, cfs	Notes
95% CEP	<1	Low flow criterion
50% CEP	3.9	Juvenile criterion for depth, velocity
5% CEP	42	How flow criterion
Q2 – 50% ACE	150	Channel forming flow (approximate)
Q5 – 20% ACE	223	-
Q25 – 4% ACE	336	-
Q100 – 1% ACE	429	Conveyance & floodplain criterion

Source: USGS Streamstats 2022 (Mean annual precipitation 58.6 in,; Basin area 3.12 mi2

These discharge values are not based on measured time series of flows (as no data is available); rather, they are estimated by regressions based on several basin characteristics including area and average annual rainfall. United States Geological Survey (USGS) Streamstats does not break out CEP flows by month, so the selected passage flows are a function of the entire calendar year as opposed to the actual time period during which fish are present. Two nearby streams (Tucca Creek and Sain Creek) which have available time series data were examined for suitability as reference streams from which seasonal CEP flows could be scaled, but neither was appropriate due to variation in basin size and rainfall amounts. Full Streamstats output is presented in Appendix C – USGS Streamstats Watershed and Flow Results.

4.1 Culvert Hydraulics – Hydraulic Design Approach

Stream hydraulics within a new crossing structure were evaluated using the hydraulic design approach, as suggested during coordination with ODFW (2022). Structure hydraulics were calculated using Manning's Equation for normal depth and gradually varied flows and a spreadsheet calculator. A detailed spreadsheet summary is available in Appendix D. Using an iterative approach, minimum structure widths that meet depth and velocity criteria for Fox Creek were developed. Resulting parameters for the hydraulic design-based culvert are summarized below.

- Approximate minimum structure width (span): **15 feet**
    - Sufficiently wide to limit velocity at high flows
- *Overall* structure / channel longitudinal slope: **0.5%**
    - Approximately matches upstream & downstream
    - Sufficient to convey sediment
- *Inset* low flow channel slope: **0.25%**
    - Meandering inset channel to confine low flows to passable depths
- Minimum vertical clearance - channel bottom to structure soffit: **7 feet**
    - Meets minimum fish passage culvert clearance criteria of 6 feet
    - Includes additional 1-foot clearance to allow for easier bed construction with large rock materials such that minimum clearance is met and access/maintenance clearance is retained
- Channel bottom Mannings Roughness (varies with depth): **0.035** to **0.08**
    - Low roughness for high flows where flow depth is large relative to bed roughness elements
    - High roughness for low flows where flow depth is insufficient to overtop and deeply inundate bed roughness elements

Culvert hydraulics resulting from these parameters are summarized in Table 4. Results show that hydraulic fish passage requirements are met by:

- Velocities that are less than 2 ft/s during the 5% CEP flow (high fish passage flow)
- Depths exceeding the minimum depth criterion during low and intermediate flows

Table 4. Summary Hydraulics for a (15-foot) Structure Span

Statistic	Limiting Species/ Lifestage	Discharge, cfs	Mannings Roughness	Depth, ft	Depth Criteria	Velocity, ft/s	Velocity Criteria
100 year flood	-	429	0.035	6.9	-	6.3	-
2 year flood	-	150	0.035	4.1	-	4.1	-
5% CEP	Adult Salmonids	42	0.08	3.3[a]	1.0 ft	1.5[b]	<2 ft/s[c]
50% CEP	Juvenile Salmonids	3.9	0.08	1.6[a]	0.5 ft	0.5[a]	<1 ft/s
95% CEP	Adult & Juveniles	1	0.08	1.2[a]	0.5 ft	0.3[a]	<1 ft/s

(a) Green cells indicate the criteria is met.

(b) Yellow cells indicate criteria is met but criteria is likely to change.

(c) Recently updated criteria reduced this threshold to 1 ft/s as well as increasing the associated flow rate. If held to updated NMFS hydraulic design guidance this culvert size is too narrow.

As a note, new federal fish passage guidance has been issued that stipulates that the high passage flow should be the 1% CEP discharge and the maximum average velocity during that flow should be 1 foot per second (ft/s) (NMFS, 2022). In the event ODFW updates Oregon state guidelines to reflect current NMFS guidance (or if NMFS becomes involved in the permit approval), the minimum required structure span using a hydraulic design approach would increase.

4.2 Fox Creek Flood Conveyance

Depths of flow in the culvert at higher flows (2-year and 100-year) indicate that these flows can be conveyed in the 15-foot span by 7-foot deep structure, assuming it is not backwatered by the Columbia River. This would leave a minimum freeboard for flooding (initiating at West C Street) equal to the sum of the culvert wall thickness and burial depth. Future design work should analyze combined peak flow and backwater conditions to verify flood conveyance targets are met considering backwater conditions on the Columbia River.

5.0 ALTERNATIVES ANALYSIS

Three alternatives were analyzed for fish passage. Fish passage requirements generally control the size of crossing structures in fish bearing streams. Therefore, the fish passage design requirements (stream simulation and hydraulic design) discussed above were used to inform the range of structure sizes considered for this analysis. Alternative 1 includes a stream crossing structure design based on the hydraulic design approach, and Alternative 2 assumes a structure design based on the stream simulation design approach. These approaches and their resulting minimum structure sizes are considered a reasonable structure size range for evaluating benefits and construction costs.

Additionally, the alternatives consider daylighting for sections of the stream under both Alternatives 1 and 2. A third alternative includes maximized stream daylighting with crossings only at West C Street and Highway 30. Alternatives are summarized in Table 5 and discussed in greater detail below.

Table 5. Alternatives Summary Table

Alternatives	Fish Passage Design Approach	Structure Span, ft	Max Structure Length, ft	Programmatic Fish Passage Review	Notes
1A – Small Structures with Stream Daylighting	Hydraulic Design	15	220	No	**High risk** for future passage deficiency and maintenance requirements, improved habitat with daylighting
1B – Small Continuous Culvert	Hydraulic Design	15	600	No	**Highest risk** for future passage deficiency and maintenance requirements
2A – Large Structures with Stream Daylighting	Stream Simulation	30	220	Yes	**Low risk** for future passage deficiency and maintenance requirements, improved habitat with daylighting
2B – Large Continuous Culvert	Stream Simulation	30	600	Yes	**Moderate risk** for future passage deficiency and maintenance requirements
3 – Large Structure with Maximum Stream Daylighting	Stream Simulation	30	100	Yes	**Lowest risk** for future passage deficiency and maintenance requirements, best habitat value

(a) Recently updated criteria reduced this threshold to 1 ft/s as well as increasing the associated flow rate. If held to updated NMFS hydraulic design guidance, this culvert size is too narrow.

5.1 Alternative 1A – Small Structure Replacements with Stream Daylighting

Alternative 1A consists of a box culvert with a 15-foot-wide and 7-foot-high clearance for maintenance vehicle access that begins just upstream of West C Street, intercepting Fox Creek and diverting flows northwest approximately 100 feet where Fox Creek meets the proposed open channel. The box culvert has 1.5-foot-thick walls and will contain a mix of streambed gravels, cobbles, and boulders as the channel bed. The open channel downstream of the culvert will be approximately 70 feet wide with a maximum depth of 15 feet and include 18-foot high benched structural walls constructed of ecoblocks that will include daylighting to existing grade on both sides. The second box culvert begins at the downstream end of the proposed open channel and extends approximately 220 feet (see Figure 7). A transition joint will be installed to connect the proposed box culvert to the existing 4-foot by 8-foot ODOT owned box culvert. Routine maintenance including removing sediment, debris, and unwanted vegetation, is expected for this alternative. The existing culvert will be removed.

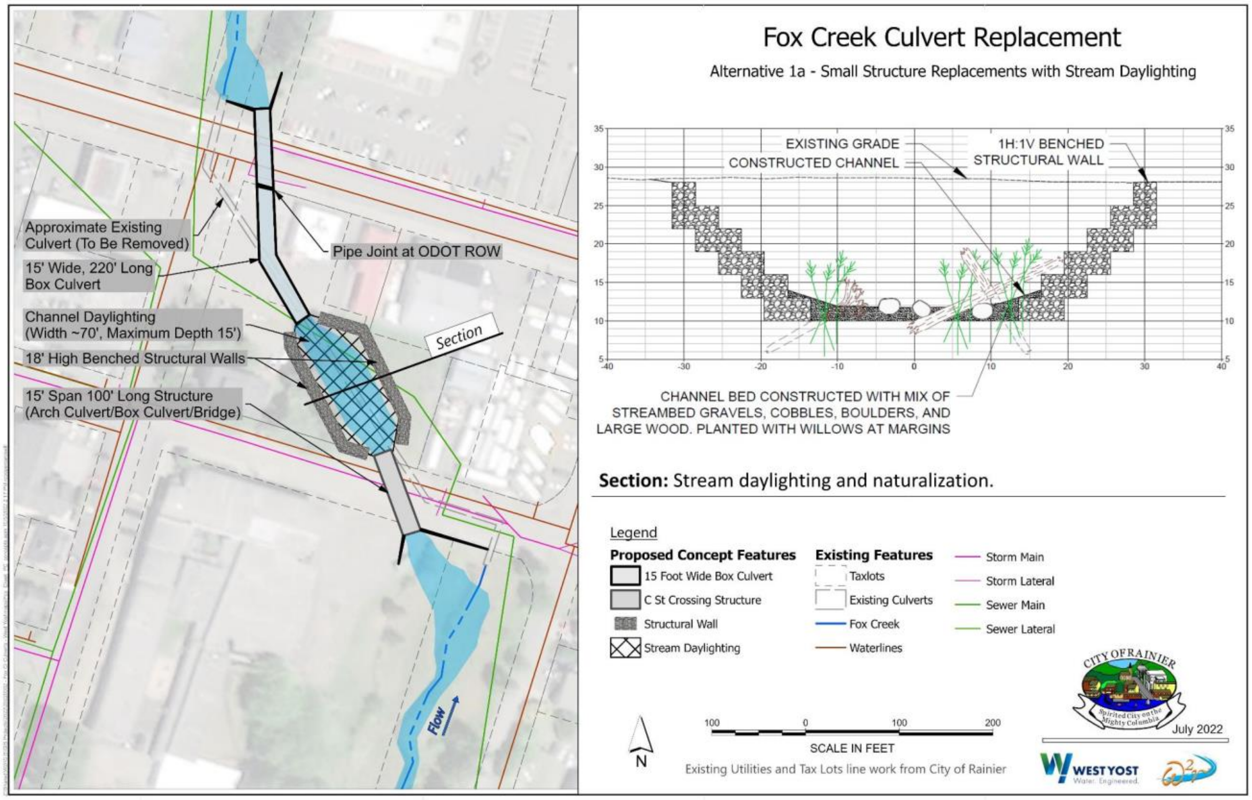


Figure 7. Plan and Section View of Alternative 1A

5.2 Alternative 1B – Small Continuous Structure Replacements

Alternative 1B includes a box culvert with a 15-foot-wide and 7-foot-high clearance that intercepts Fox Creek upstream of West C Street, directing the flow in the northwest direction (Figure 8), and connects to the existing ODOT owned 4-foot by 8-foot box culvert. A transition joint will be installed to connect the two structures. The box culvert would be 600 feet long in total (including the ODOT section), have 1.5-foot-thick walls, and contain a mix of streambed gravels, cobbles, and boulders as the channel bed. The existing culvert will be removed. Routine maintenance would include removing sediment, debris, and unwanted vegetation.

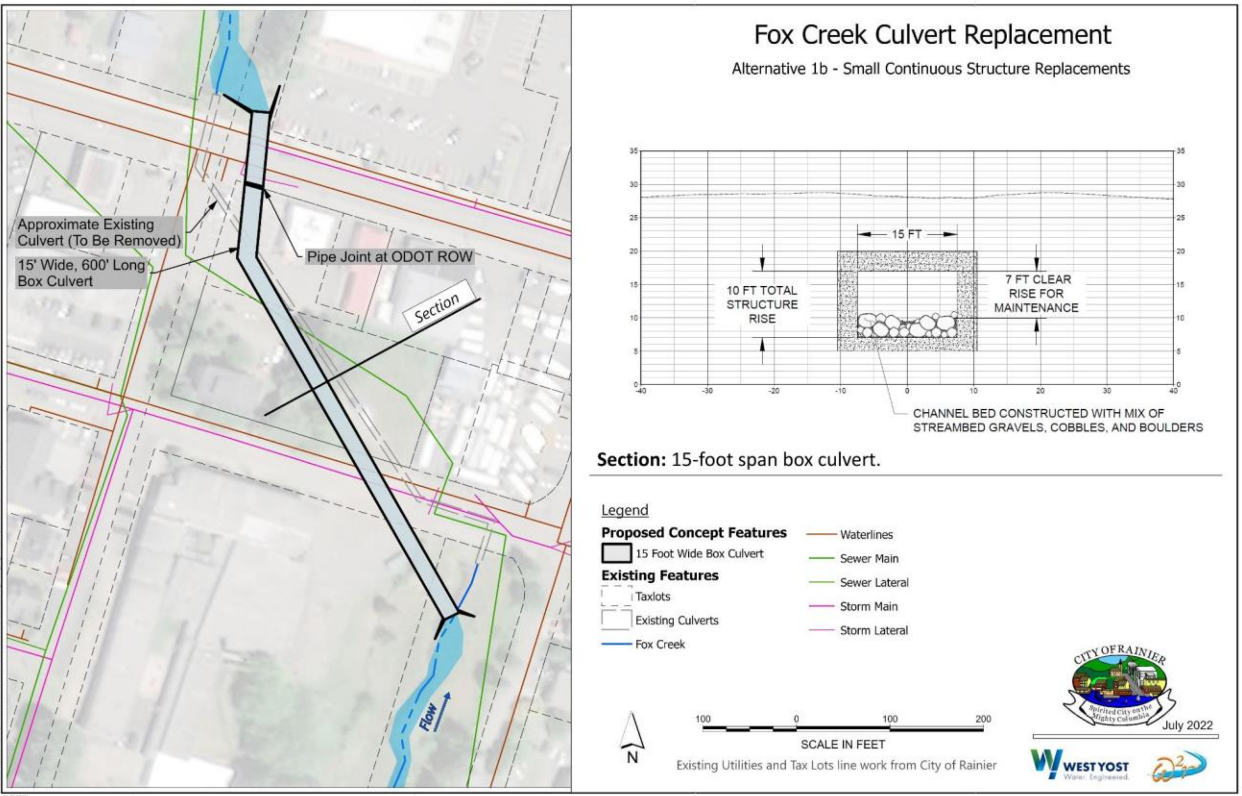


Figure 8. Plan and Section View of Alternative 1B

5.3 Alternative 2A – Large Structure Replacements with Stream Daylighting

Alternative 2A would consist of a 30-foot-wide and 15-foot-high box culvert that directs Fox Creek in the northwest direction and extends 100 feet to a proposed open channel. The open channel downstream of the culvert would be approximately 70 feet wide with a maximum depth of 15 feet, and include 18-foot high benched structural walls constructed of ecoblocks that will include daylighting to existing grade on both sides. Following the open channel, a 30-foot-wide and 15-foot-high oblong CMP extending approximately 220 feet will divert flows toward Highway 30 where it will connect with the existing 4-foot by 8-foot ODOT owned box culvert. A transition piece will be installed to connect the two strictures. The existing culvert will be removed. Figure 9 depicts the plan and section view of Alternative 2A. Routine maintenance includes removing sediment, debris, and unwanted vegetation.

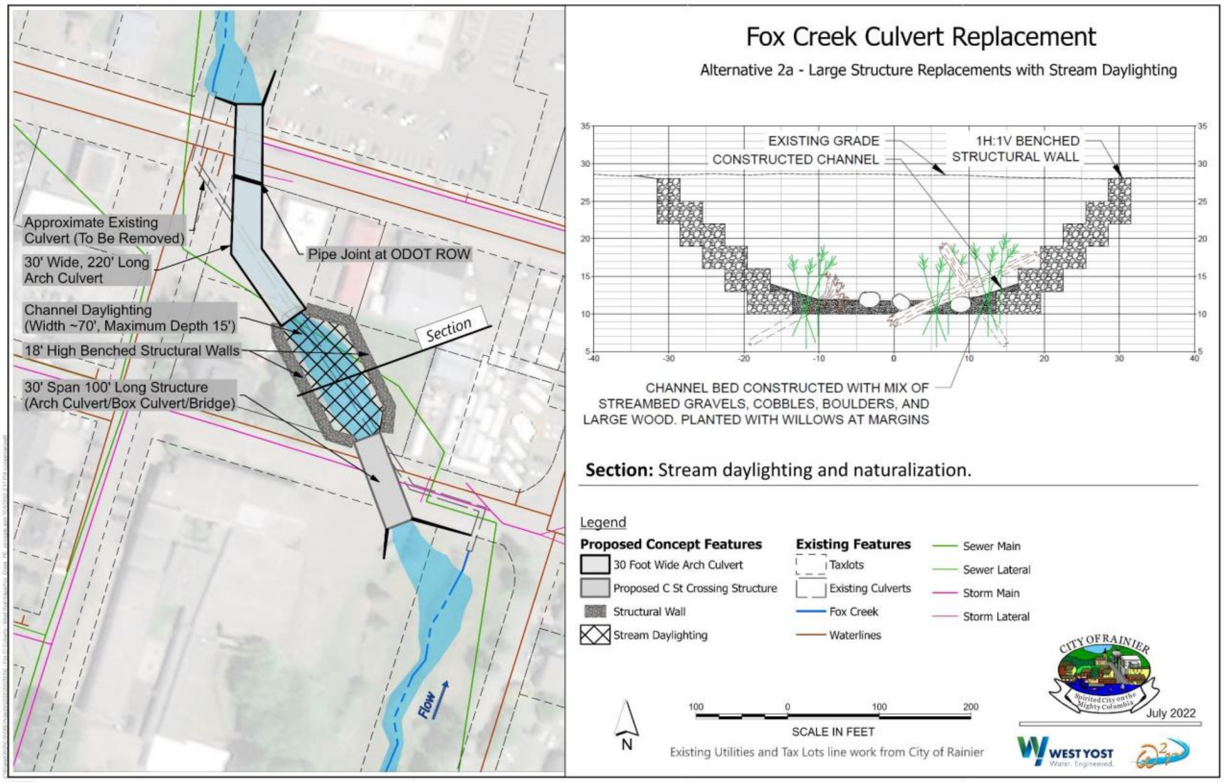


Figure 9. Plan and Section View of Alternative 2A

5.4 Alternative 2B – Large Continuous Structure Replacements

Alternative 2B includes a 30-foot wide and 7-foot-high oblong CMP that intercepts Fox Creek upstream of West C Street and the existing culvert. The structure will direct the flow in the northwest direction and extend 600 feet long in total (including the ODOT section. A transition joint will be installed to connect the two structures. The structure will contain a mix of streambed gravels, cobbles, and boulders as the channel bed. Expected maintenance for this alternative includes removing sediment, debris, and unwanted vegetation. The existing culvert will be removed. Figure 10 shows the plan and section view of Alternative 2B.

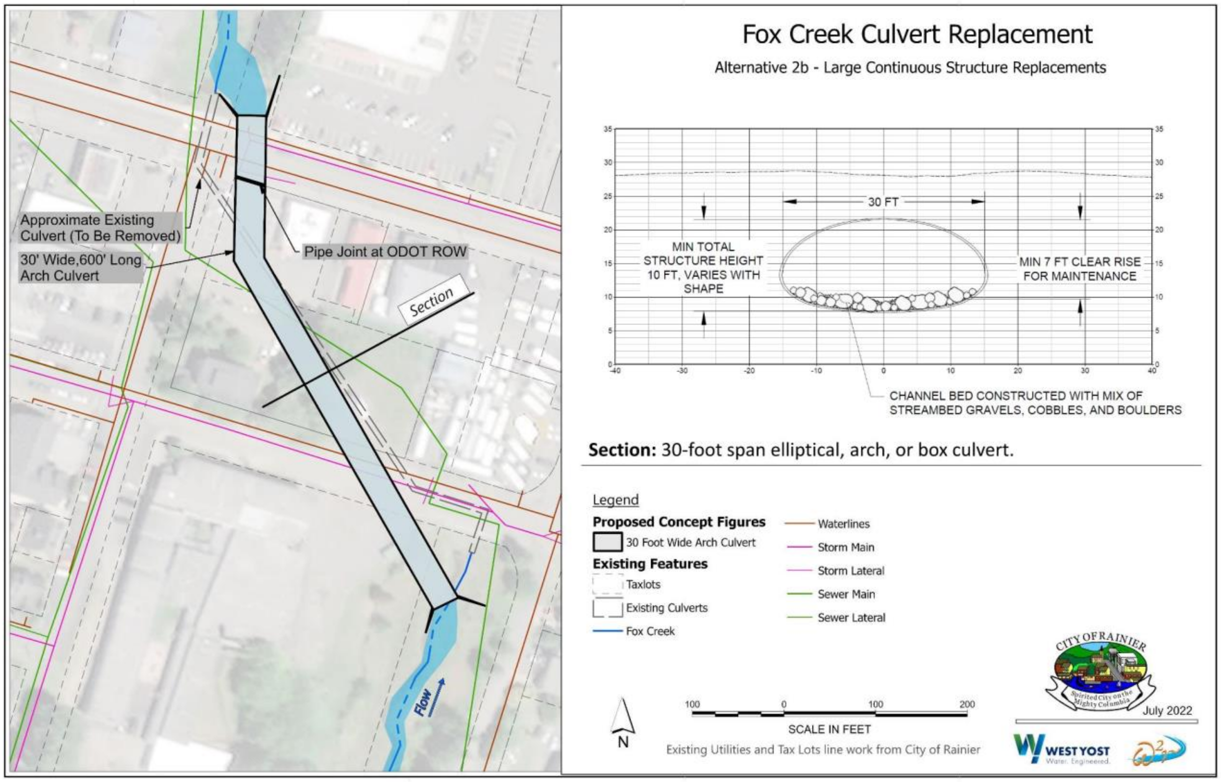


Figure 10. Plan and Section View of Alternative 2B

5.5 Alternative 3 – Large Structure Replacement with Maximized Stream Daylighting

Alternative 3 includes the installation of a 30-foot wide, 100-foot-long and 15-foot high culvert that would intercept Fox Creek just upstream of West C Street, direct flows northwest underneath the street (Figure 11), and discharge to a proposed open channel. The open channel would flow in the northwest direction where it will bend approximately 30 degrees directing flows in the north direction to the Highway 30 crossing. A transition piece will be installed to connect the open channel to the existing ODOT owned 8-foot by 4-foot box culvert. The open channel sections would include 18-foot high benched structural walls constructed of Ecoblocks that will daylight to existing grade on both sides.

The relocation of a local restaurant and real estate acquisition within the Project vicinity would be necessary for this alternative. Although this would accrue additional costs, this would eliminate the importation of a significant amount of material necessary to stabilize ground conditions for structures. Therefore, overall this would lower cost and potentially allow the City to stay out of Federal funding and permitting.

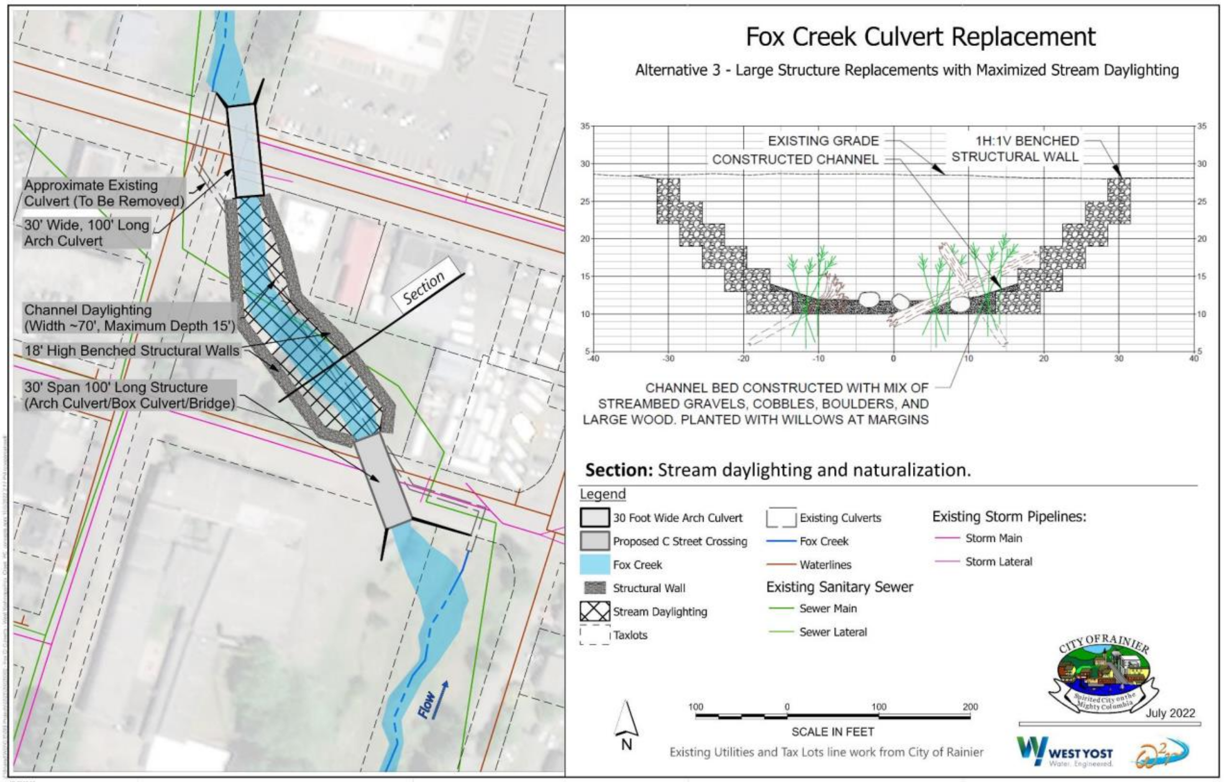


Figure 11. Plan and Section View of Alternative 3

5.6 Costs Analysis

Cost estimates were developed for the five alternatives presented above. The factors considered in the cost analysis include construction duration, traffic control, bypass, restoration, mobilization, and a 40 percent contingency. Costs such as permit fees, real estate acquisition, design, and coordination are not included in this analysis. Table 6 summarizes the anticipated construction costs for each alternative. A detailed cost breakdown is shown in Appendix E.

Table 6. Summary of Preliminary Costs, dollars

Description	Alternative 1A	Alternative 1B	Alternative 2A	Alternative 2B	Alternative 3
Excavation	600,000	425,000	800,000	750,000	1,000,000
Shoring	600,000	1,000,000	600,000	1,000,000	400,000
Subgrade Stabilization	150,000	280,000	280,000	550,000	180,000
Ecoblocks	237,500	NA	237,500	NA	399,000
Box Culvert/CMP	960,000	1,800,000	1,075,200	2,016,000	672,000
Stream Bed Material	163,600	275,500	175,600	499,500	199,000
Additional Items[(a)]	3,828,900	3,409,500	4,361,700	4,164,500	3,940,000
Subtotal	**$6,540,000**	**$7,190,000**	**$7,530,000**	**$8,980,000**	**$6,790,000**

(a) Includes clearing and grubbing, backfill, demolition, stream diversion, utility relocation, surface restoration, ODOT transition piece, dewatering, paving traffic control, mobilization, contractor overhead and profit, market adjustment, and contingency.

6.0 ALTERNATIVE EVALUATION AND RECOMMENDATIONS

Considering fish passage and stream functions, Alternatives 1a and 1b (the hydraulic design approach alternatives) are not recommended because:

- The hydraulic design approach may not be the accepted fish passage design approach, especially if there is a federal nexus (funding, etc.) that necessitates National Oceanic and Atmospheric Administration (NOAA)/NMFS review and not just ODFW review. Additionally, in lieu of a federal funding nexus, ODFW may revise state fish passage requirements for a hydraulic passage approach to be in-line with NMFS guidance that was made more restrictive during this analysis. The structure span described in Alternatives 1a and 1B is likely to be insufficient for hydraulic fish passage in the future
- The resulting stream habitat within the structure(s) would be lower quality due to:
  - Higher likelihood of stream bed simplification to plane bed morphology (flat section) or entrainment (flows confined against culvert wall which are undesirable) which are detrimental to fish passage;
  - Less opportunity for morphological diversity from habitat wood (embedded log) placement in or near the structure(s), as risk of debris accumulation would be too high with a small structure.
- City and ODOT maintenance would be more difficult with respect to:
  - Limited access (space to work) within a smaller structure that is also potentially very long, and
  - The risk of displacement/loss of streambed materials and subsequent required maintenance and replacement of the streambed by much higher, especially in a structure that will likely have at least one angle or bend, which tends to focus scour.

Alternatives 2 and 3 (which are based on the stream simulation design approach) are recommended:

- The wider structure span is based on geomorphic principles and more likely to function under higher future flows and natural sediment and large log (debris) transport processes that will occur during the lifespan of the structure(s).
- Maintenance costs will be reduced with the wider structure, as there will be:
  - Improved access for small machinery for faster and safer machine and crew work; and
  - Lower hydraulic scour forces and reduced likelihood of streambed material loss that would necessitate rock replacement to maintain fish passage depths and velocities.

Fox Creek daylighting options are recommended for the following:

- Daylighting options provide significantly better fish passage conditions due to increased lighting and increased slack water margin habitat at stream edges. Upstream and downstream migrating fish would be reluctant to enter long dark crossings associated with non-daylighting options.
- The daylighted stream would offer a visible/tangible public amenity and park setting benefits.

- Maximizing the extent of daylighting is expected to be more cost effective and beneficial to stream habitat, as daylighting costs would become incrementally lower but more beneficial to habitat as the daylighting segment(s) increases.

Stream reconnection associated with fish passage structure replacement will likely have to extend upstream of West C Street to some degree for connectivity / continuity reasons, and to appropriately consider the relatively “fine” sands and gravels present in this reach due to backwatering. Upstream restoration would reduce the risk of erosion / headcuts that form as future unimpeded flows approach the new crossing at West C Street, and reduce the risk of inadvertent fish passage barriers forming in this reach. Reconnection would also improve floodplain habitat and raise groundwater levels which will also improve floodplain planting survival.

7.0 NEXT STEPS

The following list details the next steps required after selecting the preferred Alternative:

- Funding sources
- Phase 1 Environmental Study
- Further geotechnical investigation for contaminated soil
- Appraisal of restaurant relocation and real estate acquisition (Alternative 3)
- Detailed hydraulic analysis

Appendix A

Preliminary Geotechnical Recommendation Technical Memorandum Prepared by McMillen Jacobs Associates

Technical Memorandum

To:	Preston Van Meter West Yost Associates	Project:	Fox Creek Culvert Feasibility Study
From:	Wolfe Lang, PE, GE Jeremy Fissel, PE	cc:	Sandrine Ganry West Yost Associates
Date:	June 20, 2022	Job No.	6353.0
Subject:	Preliminary Geotechnical Recommendations		

Revision Log

Revision No.	Date	Revision Description
0	June 20, 2022	Draft issued for review

1.0 Introduction and Background Information

1.1 General

McMillen Jacobs Associates (MJ) has been retained by West Yost Associates to provide geotechnical engineering services for their feasibility study of the Fox Creek culvert in Rainier, OR. This memorandum includes a summary of our background review, site reconnaissance, geotechnical investigation, subsurface soil condition assessment, and preliminary geotechnical recommendations for the use in culvert design.

1.2 Project Description

The site is located between West C and West B (Highway 30) Streets, and between West 2nd and West 3rd Streets in Rainier, Oregon. Open channel flow from Fox Creek enters the culvert system at West C Street and is conveyed west through a culvert system of various sizes, then to the north beneath West B Street where it discharges to open channel flow that confluences with the Columbia River. The culvert system traverses properties owned by The City of Rainier, private individuals, private businesses, and the Oregon Department of Transportation (ODOT).

The existing culvert system is 66-inch diameter corrugated metal pipe (CMP) at it's inlet, transitions to a 72-inch corrugated metal pipe (CMP), then to an 84-inch CMP. The 84-inch diameter CMP then feeds an 8 by 4-foot box culvert beneath Highway 30, which is ODOT jurisdiction. Figure 1 in Section 3.2 of this report shows the culvert alignment and approximate location of the various sizes of the system's components.

Ground surface subsidence had been documented in 2014 when a sinkhole developed above a section of the 66-inch diameter culvert within a portion of a privately owned property. A significant section of the culvert system in the affected area was replaced in 2017. This construction included discharging nearby storm drains into the repaired section.

Since replacement of this section of the culvert system, after heavy rainfall in February 2019 the properties between West C Street and Highway 30 had experienced flooding. It was noted that City of Rainier staff had not observed flooded conditions prior to the replacement of this section of the culvert system.

A hydraulic evaluation of the stormwater from Fox Creek and the existing culvert system was previously performed. Preliminary recommendations included an option of increasing the size of the entire culvert system. Another option identified would be to only increase the culvert sizes beneath West C Street and Highway 30, and then replace the remaining culvert portion with a fish-friendly stream channel.

1.3 Site Description

The existing culvert system is generally located beneath nearly level to gently sloping terrain of a commercially and privately developed area of Rainier, Oregon. The alignment traverses beneath portions of asphalt and gravel parking lots used by the nearby business and residences. Figure 1 in Section 3.2 shows the approximate location of the culvert system relative to surrounding features.

2.0 Geologic Setting

The site is located in northwest Oregon along the boundary between the Coast Range and Willamette Valley physiographic provinces. More specifically it is near the northern extent of the Portland Basin, a subbasin of the Willamette Valley (Orr, 2000). The Portland Basin is a structurally controlled lowlands through which the Columbia River passes on route to the Pacific Ocean. The Columbia River is about 900 feet north of the Project site.

The site is underlain by the Eocene-aged volcaniclastic sedimentary rock member of the Goble Volcanics (Phillips, 1987). This unit consists of light-colored volcanic-lithic sandstone, siltstone and conglomerate with lesser amounts of ash tuff beds, breccia and coal and carbonaceous shale. This formation weathers to a bright red, clay-rich soil that is typically more than 100 feet thick.

3.0 Field Exploration and Laboratory Testing

3.1 Site Reconnaissance

McMillen Jacobs completed a site reconnaissance on May 19, 2022. The purpose of the site reconnaissance was to identify potential geologic hazards associated with construction and installation of a new covert system.

Generally, the footprint of the existing culvert system, a gently sloping area, did not exhibit signs of subsurface instabilities, such as significant depressions at the ground surface or cracking in the asphalt surface. The was however, standing water located at the junction of a gravel driveway and asphalt pavement near the central portion of the current alignment, on privately owned property.

Clearly identifiable erosion at the culvert system inlet and discharge point was not observed. There are steeply sloping banks downstream of the box culvert beneath Highway 30 which are covered with vegetation that we consider at-risk of erosion and potential instabilities, particularly during heavy rain events. Also, the water pool appeared to deepen a few feet downstream of the box culvert discharge, which may be indication of erosion.

3.2 Geotechnical Exploration

To evaluate the subsurface conditions, one geotechnical soil boring (B-1) was completed on May 19, 2022. B-1 was advanced to approximately 26.5 feet below the asphalt pavement surface at West 3rd Street using solid stem auger drilling methods. The drilling was performed by Western States Soil Conservation, Inc., of Hubbard Oregon, using a trailer-mounted Simco drill. The approximate location of our recent exploration B-1 is shown below in Figure 1.

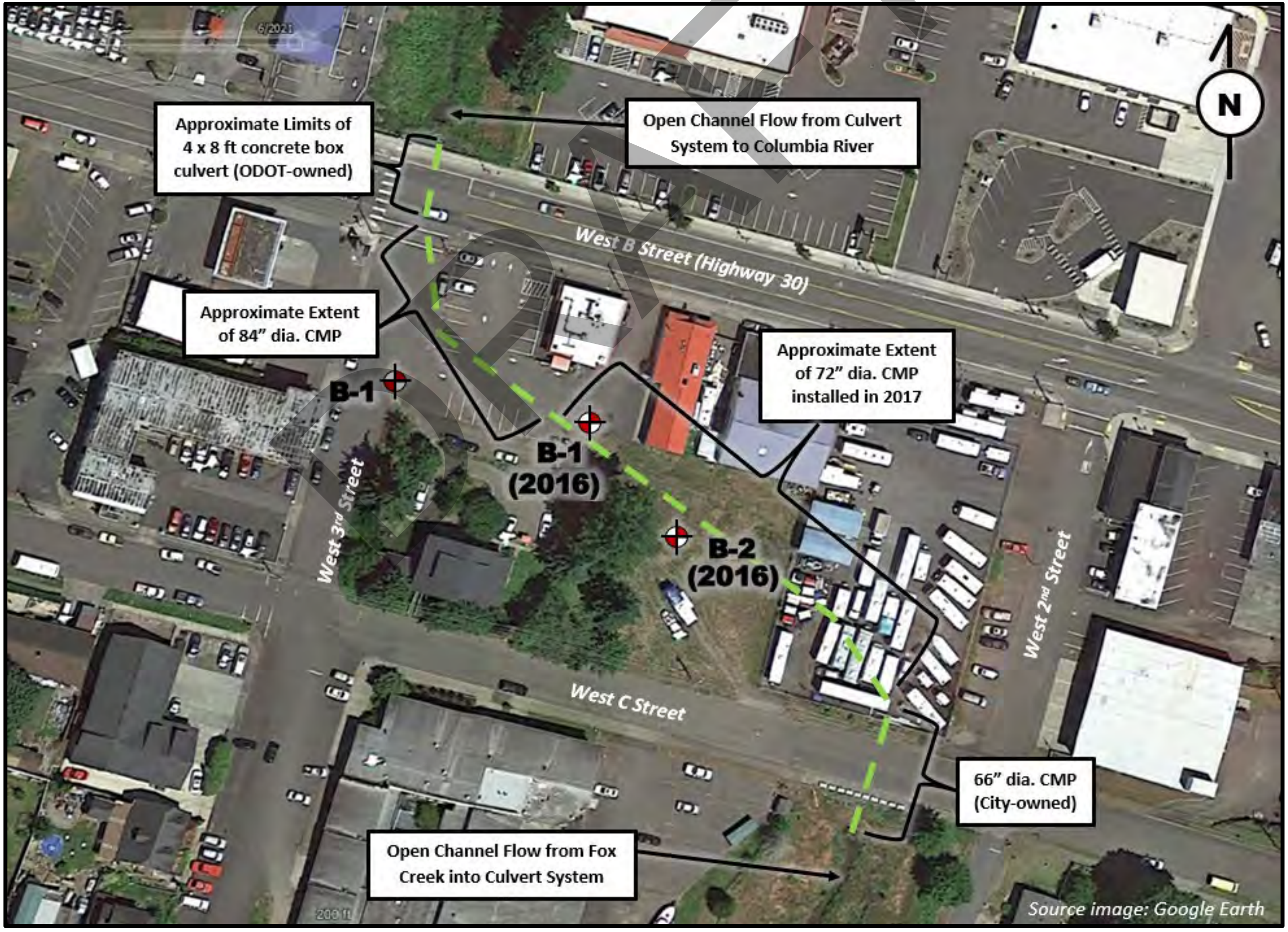


Figure 1: Site Plan of existing culvert system (approximate alignment shown in green) and soil boring locations.

Disturbed soil samples were collected using Standard Penetration Testing (SPT) techniques at 2.5-foot intervals using a standard 2-inch diameter split-barrel sampler and manual (cathead) hammer. In each test, the sampler was advanced 18 inches by dropping a 140-pound hammer 30 inches for each blow in accordance with ASTM D1586. The number of hammer blows for each six inches of penetration was recorded and the standard penetration resistance (designated as the letter N) of the soil was calculated as the sum of the number of blows required for the final 12 inches of sampler penetration.

A summary log of our recent soil boring is included in Attachment A. The stratigraphic contacts indicated on the boring log represent the approximate boundaries between soil types and actual transitions may be more gradual.

3.3 Laboratory Testing

Representative samples were selected for moisture content testing. The moisture content tests were completed in accordance with ASTM D2216 by Breccia Geotechnical Testing, LLC, of Tigard, Oregon. The results of laboratory tests are graphically shown on the boring log and detailed results are provided in Attachment B.

3.4 Previous Site Explorations

Logs of two previously completed soil borings by Redmond Geotechnical Services were found publicly, each dated September 2, 2016. The project identified on the available documents is CSWD Emergency Projects and CSWCD Rainier Sinkhole. Each boring was drilled to a depth of 36.5 feet below ground surface (bgs). The location of these borings, B-1 (2016) and B-2 (2016), are shown in Figure 1 in Section 3.2.

4.0 Subsurface Conditions

Recent boring B-1 encountered a 3.75-inch thick section of asphalt pavement underlain by about 12 inches of base aggregate. Fill was encountered beneath the pavement section and extended to a depth of approximately 10.5 feet bgs. The fill soils were generally, fine to mediums, poorly graded sand, with trace gravel and trace fines. N-values from SPT samples within the fill ranged from 4 to 11, indicating very loose to loose conditions. A 4-inch cobble was encountered in the fill stratum at B-1.

Similarly, fill was encountered in the historical borings B-1 (2016) and B-2 (2016). The respective boring logs cite the fill in the upper 13 and 8 feet. N-values from SPT tests ranged from 9 to 13 in the fill. Boulders at various depths are described on the historical boring logs within the fill stratum.

Beneath the fill, we encountered native alluvial soils comprised of gray and light brown poorly graded, fine to medium sand with trace fines that extended to a depth of about 22 feet bgs in B-1. Based on N-values, these soils were in a very loose to loose conditions. Laboratory test results for moisture content within the alluvial soils ranged from 9 to 29 percent.

In historical borings B-1 (2016) and B-2 (2016), the sandy fill soils were underlain by a 1-foot-thick layer of native soil comprised of very soft, wet, organic, sandy, clayey silt. This was followed by very loose, wet, clayey, silty fine sand with trace organics (SM). N-values from SPT samples obtained within the stratum ranged from 2 to 11. The color of the unit varied from bluish-gray at its surface and cited to change to orange-brown at 15 and 20 feet bgs in B-1 (2016) and B-2 (2016), respectively. Each of these historical boring terminated within the silty sand unit.

The final stratum encountered in our recent boring B-1, was a light brown and red-brown sandy fat clay (CH). Coarse sand to fine gravel-sized nodules of hard clay were apparent in the unit. The two SPT samples obtained within the unit were 39 and 50, while laboratory moisture content results were 40 and 44 percent. Based on SPT results, we consider this unit Residual Soil of Goble Volcanics. Our solid stem auger soil boring terminated within this unit due to practical auger refusal.

Groundwater was measured inside recent boring B-1 prior to backfilling. A groundwater depth of 16 feet below the top of the asphalt was observed.

5.0 Design and Construction Recommendations

The following sections includes preliminary geotechnical recommendations for the design and construction of a new culvert system. These recommendations are based on information derived from our recent soil boring, the historical soil borings, and the previous geotechnical issues documented at the site.

5.1 Bearing Capacity

Based on the groundwater level and the loose sandy soils encountered, the project site is subject to seismic hazards such as liquefaction and lateral spread. Mitigation of these hazards would likely consist of ground improvement methods. We assume costs of such improvements are not within the Project budget. Therefore, we are providing recommendations for soil bearing capacity under static conditions only.

Our soil bearing capacity recommendations vary based on possible depths of the new culvert. These recommendations assume the subgrade soils are prepared in accordance with our recommendations in Section 5.1.1.

A net allowable bearing capacity of 2,000 pounds per square foot (psf) can be used in the design for culvert invert elevations and foundations up to 10 feet bgs, The subgrade soils at this depth are expected to be either loose sand fill, or loose native alluvial sandy deposits. Groundwater is not expected to be encountered at this depth.

Culvert invert elevations and other foundations below 10 feet bgs, can be designed using a net allowable bearing capacity of 1,500 psf. The soils at this depth are expected to be either loose, wet, sandy alluvial deposits or soft sandy clay. Groundwater can be expected below 10 feet bgs.

5.1.1 Subgrade Preparation

To achieve the recommended bearing capacities provided in the above section, we recommend subgrade stabilization and dewatering methods be employed.

The foundation stabilization layer should consist of clean, open-graded, 2-inch to ¼-inch crushed aggregate. The foundation stabilization layer should be a minimum 12 inches thick and placed upon a reinforced geotextile fabric that provides both filtration/separation and reinforcement, The stabilization materials should be mechanically compacted using a drum roller in static mode. This subgrade stabilization backfill may also be used as the drainage layer for in-trench dewatering discussed in the subsequent sections.

5.2 Excavations

We expect installation of a new culvert system to consist primarily of trenching methods. We also anticipate installation of deep structures, such as manholes at some locations within the alignment.

However, at the downsteam end of the culvert system at Highway 30 less conventional means to install a new drainage system are likely. This section of the alignment is part of a bridge structure owned by ODOT. Methods to increase the size of the culvert beneath the bridge may require modification or replacement of the bridge structure. Trenchless methods could be possible but are dependent of the structural entities of the existing bridge and the invert elevation of the underlying new culvert.

The following sections include our concerns regarding the construction activities to replace the existing culvert system within the City of Rainier’s jurisdiction and the adjacent private properties.

5.2.1 Trenching

The near surface soils at the site consist of sandy soils. Installation of the new culvert system using open cut or cut slope methods are likely not feasible based on City-owned easements and surrounding structures. Trench shoring or shielding will likely be necessary for installation. Based on our experience conventional trench box systems can be used during installation.

Groundwater in conjunction with the sandy soils within the trench zone could adversely impact the site. Potential flowing soil conditions may create ground surface subsidence, such as sinkholes. Voids between the trench wall and the outside face of the shoring should be immediately backfilled after the trench is shoring is placed. This backfill material should be imported crushed rock, approximately ¾-inch minus, when used beneath groundwater up to 2 feet above the groundwater level. The onsite sandy soils can be used to backfill the trench box system from 1 foot above the groundwater level to the ground surface.

5.2.2 Boulders

The historic soil borings identified boulders in the upper 13 feet within the culvert alignment. Earthwork activities should expect removal and disposal of boulders.

5.2.3 Groundwater Control

A groundwater level of 16 feet bgs was observed in our recent soil boring. Construction excavations below groundwater levels will require additional measures to minimize subgrade disturbance which can cause reduction of soil shear strengths. Unless a water-tight shoring system (such as steel sheet piles) is used to cutoff the groundwater inflow, a positive dewatering system will need to be used to lower the groundwater table. For the feasible dewatering system, vacuum wellpoints or deep gravity wells can be considered. In addition to wells or wellpoints installation, water collection, treatment and discharge systems of the groundwater will need to be considered.

5.3 Trench Backfill

The current culvert alignment traverse beneath asphalt pavement, gravel driveways, and grass surfaced regions. Backfill of the drainage system should consist of imported crushed rock, approximately ¾-inch minus in grading where the finished surface is paved, subjected to vehicle loading, or within a zone that may impact adjacent structures.

Backfill material where surface settlement is not a concern, such as grass surface lawns and areas that do not include adjacent structures, can be the on-site excavated sandy soils. The on-site soils reused as backfill should have particle sizes greater than 4-inches removed and be free of organic matter, or soft, wet fine-grained soils.

All backfill materials should be compacted to 95 percent of the maximum dry density as determined by ASTM D698.

5.4 Structural Fill

Where needed, structural fill should be placed on subgrade that has been mechanically compacted to firm and unyielding conditions. The subgrade should be dewatered prior to compaction and placement of fill.

Structural fill should consist of imported crushed rock with a grading of ¾-inch minus. Loose lifts of should be no more than 12 inches and compacted to at least 95 percent of the maximum dry density as determined by ASTM D698 (Standard Proctor). Lift thicknesses may need to be reduced depending on the contractor compaction equipment and methods. Structural fill should extend at least 12 inches beyond the footprint of the supported foundation.

6.0 Closure

This memorandum was prepared for the Fox Creek Culvert Study in Rainier, Oregon. The data, analyses, and preliminary recommendations presented in this report are based on the subsurface conditions at the time that the geotechnical investigation for the project was completed. This report also contains information and data collected from other relevant studies, as well as our professional experience and judgement. Additional geotechnical investigations and analyses will be required for the detailed design of the culvert improvement project.

In the performance of geotechnical work, specific information is obtained at specific locations at specific times, and geologic conditions can change over time. It should be acknowledged that variations in soil conditions may exist between exploration and exposed locations and this report does not necessarily reflect variations between different explorations. The nature and extent of variation may not become evident until construction. McMillen Jacobs Associates is not responsible for the interpretation of the data contained in this report by anyone; as such interpretations are dependent on each person's subjectivity. If, during construction, conditions different from those disclosed by this report are observed or encountered, McMillen Jacobs Associates should be notified at once so we can observe and review these conditions and reconsider our recommendations where necessary.

The site investigation and this report were completed within the limitations of the McMillen Jacobs Associates approved scope of work, schedule, budget, and terms and the conditions of subcontract agreement. The services rendered have been performed in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the same area. McMillen Jacobs Associates is not responsible for the use of this report in connection with anything other than the project at the location described above.

7.0 References

Orr, E.L. and Orr, W.N., 2000, Geology of Oregon, Kendall/Hunt Publishing Company, Fifth Addition.

Philips, W.M., 1987, Geologic Map of the Mount St. Helens Quadrangle, Washington and Oregon, Washington Division of Geology and Earth Resources, Open File Report 87-4.

ATTACHMENTS

Attachment A – Boring Log

Attachment B – Laboratory Tests Results

Attachment A – Boring Log

MOISTURE CONTENT

DESCRIPTION	CONDITION
Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp, but no visible water.
Wet	Visible free water, typically below water table.

ABBREVIATIONS

SYMBOL	DEFINITION
├┤	Atterberg Limits
○	Moisture Content
□	Blows per foot (N)

FINE-GRAINED SOIL CONSISTENCY

RELATIVE CONSISTENCY	N, SPT *Blows/foot*
Very Soft	0 to 1
Soft	2 to 4
Medium stiff	5 to 8
Stiff	9 to 15
Very Stiff	16 to 30
Hard	> 30

COARSE-GRAINED SOIL DENSITY

Relative Density	N, SPT *Blows/foot*
Very Loose	0 to 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	> 50

PERCENTAGE RANGE TERMS[1,2]

DESCRIPTION	RANGE
Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

1. Gravel, Sand and fines are estimated by mass. Other constituents such as organics, cobbles, and boulders are estimated by volume.
2. Percentages per ASTM D2488.

SOIL CONSTITUENCY DEFINITIONS

CONSTITUENT	COARSE-GRAINED	FINE-GRAINED
Major	Less than 50% fines: **SAND** or **GRAVEL**	More than 50% fines: **SILT, ELASTIC SILT, LEAN CLAY, FAT CLAY, ORGANIC SOIL**
Secondary	12%[1] or more fine-grained: **Silty** or **Clayey**	30% or more coarse-grained: **Sandy** or **Gravelly**
Minor	5 to 12%[1] fine-grained: **with Silt** or **with Clay**	15 to 30% coarse-grained: **with Sand** or **with Gravel**
	15% or more of a second coarse-grained constituent: **with Sand** or **with Gravel**	30% or more total coarse-grained and the lesser coarse constituent is 15% or more: **with Sand** or **with Gravel**

1. ASTM D2488 specifies more than 15% fines

PARTICLE SIZE DEFINITIONS

DESCRIPTON		SIEVE SIZE *PER ASTM D2488*
FINES		< #200 (0.075 mm)
SAND	*Fine*	#200 to #40 (0.075 to 0.4 mm)
	Medium	#40 to #10 (0.4 to 2 mm)
	Coarse	#10 to #4 (0.4 to 4.75 mm)
GRAVEL	*Fine*	#4 to ¾ in. (4.75 to 19 mm)
	Medium	¾ to 3 in. (19 to 76 mm)
COBBLES		3 to 12 in. (76 to 305 mm)
BOULDERS		> 12 in. (305 mm)

McMILLEN JACOBS ASSOCIATES

KEY TO SUBSURFACE LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)[1]

MAJOR DIVISIONS			SYMBOL		TYPICAL DESCRIPTION	ALTERNATE DESCRIPTIONS
COARSE-GRAINED SOILS (50% OR MORE RETAINED BY NO. 200 SIEVE)	**GRAVELS** (MORE THAN 50% RETAINED ON NO. 4 SIEVE)	**CLEAN GRAVELS** (≤ 5% FINES)	**GW**	▩	WELL-GRADED GRAVEL	WELL-GRADED GRAVEL WITH SAND
			GP	▩	POORLY GRADED GRAVEL	POORLY GRADED GRAVEL WITH SAND
		GRAVELS[2,4] (5 – 12 % FINES)	**GW-GM**	▩	WELL-GRADED GRAVEL WITH SILT	WELL-GRADED GRAVEL WITH SILT AND SAND
			GW-GC	▩	WELL-GRADED GRAVEL WITH CLAY	WELL-GRADED GRAVEL WITH CLAY AND SAND
			GP-GM	▩	POORLY GRADED GRAVEL WITH SILT	POORLY GRADED GRAVEL WITH SILT AND SAND
			GP-GC	▩	POORLY GRADED GRAVEL WITH CLAY	POORLY GRADED GRAVEL WITH CLAY AND SAND
		GRAVELS WITH FINES[2] (≥ 12% FINES)	**GM**	▩	SILTY GRAVEL	SILTY GRAVEL WITH SAND
			GC	▩	CLAYEY GRAVEL	CLAYEY GRAVEL WITH SAND
	SANDS (LESS THAN 50% RETAINED ON NO. 4 SIEVE)	**CLEAN SANDS** (≤ 5% FINES)	**SW**	░	WELL-GRADED SAND	WELL-GRADED SAND WITH GRAVEL
			SP	░	POORLY GRADED SAND	POORLY GRADED SAND WITH GRAVEL
		SANDS[2,4] (5 – 12 % FINES)	**SW-SM**	░	WELL-GRADED SAND WITH SILT	WELL-GRADED SAND WITH SILT AND GRAVEL
			SW-SC	░	WELL-GRADED SAND WITH CLAY	WELL-GRADED SAND WITH CLAY AND GRAVEL
			SP-SM	░	POORLY GRADED SAND WITH SILT	POORLY GRADED SAND WITH SILT AND GRAVEL
			SP-SC	░	POORLY GRADED SAND WITH CLAY	POORLY GRADED SAND WITH CLAY AND GRAVEL
		SANDS WITH FINES[3] (> 12% FINES)	**SM**	░	SILTY SAND	SILTY SAND WITH GRAVEL
			SC	░	CLAYEY SAND	CLAYEY SAND WITH GRAVEL
FINE-GRAINED SOILS (50% OR MORE PASSES NO. 200 SIEVE)	**SILTS AND CLAYS** (LL < 50)	INORGANIC	**ML**	▥	SILT	SILT WITH SAND OR GRAVEL; SANDY OR GRAVELLY SILT
			CL	▨	LEAN CLAY	LEAN CLAY WITH SAND OR GRAVEL; SANDY OR GRAVELLY LEAN CLAY
		ORGANIC	**OL**	▨	ORGANIC SOIL	ORGANIC SOIL WITH SAND OR GRAVEL; SANDY OR GRAVELLY ORGANIC SOIL
	SILTS AND CLAYS (LL ≥ 50)	INORGANIC	**MH**	▥	ELASTIC SILT	ELASTIC SILT WITH SAND OR GRAVEL; SANDY OR GRAVELLY ELASTIC SILT
			CH	▨	FAT CLAY	FAT CLAY WITH SAND OR GRAVEL; SANDY OR GRAVELLY FAT CLAY
		ORGANIC	**OH**	▥	ORGANIC SOIL	ORGANIC SOIL WITH SAND OR GRAVEL; SANDY OR GRAVELLY ORGANIC SOIL
	SILT/CLAY[2]	INORGANIC	**CL-ML**	▨	SILTY CLAY	SILTY CLAY WITH SAND OR GRAVEL; SANDY OR GRAVELLY SILTY CLAY
HIGHLY ORGANIC SOILS		ORGANIC	**PT**	▭	PEAT	

NOTES:

1. The USCS described here is based on ASTM standards D2487 & D2488.
2. Dual symbol materials (e.g., SP-SM) are used for soils between 5% and 12% fines or when liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart, (LL: 12 -25, PI: 4-7).
3. ASTM D2488 specifies the use of dual symbol coarse-grained soils between 5% and 15% fines.

BACKFILL, WELL, AND SAMPLE SYMBOLS					
▦	Bentonite Chips	▧	Grout	⧗	2” OD Split Barrel Sampler
▩	Concrete	◫	Observation Well - Solid	■	Shelby Tube Sample
░	Sand	▤	Observation Well – Screen	✋	Grab Sample
■	Asphalt	▮	Vibrating Wire Piezometer	▯▯	Rock Core Run
░	Gravel	▼	Measured Groundwater Level		

McMILLEN JACOBS ASSOCIATES

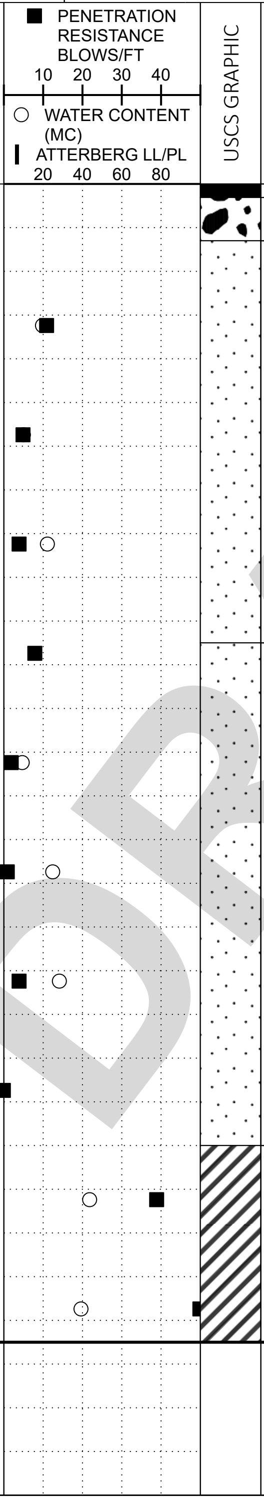
KEY TO SUBSURFACE LOGS

Project: Fox Creek Culvert Feasibility Study
Project Location: Rainier, OR
Project Number: 6353.0

Log of Boring B-1

Date(s) Drilled	05/19/2022	Geotechnical Consultant	McMillen Jacobs Associates	Logged By	J. Fissel	Checked By	W. Lang
Drilling Method/ Rig Type	Solid Stem Auger	Drilling Contractor	Western States Soil Conservation, Inc.	Total Depth of Borehole	26.5 ft		
Hole Diameter	4.25 in	Hammer Weight/Drop (lb/in.)/Type	140 lb / 30 in / Cathead Winch	Ground Surface Elevation/Datum	29.0 ft		
Location	West 3rd Street	Coordinates	- -	Elevation Source	Google Earth		

ELEV. (FT)	WATER LEVEL	DEPTH (FT)	SAMPLE TYPE	RECOVERY (%)	BLOW COUNTS	SAMPLE NUMBER
			⧗	50	5-5-6 (N=11)	S-1
24		5	⧗	50	2-3-2 (N=5)	S-2
			⧗	50	2-2-2 (N=4)	S-3
19		10	⧗	11	1-3-5 (N=8)	S-4
			⧗	67	1-1-1 (N=2)	S-5
14	▼	15	⧗	33	1-0-1 (N=1)	S-6
			⧗	11	6-2-2 (N=4)	S-7
9		20	⧗	11	1-0-0	S-8
			⧗	83	16-18-21 (N=39)	S-9
4		25	⧗	100	21-25-25 (N=50)	S-10



USCS	MATERIAL DESCRIPTION	REMARKS AND TESTS
GW	Hot Mix Aphalt - 3.75 inches thick. **Pavement**	
	Dry to moist, gray and light brown, Well Graded GRAVEL with Sand (GW); fine to coarse angular gravel, fine to coarse sand, trace cobbles up to 4 inch particle size, trace fines. **Base Aggregate**	
SP	Very loose to loose, moist, gray, Poorly Graded SAND (SP); fine to medium, trace fine gravel, trace fines. **Fill** *Encountered red-brown coarse sand at 10 feet; minimal recovery.*	
SP	Very loose to loose, moist, gray and light brown, Poorly Graded SAND (SP); mostly fine to medium sand, trace fines. **Alluvium** *Becomes wet below 15 feet.* *Encountered fibrous wood fragment at 20 feet.*	Groundwater level inside borehole measured to be 16 feet bgs after drilling on 5/19/2022.
CH	Hard, moist, light brown and red-brown, Sandy FAT CLAY (CH); high plasticity, mostly medium to coarse sand, with coarse sand to fine gravel sized hard clay nodules. **Residual Soil of Goble Volcanics**	Practical auger refusal at 25 feet.
		Borehole completed at 26.5 feet below ground surface (bgs).

BACKFILL/INSTALL.

McMILLEN JACOBS ASSOCIATES

Boring B-1

Sheet 1

Attachment B – Laboratory Test Results

Breccia Geotechnical Testing, LLC.	**Natural Moisture Content (ASTM D2216)**

Client:	McMillen Jacobs Associates	By:	JF
Project Name:	Rainier Fox Creek Culvert Study	Date:	5/24/2022
Project Number:	6353.0		

Exploration ID	B-1	B-1	B-1	B-1	B-1	B-1
Samples ID	S-1	S-2	S-3	S-5	S-6	S-7
Samples Depth (ft.)	2.5-4	5-6.5	7.5-9	12.5-14	15-16.5	17.5-19
Moisture Content (%)	19.9	10.2	22.4	9.6	25.1	28.5

Exploration ID	B-1	B-1				
Samples ID	S-9	S-10				
Samples Depth (ft.)	22.5-24	25-26.5				
Moisture Content (%)	43.9	39.5				

Appendix B

Fox Creek Field Data Summary

Table 1. Active channel width data table – FC-01 located upstream of C Street.

Location ID:	**FC-01**	**Photo view:**	
Location:	Fox Creek – Upstream of C ST culvert	*Tape measurement value (#1826.jpg)*	
Observ. Date:	03-09-2022 1200 HRS		
Distance from culvert (ft):	1,200 upstream (south)		
Measured ACW (ft):	22		
Primary Visual Indicators:	Clear erosion/ cut-bank and deposition on rt bank		
Channel morphology:	Riffle-pool		
Dominant bed substrate:	Small, medium gravels		
Bed substrate D50 (mm/in):	TBD	*Tape across channel, looking U/S (#1827)*	
Long. Slope:	Estim. 1%±		
Other notes:	Second location upstream and beyond influence of C ST culvert; Downed log spanning channel immediate u/s of measurement location; small mid-channel sand/gravel bar		
		View looking across channel from rt bank (#1828)	

Notes: ACW – active channel width; D/S – downstream; U/S – upstream; Long. - longitudinal

Table 2. Active channel width data table – FC-02 located upstream of C Street.

Location ID:	**FC-02**	**Photo view:**	
Location:	Fox Creek – Upstream of C ST culvert	*Tape measurement value (#1831.jpg)*	
Observ. Date	03-09-2022 1210 HRS		
Distance from culvert (ft)	1,300 upstream (south)		
Measured ACW (ft)	23		
Primary Visual Indicators	Limit of scour/erosion on bench near channel		
Channel morphology	Riffle-run, glide		
Dominant bed substrate	Small to large gravels		
Bed substrate D50 (mm/in)	TBD	*Tape across channel, looking D/S (#1832)*	
Long. Slope:	Estim. 1%±		
Other notes:	**Third location upstream** and beyond influence of C ST culvert; Inset bench on rt bank; visible flood prone width outside of ACW visible in photo #1832;		
		View looking upstream from measurement location (#1835)	

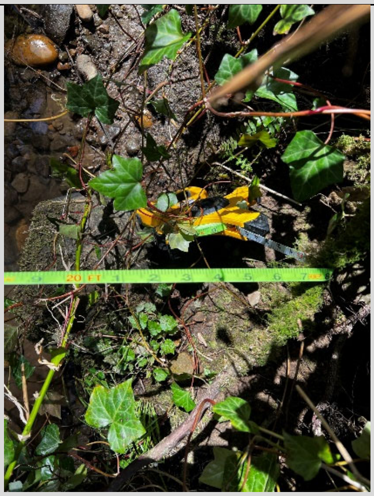
Notes: ACW – active channel width; D/S – downstream; U/S – upstream; Long. - longitudinal

Table 3. Active channel width data table – FC-03 located upstream of C Street.

Location ID:	**FC-03**	**Photo view:**	
Location:	Fox Creek – Upstream of C ST culvert	*Tape measurement value (#1841.jpg)*	
Observ. Date	03-09-2022 1220 HRS		
Distance from culvert (ft)	1,500 upstream (south)		
Measured ACW (ft)	18		
Primary Visual Indicators	Rt bank limit taken as edge of cobble & cut bank		
Channel morphology	Riffle-run		
Dominant bed substrate	Medium gravels to medium cobbles		
Bed substrate D50 (mm/in)	TBD	*Tape across channel, looking D/S (#1843)*	
Long. Slope:	Estim. 1%±		
Other notes:	**Upstream-most location**; adjacent to large terrace (field) west of stream; Narrow eroded bench with grass on rt bank & eroding vegetated lft bank		
		View looking upstream from measurement location (#1844)	

Notes: ACW – active channel width; D/S – downstream; U/S – upstream; Long. - longitudinal

Table 4. Active channel width data table – FC-04 located upstream of C Street.

Location ID:	**FC-04**	**Photo view:**	
Location:	Fox Creek – Upstream of C ST culvert	*Tape measurement value (#1841.jpg)*	
Observ. Date	03-09-2022 1230 HRS		
Distance from culvert (ft)	1,000 upstream (south)		
Measured ACW (ft)	20		
Primary Visual Indicators	Rt bank limit taken as edge of cobble & cut bank		
Channel morphology	Run-glide		
Dominant bed substrate	Small to large gravels		
Bed substrate D50 (mm/in)	TBD	*Tape across channel, looking D/S (#1847)*	
Long. Slope:	Estim. 1%±		
Other notes:	**Downstream -most location**; Extent on rt bank taken as limit of recent erosion/flow (see position of person in photo), not at narrower small cut next to channel		
		View looking upstream from measurement location (#1848)	

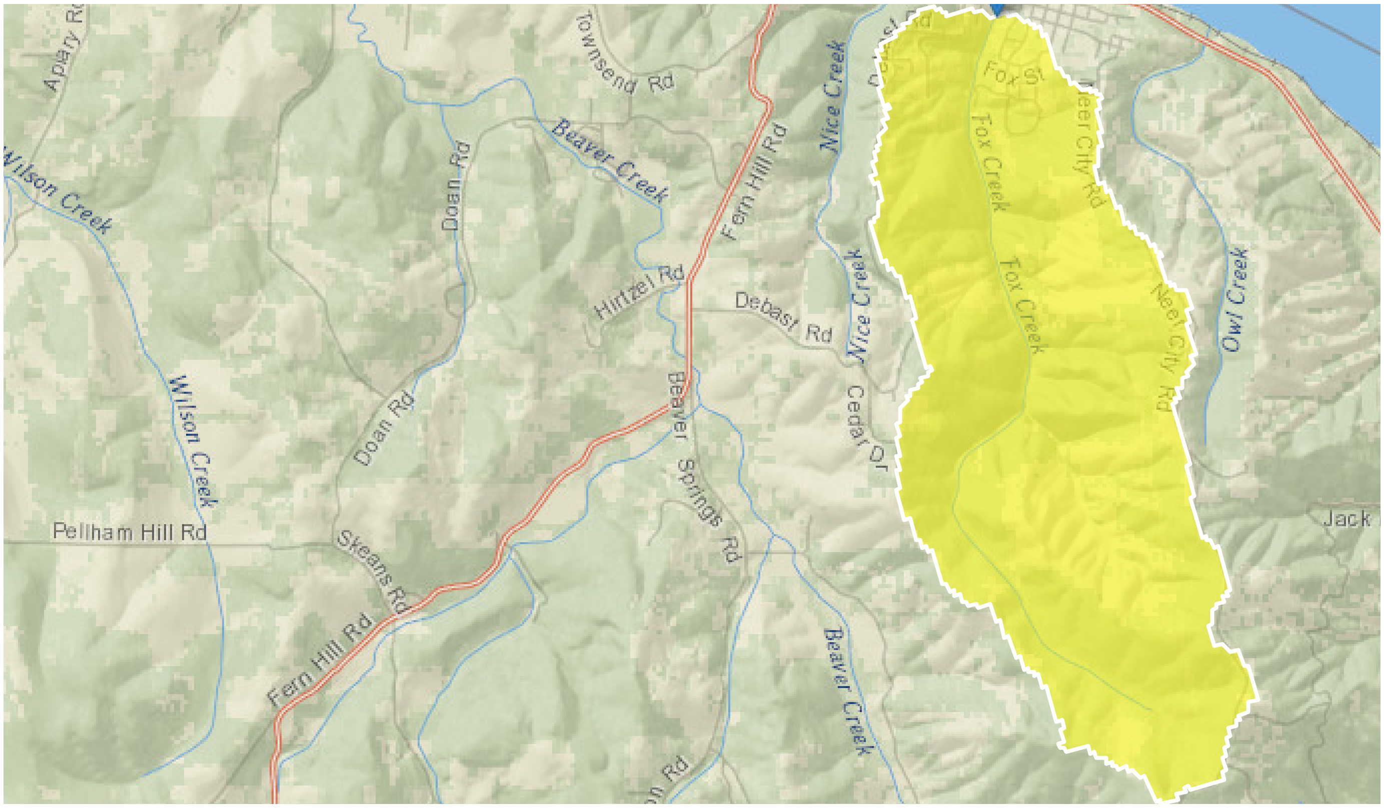
Notes: ACW – active channel width; D/S – downstream; U/S – upstream; Long. - longitudinal

Appendix C

USGS Streamstats Watershed and Flow Results

StreamStats Report

Region ID: OR
Workspace ID: OR20220914230233650000
Clicked Point (Latitude, Longitude): 46.08663, -122.93877
Time: 2022-09-14 16:02:57 -0700



⊞ Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
ASPECT	basin average of topographic slope compass directions from elevation grid	185	degrees
BSLOPD	Mean basin slope measured in degrees	11.7	degrees
DRNAREA	Area that drains to a point on a stream	3.09	square miles
DRNDENSITY	Basin drainage density defined as total stream length divided by drainage area.	0.69	dimensionless
ELEV	Mean Basin Elevation	653	feet

Parameter Code	Parameter Description	Value	Unit
ELEVMAX	Maximum basin elevation	1190	feet
FOREST	Percentage of area covered by forest	90.9	percent
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	2.1	inches
IMPERV	Percentage of impervious area	2.65	percent
JANAVPRE2K	Mean January Precipitation	9.08	inches
JANMAXT2K	Mean Maximum January Temperature from 2K resolution PRISM 1961-1990 data	44.3	degrees F
JANMAXTMP	Mean Maximum January Temperature	44.4	degrees F
JANMINT2K	Mean Minimum January Temperature from 2K resolution PRISM PRISM 1961-1990 data	31.2	degrees F
JANMINTMP	Mean Minimum January Temperature	31.4	degrees F
JULAVPRE2K	Mean July Average Precipitation	0.75	inches
LC11BARE	Percentage of barren from NLCD 2011 class 31	0	percent
LC11CRPHAY	Percentage of cultivated crops and hay, classes 81 and 82, from NLCD 2011	0	percent
LC11DEVHI	Percentage of area developed, high intensity, NLCD 2011 class 24	0	percent
LC11DVLO	Percentage of developed area, low intensity, from NLCD 2011 class 22	2	percent
LC11DVMD	Percentage of area developed, medium intensity, NLCD 2011 class 23	0	percent
LC11DVOPN	Percentage of developed open area from NLCD 2011 class 21	6	percent
LC11FORSHB	Percentage of forests and shrub lands, classes 41 to 52, from NLCD 2011	88	percent
LC11HERB	Percentage of herbaceous from NLCD 2011 classes 71-74	4	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	1.11	percent
LC11WATER	Percent of open water, class 11, from NLCD 2011	0	percent

Parameter Code	Parameter Description	Value	Unit
LC11WETLND	Percentage of wetlands, classes 90 and 95, from NLCD 2011	0	percent
MAJ_ROADS	Length of non-state major roads in basin	0	miles
MAXBSLOPD	Maximum basin slope, in degrees, using ArcInfo Grid with NHDPlus 30-m resolution elevation data.	30	degrees
MAXTEMP	Mean annual maximum air temperature over basin area from PRISM 1971-2000 800-m grid	60.3	degrees F
MIN_ROADS	Length of non-state minor roads in basin	5.67	miles
MINBELEV	Minimum basin elevation	19.7	feet
MINBSLOPD	Minimum basin slope, in degrees, using ArcInfo Grid with NHDPlus 30-m resolution elevation data.	0.21	degrees
MINTEMP	Mean annual minimum air temperature over basin surface area as defined in SIR 2008-5126	40.2	degrees F
OR_HIPERMA	Percent basin surface area containing high permeability aquifer units as defined in SIR 2008-5126	23.1	percent
OR_HIPERMG	Percent basin surface area containing high permeability geologic units as defined in SIR 2008-5126	0	percent
ORREG2	Oregon Region Number	10001	dimensionless
PRECIP	Mean Annual Precipitation	58.7	inches
RELIEF	Maximum - minimum elevation	1170	feet
SOILPERM	Average Soil Permeability	0.76	inches per hour
STATE_HWY	Length of state highways in basin	0	miles
STATSGODEP	Area-weighted average soil depth from NRCS STATSGO database	58.5	inches
STRMTOT	total length of all mapped streams (1:24,000-scale) in the basin	3.42	miles
WATCAPORC	Available water capacity from STATSGO data using methods from SIR 2005-5116	0.14	inches
WATCAPORR	Available water capacity from STATSGO data using methods from SIR 2008-5126	0.14	inch per inch

January Flow-Duration Statistics

January Flow-Duration Statistics Parameters [LowFlow Jan Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
IMPERV	Percent Impervious	2.65	percent	0	2.961
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

January Flow-Duration Statistics Disclaimers [LowFlow Jan Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

January Flow-Duration Statistics Flow Report [LowFlow Jan Region01 2008 5126]

Statistic	Value	Unit
January 5 Percent Duration	69.2	ft^3/s
January 10 Percent Duration	50.4	ft^3/s
January 25 Percent Duration	28	ft^3/s
January 50 Percent Duration	18.4	ft^3/s
January 95 Percent Duration	4.19	ft^3/s

January Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

December Flow-Duration Statistics

December Flow-Duration Statistics Parameters [LowFlow Dec Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482

December Flow-Duration Statistics Disclaimers [LowFlow Dec Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

December Flow-Duration Statistics Flow Report [LowFlow Dec Region01 2008 5126]

Statistic	Value	Unit
December 5 Percent Duration	52	ft^3/s
December 10 Percent Duration	42.9	ft^3/s
December 25 Percent Duration	31	ft^3/s
December 50 Percent Duration	16	ft^3/s
December 95 Percent Duration	2.38	ft^3/s

December Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

› November Flow-Duration Statistics

November Flow-Duration Statistics Parameters [LowFlow Nov Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482
MAXBSLOPD	Maximum Basin Slope in deg	30	degrees	34.073	68.78

November Flow-Duration Statistics Disclaimers [LowFlow Nov Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

November Flow-Duration Statistics Flow Report [LowFlow Nov Region01 2008 5126]

Statistic	Value	Unit
November 5 Percent Duration	37.4	ft^3/s
November 10 Percent Duration	26.9	ft^3/s
November 25 Percent Duration	12.4	ft^3/s
November 50 Percent Duration	4.82	ft^3/s
November 95 Percent Duration	2.4	ft^3/s

November Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

October Flow-Duration Statistics

October Flow-Duration Statistics Parameters [LowFlow Oct Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	219.691
ELEV	Mean Basin Elevation	653	feet	520.406	2101.874
PRECIP	Mean Annual Precipitation	58.7	inches	71.6651	143.4891

October Flow-Duration Statistics Disclaimers [LowFlow Oct Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

October Flow-Duration Statistics Flow Report [LowFlow Oct Region01 2008 5126]

Statistic	Value	Unit
October 5 Percent Duration	6.99	ft^3/s
October 10 Percent Duration	4.32	ft^3/s
October 25 Percent Duration	1.54	ft^3/s
October 50 Percent Duration	0.499	ft^3/s
October 95 Percent Duration	0.176	ft^3/s

October Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

September Flow-Duration Statistics

September Flow-Duration Statistics Parameters [LowFlow Sep Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	590.347

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
MINBELEV	Minimum Basin Elevation	19.7	feet	10.5648	1381.5307
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

September Flow-Duration Statistics Disclaimers [LowFlow Sep Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

September Flow-Duration Statistics Flow Report [LowFlow Sep Region01 2008 5126]

Statistic	Value	Unit
September 5 Percent Duration	2.29	ft^3/s
September 10 Percent Duration	1.59	ft^3/s
September 25 Percent Duration	0.98	ft^3/s
September 50 Percent Duration	0.391	ft^3/s
September 95 Percent Duration	0.157	ft^3/s

September Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

› August Flow-Duration Statistics

August Flow-Duration Statistics Parameters [LowFlow Aug Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
MINBELEV	Minimum Basin Elevation	19.7	feet	10.5648	1381.5307

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

August Flow-Duration Statistics Disclaimers [LowFlow Aug Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

August Flow-Duration Statistics Flow Report [LowFlow Aug Region01 2008 5126]

Statistic	Value	Unit
August 5 Percent Duration	1.66	ft^3/s
August 10 Percent Duration	0.842	ft^3/s
August 25 Percent Duration	0.671	ft^3/s
August 50 Percent Duration	0.528	ft^3/s
August 95 Percent Duration	0.224	ft^3/s

August Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

July Flow-Duration Statistics

July Flow-Duration Statistics Parameters [LowFlow Jul Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
WATCAPORR	Available_Water_Capacity_OR_Risley	0.14	inch per inch	0.12	0.23

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482

July Flow-Duration Statistics Disclaimers [LowFlow Jul Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

July Flow-Duration Statistics Flow Report [LowFlow Jul Region01 2008 5126]

Statistic	Value	Unit
July 5 Percent Duration	2.37	ft^3/s
July 10 Percent Duration	1.9	ft^3/s
July 25 Percent Duration	1.35	ft^3/s
July 50 Percent Duration	0.733	ft^3/s
July 95 Percent Duration	0.353	ft^3/s

July Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

› June Flow-Duration Statistics

June Flow-Duration Statistics Parameters [LowFlow Jun Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482
WATCAPORR	Available_Water_Capacity_OR_Risley	0.14	inch per inch	0.12	0.23

June Flow-Duration Statistics Disclaimers [LowFlow Jun Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

June Flow-Duration Statistics Flow Report [LowFlow Jun Region01 2008 5126]

Statistic	Value	Unit
June 5 Percent Duration	5.15	ft^3/s
June 10 Percent Duration	3.55	ft^3/s
June 25 Percent Duration	2.1	ft^3/s
June 50 Percent Duration	1.54	ft^3/s
June 95 Percent Duration	1.03	ft^3/s

June Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

May Flow-Duration Statistics

May Flow-Duration Statistics Parameters [LowFlow May Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	1.953	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482
WATCAPORR	Available_Water_Capacity_OR_Risley	0.14	inch per inch	0.12	0.23

May Flow-Duration Statistics Disclaimers [LowFlow May Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

May Flow-Duration Statistics Flow Report [LowFlow May Region01 2008 5126]

Statistic	Value	Unit
May 5 Percent Duration	8.45	ft^3/s
May 10 Percent Duration	6.82	ft^3/s
May 25 Percent Duration	4.63	ft^3/s
May 50 Percent Duration	3.15	ft^3/s
May 95 Percent Duration	1.88	ft^3/s

May Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

April Flow-Duration Statistics

April Flow-Duration Statistics Parameters [LowFlow Apr Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482

April Flow-Duration Statistics Disclaimers [LowFlow Apr Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

April Flow-Duration Statistics Flow Report [LowFlow Apr Region01 2008 5126]

Statistic	Value	Unit
April 5 Percent Duration	20.5	ft^3/s

Statistic	Value	Unit
April 10 Percent Duration	15.9	ft^3/s
April 25 Percent Duration	9.74	ft^3/s
April 50 Percent Duration	6.09	ft^3/s
April 95 Percent Duration	3.34	ft^3/s

April Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

› March Flow-Duration Statistics

March Flow-Duration Statistics Parameters [LowFlow Mar Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
IMPERV	Percent Impervious	2.65	percent	0	2.961
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482

March Flow-Duration Statistics Disclaimers [LowFlow Mar Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

March Flow-Duration Statistics Flow Report [LowFlow Mar Region01 2008 5126]

Statistic	Value	Unit
March 5 Percent Duration	30.5	ft^3/s
March 10 Percent Duration	25.5	ft^3/s
March 25 Percent Duration	18.3	ft^3/s

Statistic	Value	Unit
March 50 Percent Duration	11.1	ft^3/s
March 95 Percent Duration	4.5	ft^3/s

March Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

February Flow-Duration Statistics

February Flow-Duration Statistics Parameters [LowFlow Feb Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
IMPERV	Percent Impervious	2.65	percent	0	2.961
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906
BSLOPD	Mean Basin Slope degrees	11.7	degrees	10.382	25.482

February Flow-Duration Statistics Disclaimers [LowFlow Feb Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

February Flow-Duration Statistics Flow Report [LowFlow Feb Region01 2008 5126]

Statistic	Value	Unit
February 5 Percent Duration	39.4	ft^3/s
February 10 Percent Duration	34.4	ft^3/s
February 25 Percent Duration	22.9	ft^3/s
February 50 Percent Duration	15.8	ft^3/s
February 95 Percent Duration	5	ft^3/s

February Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

Flow-Duration Statistics

Flow-Duration Statistics Parameters [LowFlow Ann Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	590.347
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	122.9843
WATCAPORR	Available_Water_Capacity_OR_Risley	0.14	inch per inch	0.12	0.23

Flow-Duration Statistics Disclaimers [LowFlow Ann Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Flow-Duration Statistics Flow Report [LowFlow Ann Region01 2008 5126]

Statistic	Value	Unit
5 Percent Duration	41.2	ft^3/s
10 Percent Duration	27	ft^3/s
25 Percent Duration	11.8	ft^3/s
50 Percent Duration	3.82	ft^3/s
95 Percent Duration	0.37	ft^3/s

Flow-Duration Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological

Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Reg 2B Western Interior LT 3000 ft Cooper]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.37	7270
BSLOPD	Mean Basin Slope degrees	11.7	degrees	5.62	28.3
I24H2Y	24 Hour 2 Year Precipitation	2.1	inches	1.53	4.48
ELEV	Mean Basin Elevation	653	feet		
ORREG2	Oregon Region Number	10001	dimensionless		

Peak-Flow Statistics Flow Report [Reg 2B Western Interior LT 3000 ft Cooper]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	ASEp	Equiv. Yrs.
50-percent AEP flood	150	ft^3/s	88.5	254	32.6	32.6	2
20-percent AEP flood	223	ft^3/s	132	377	32.4	32.4	2.8
10-percent AEP flood	272	ft^3/s	160	463	33	33	3.6
4-percent AEP flood	335	ft^3/s	194	580	34.1	34.1	4.8
2-percent AEP flood	382	ft^3/s	217	672	35.1	35.1	5.5
1-percent AEP flood	428	ft^3/s	239	766	36.2	36.2	6.2
0.2-percent AEP flood	537	ft^3/s	288	1000	39.1	39.1	7.5

Peak-Flow Statistics Citations

Cooper, R.M.,2005, Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon: U.S. Geological Survey Scientific Investigations Report 2005-5116, 76 p. (http://pubs.usgs.gov/sir/2005/5116/pdf/sir2005-5116.pdf)

Low-Flow Statistics

Low-Flow Statistics Parameters [LowFlow Ann Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	590.347
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	122.9843
WATCAPORR	Available_Water_Capacity_OR_Risley	0.14	inch per inch	0.12	0.23

Low-Flow Statistics Disclaimers [LowFlow Ann Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Low-Flow Statistics Flow Report [LowFlow Ann Region01 2008 5126]

Statistic	Value	Unit
7 Day 2 Year Low Flow	0.327	ft^3/s
7 Day 10 Year Low Flow	0.204	ft^3/s

Low-Flow Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

> Monthly Flow Statistics

Monthly Flow Statistics Parameters [LowFlow Apr Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Aug Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
JANMINTMP	Mean Min January Temperature	31.4	degrees F	30.678	34.661
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Dec Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Feb Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Jan Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Jul Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
JANMINTMP	Mean Min January Temperature	31.4	degrees F	30.678	34.661
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Jun Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Mar Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow May Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	1.953	673.359
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Nov Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	673.359
ELEV	Mean Basin Elevation	653	feet	520.406	2101.874
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Parameters [LowFlow Oct Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	219.691
ELEV	Mean Basin Elevation	653	feet	520.406	2101.874
PRECIP	Mean Annual Precipitation	58.7	inches	71.6651	143.4891

Monthly Flow Statistics Parameters [LowFlow Sep Region01 2008 5126]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.367	590.347
PRECIP	Mean Annual Precipitation	58.7	inches	65.5923	151.2906

Monthly Flow Statistics Disclaimers [LowFlow Apr Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Apr Region01 2008 5126]

Statistic	Value	Unit
Apr 7 Day 2 Year Low Flow	4.99	ft^3/s
Apr 7 Day 10 Year Low Flow	2.9	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Aug Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Aug Region01 2008 5126]

Statistic	Value	Unit
Aug 7 Day 2 Year Low Flow	0.224	ft^3/s
Aug 7 Day 10 Year Low Flow	0.135	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Dec Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Dec Region01 2008 5126]

Statistic	Value	Unit
Dec 7 Day 2 Year Low Flow	7.91	ft^3/s
Dec 7 Day 10 Year Low Flow	2.41	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Feb Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Feb Region01 2008 5126]

Statistic	Value	Unit
Feb 7 Day 2 Year Low Flow	9.39	ft^3/s
Feb 7 Day 10 Year Low Flow	4.51	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Jan Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Jan Region01 2008 5126]

Statistic	Value	Unit

Statistic	Value	Unit
Jan 7 Day 2 Year Low Flow	10.5	ft^3/s
Jan 7 Day 10 Year Low Flow	4.85	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Jul Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Jul Region01 2008 5126]

Statistic	Value	Unit
Jul 7 Day 2 Year Low Flow	0.354	ft^3/s
Jul 7 Day 10 Year Low Flow	0.244	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Jun Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Jun Region01 2008 5126]

Statistic	Value	Unit
Jun 7 Day 2 Year Low Flow	1.5	ft^3/s
Jun 7 Day 10 Year Low Flow	1.03	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Mar Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Mar Region01 2008 5126]

Statistic	Value	Unit
Mar 7 Day 2 Year Low Flow	8.01	ft^3/s
Mar 7 Day 10 Year Low Flow	4.53	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow May Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow May Region01 2008 5126]

Statistic	Value	Unit
May 7 Day 2 Year Low Flow	3.38	ft^3/s
May 7 Day 10 Year Low Flow	2.44	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Nov Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Nov Region01 2008 5126]

Statistic	Value	Unit
Nov 7 Day 2 Year Low Flow	2.13	ft^3/s
Nov 7 Day 10 Year Low Flow	0.802	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Oct Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Oct Region01 2008 5126]

Statistic	Value	Unit
Oct 7 Day 2 Year Low Flow	0.28	ft^3/s
Oct 7 Day 10 Year Low Flow	0.146	ft^3/s

Monthly Flow Statistics Disclaimers [LowFlow Sep Region01 2008 5126]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [LowFlow Sep Region01 2008 5126]

Statistic	Value	Unit

Statistic	Value	Unit
Sep 7 Day 2 Year Low Flow	0.304	ft^3/s
Sep 7 Day 10 Year Low Flow	0.164	ft^3/s

Monthly Flow Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Apr 7 Day 2 Year Low Flow	4.99	ft^3/s
Apr 7 Day 10 Year Low Flow	2.9	ft^3/s
Aug 7 Day 2 Year Low Flow	0.224	ft^3/s
Aug 7 Day 10 Year Low Flow	0.135	ft^3/s
Dec 7 Day 2 Year Low Flow	7.91	ft^3/s
Dec 7 Day 10 Year Low Flow	2.41	ft^3/s
Feb 7 Day 2 Year Low Flow	9.39	ft^3/s
Feb 7 Day 10 Year Low Flow	4.51	ft^3/s
Jan 7 Day 2 Year Low Flow	10.5	ft^3/s
Jan 7 Day 10 Year Low Flow	4.85	ft^3/s
Jul 7 Day 2 Year Low Flow	0.354	ft^3/s
Jul 7 Day 10 Year Low Flow	0.244	ft^3/s
Jun 7 Day 2 Year Low Flow	1.5	ft^3/s
Jun 7 Day 10 Year Low Flow	1.03	ft^3/s
Mar 7 Day 2 Year Low Flow	8.01	ft^3/s
Mar 7 Day 10 Year Low Flow	4.53	ft^3/s
May 7 Day 2 Year Low Flow	3.38	ft^3/s
May 7 Day 10 Year Low Flow	2.44	ft^3/s
Nov 7 Day 2 Year Low Flow	2.13	ft^3/s
Nov 7 Day 10 Year Low Flow	0.802	ft^3/s
Oct 7 Day 2 Year Low Flow	0.28	ft^3/s
Oct 7 Day 10 Year Low Flow	0.146	ft^3/s
Sep 7 Day 2 Year Low Flow	0.304	ft^3/s
Sep 7 Day 10 Year Low Flow	0.164	ft^3/s

Monthly Flow Statistics Citations

Risley, John, Stonewall, Adam, and Haluska, Tana,2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p. (http://pubs.usgs.gov/sir/2008/5126/)

Bankfull Statistics

Bankfull Statistics Parameters [Pacific Mountain System D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	6.1776	8079.9147

Bankfull Statistics Parameters [Pacific Border P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	6.169878	3938.976756

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	0.07722	59927.7393

Bankfull Statistics Parameters [Pac Maritime Mtn CastroJackson 2001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.09	square miles	54.8	3093

Bankfull Statistics Disclaimers [Pacific Mountain System D Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Pacific Mountain System D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	20.8	ft
Bieger_D_channel_depth	1.39	ft
Bieger_D_channel_cross_sectional_area	36.3	ft^2

Bankfull Statistics Disclaimers [Pacific Border P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Pacific Border P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	18	ft
Bieger_P_channel_cross_sectional_area	33.4	ft^2
Bieger_P_channel_depth	1.37	ft

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	18.4	ft
Bieger_USA_channel_depth	1.53	ft
Bieger_USA_channel_cross_sectional_area	31.4	ft^2

Bankfull Statistics Disclaimers [Pac Maritime Mtn CastroJackson 2001]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Pac Maritime Mtn CastroJackson 2001]

Statistic	Value	Unit
Bankfull Width	20.1	ft
Bankfull Depth	1.02	ft
Bankfull Area	32.8	ft^2
Bankfull Streamflow	194	ft^3/s

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bieger_D_channel_width	20.8	ft
Bieger_D_channel_depth	1.39	ft

Statistic	Value	Unit
Bieger_D_channel_cross_sectional_area	36.3	ft^2
Bieger_P_channel_width	18	ft
Bieger_P_channel_cross_sectional_area	33.4	ft^2
Bieger_P_channel_depth	1.37	ft
Bieger_USA_channel_width	18.4	ft
Bieger_USA_channel_depth	1.53	ft
Bieger_USA_channel_cross_sectional_area	31.4	ft^2
Bankfull Width	20.1	ft
Bankfull Depth	1.02	ft
Bankfull Area	32.8	ft^2
Bankfull Streamflow	194	ft^3/s

Bankfull Statistics Citations

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_

Castro, J.M, and Jackson, P.L.Castro, J.M, and Jackson, P.L., 2001, Bankfull Discharge Recurrence Intervals and Regional Hydraulic Geometery Relationships: Patterns in the Pacific Northwest, USA, Journal of the American Water Resources Association, Volume 37, No. 5, 14 p. (https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-1688.2001.tb03636.x)

Application Version: 4.10.1
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

Appendix D

Hydraulic Analysis Results

Feasibility Level Mannings Culvert/Channel Hydraulics

Project : Fox Creek Culvert
Date: 9/15/2022
Staff: RCC
QC: CJL

Statistic	Limiting Species/Lifestage	Discharge (CFS)	Discharge (Mannings computed)	Difference	Mannings Roughness	Depth (ft)	Depth (ft) (varied)	Depth Criteria	Velocity (ft/s)	Velocity Criteria
100 year flood	-	429	429	0.0	0.035	6.9	6.9	-	6.3	-
2 year flood	-	150	150	0.0	0.035	4.1	4.1	-	4.1	-
5% Continuous Exceedance Probability	Adult Salmonids	42	42	0.0	0.08	3.3	3.3	1.0 ft	1.5	<2 ft/s*
50% Continuous Exceedance Probability	Juvenile Salmonids	3.9	3.9	0.0	0.08	1.6	1.6	0.5 ft	0.5	<1 ft/s
95% Continuous Exceedance Probability	Adults & Juveniles	1	1	0.0	0.08	1.2	1.2	0.5 ft	0.3	<1 ft/s
			Sum	0.00	set sum to zero to solve all simultaneously					

Input Parameters	
Culvert/Channel Width (ft)	15
Inset Channel Depth (ft)	1
Inset Channel Width (ft)	1.5
Inset Ch Side Slopes (H:V)	1
Inset channel slope	0.0025
Streambed Roughness	0.035
Moderate Flow Roughness	0.08
Inset Channel Roughness	0.08
Outlet Elevation (ft)	12.3
Inlet Elevation (ft)	15.3
Culvert/Reach length (ft)	600
Slope	0.005

Input parameters entered at left are passed to Mannings Computations sheets for each flow.

"Discharge (Mannings Computed)" column above is calculated in each sheet using the "Depth (ft) (varied)" column above and other entered values.

Computed discharge above is subtracted from design discharge and the sum of differences is set to zero with Excelss solver function to compute expected depth in the culvert/channel section for each flow.

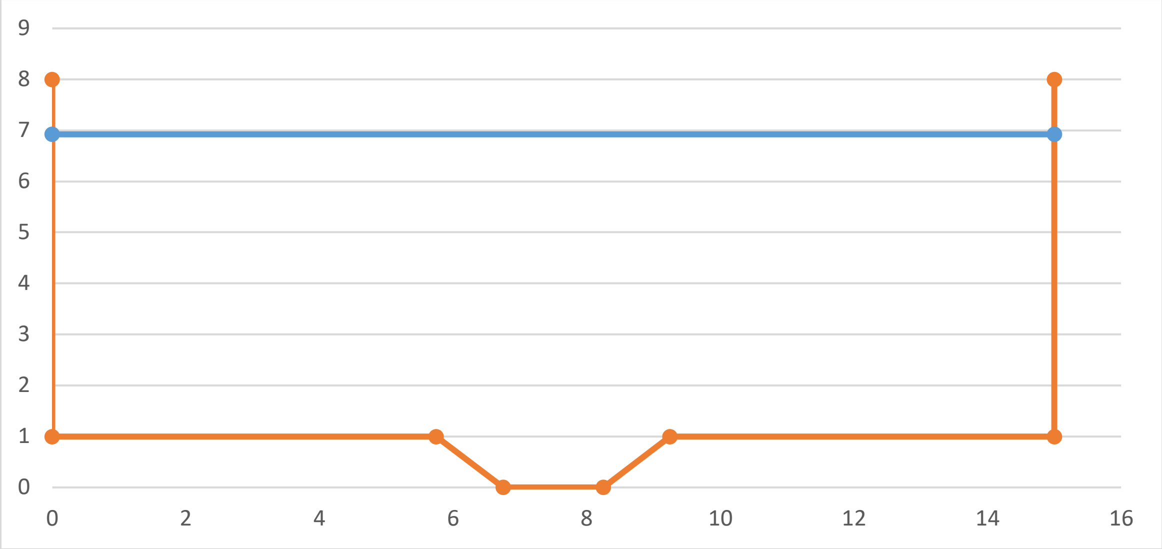
Color Code
Entered Value
Computed Intermediate
Meets Criteria
Does Not Meet Criteria
Complex Criteria Evaluation

Project : Fox Creek Culvert
Date: 9/15/2022
Staff: RCC
QC: CJL
Flow: Q100

Location	Station (ft)	Elevation (ft NAVD88)	Wetted Perimeter (ft)	Sectional Area (ft^2)
1	0	8		0
2	0	1	6.38	8.51
3	5.75	1	3.58	18.51
4	6.75	0	1.46	6.06
5	8.25	0	1.46	6.92
6	9.25	1	3.58	11.47
7	15	1	6.38	17.03
8	15	8	0	0

Manning's Parameters

Depth (ft)	6.92
average slope	0.005
k	1.49
n (selected)	0.035
WP (ft)	22.8
Sectional Area (ft^2)	68.5
Hydraulic Radius (ft)	3.0
Discharge (CFS)	429
Velocity (ft/s)	6.3



Manning's Equation:

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

Under the assumption of uniform flow conditions the bottom slope is the same as the slope of the energy grade line and the water surface slope. The Manning's n is a coefficient which represents the roughness or friction applied to the flow by the channel. Manning's n-values are often selected from tables, but can be back calculated from field measurements. In many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results.

Project : Fox Creek Culvert
Date: 9/15/2022
Staff: RCC
QC: CJL
Flow: Q2

Location	Station (ft)	Elevation (ft NAVD88)	Wetted Perimeter (ft)	Sectional Area (ft^2)
1	0	8		0
2	0	1	6.38	4.42
3	5.75	1	3.58	9.61
4	6.75	0	1.46	3.57
5	8.25	0	1.46	4.07
6	9.25	1	3.58	5.96
7	15	1	6.38	8.84
8	15	8	0	0

Manning's Parameters

Depth (ft)	4.07
average slope	0.005
k	1.49
n (selected)	0.035
WP (ft)	22.8
Sectional Area (ft^2)	36.5
Hydraulic Radius (ft)	1.6
Discharge (CFS)	150
Velocity (ft/s)	4.1

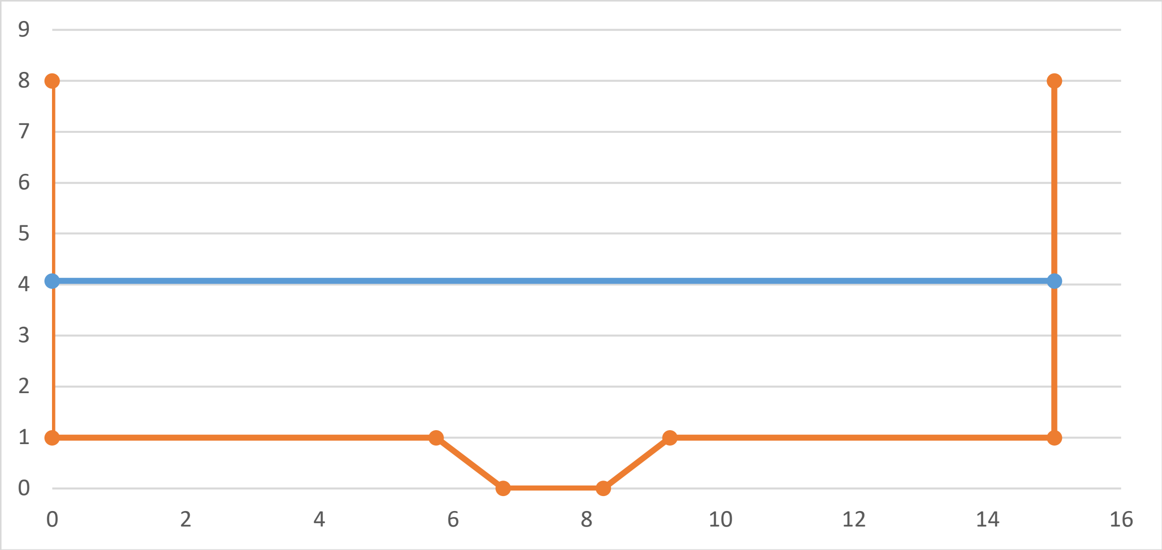
Manning's Equation:

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)



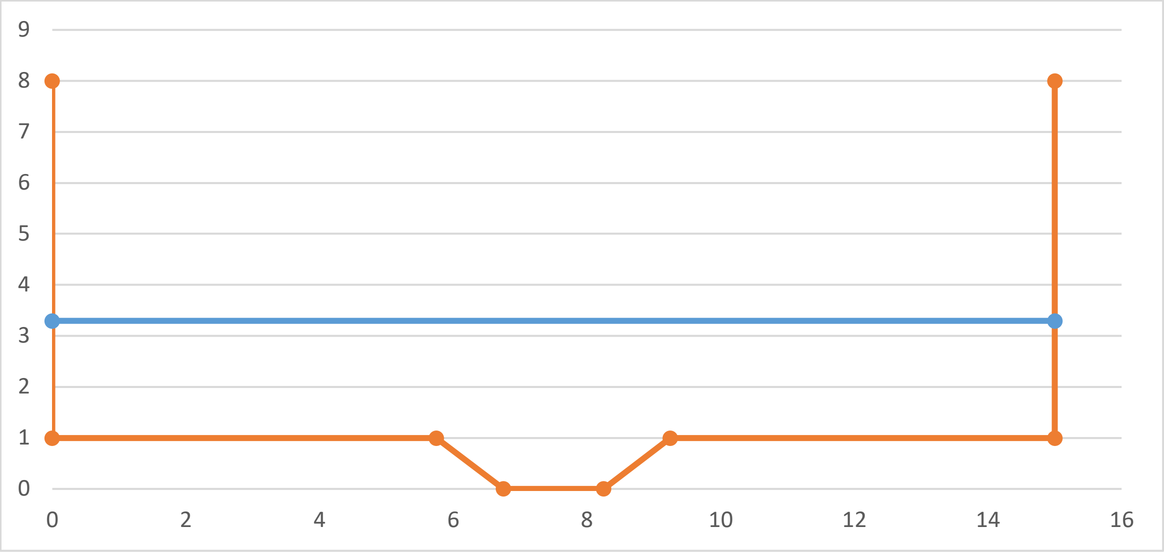
Under the assumption of uniform flow conditions the bottom slope is the same as the slope of the energy grade line and the water surface slope. The Manning's n is a coefficient which represents the roughness or friction applied to the flow by the channel. Manning's n-values are often selected from tables, but can be back calculated from field measurements. In many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results.

Project : Fox Creek Culvert
Date: 9/15/2022
Staff: RCC
QC: CJL
Flow: 5% Exceedance

Location	Station (ft)	Elevation (ft NAVD88)	Wetted Perimeter (ft)	Sectional Area (ft^2)
1	0	8		0
2	0	1	6.38	3.30
3	5.75	1	3.58	7.17
4	6.75	0	1.46	2.88
5	8.25	0	1.46	3.30
6	9.25	1	3.58	4.45
7	15	1	6.38	6.60
8	15	8	0	0

Manning's Parameters

Depth (ft)	3.30
average slope	0.005
k	1.49
n (selected)	0.08
WP (ft)	22.8
Sectional Area (ft^2)	27.7
Hydraulic Radius (ft)	1.2
Discharge (CFS)	42
Velocity (ft/s)	1.5



Manning's Equation:

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

Under the assumption of uniform flow conditions the bottom slope is the same as the slope of the energy grade line and the water surface slope. The Manning's n is a coefficient which represents the roughness or friction applied to the flow by the channel. Manning's n-values are often selected from tables, but can be back calculated from field measurements. In many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results.

Project : Fox Creek Culvert
Date: 9/15/2022
Staff: RCC
QC: CJL
Flow: 50% Exceedance

Location	**Station (ft)**	**Elevation (ft NAVD88)**	**Wetted Perimeter (ft)**	**Sectional Area (ft^2)**
1	0	8		0
2	0	1	6.38	0.81
3	5.75	1	3.58	1.75
4	6.75	0	1.46	1.37
5	8.25	0	1.46	1.56
6	9.25	1	3.58	1.09
7	15	1	6.38	1.61
8	15	8	0	0

Manning's Parameters

Depth (ft)	1.56
average slope	0.0025
k	1.49
n (selected)	0.08
WP (ft)	22.8
Sectional Area (ft^2)	8.2
Hydraulic Radius (ft)	0.4
Discharge (CFS)	4
Velocity (ft/s)	0.5

Manning's Equation:

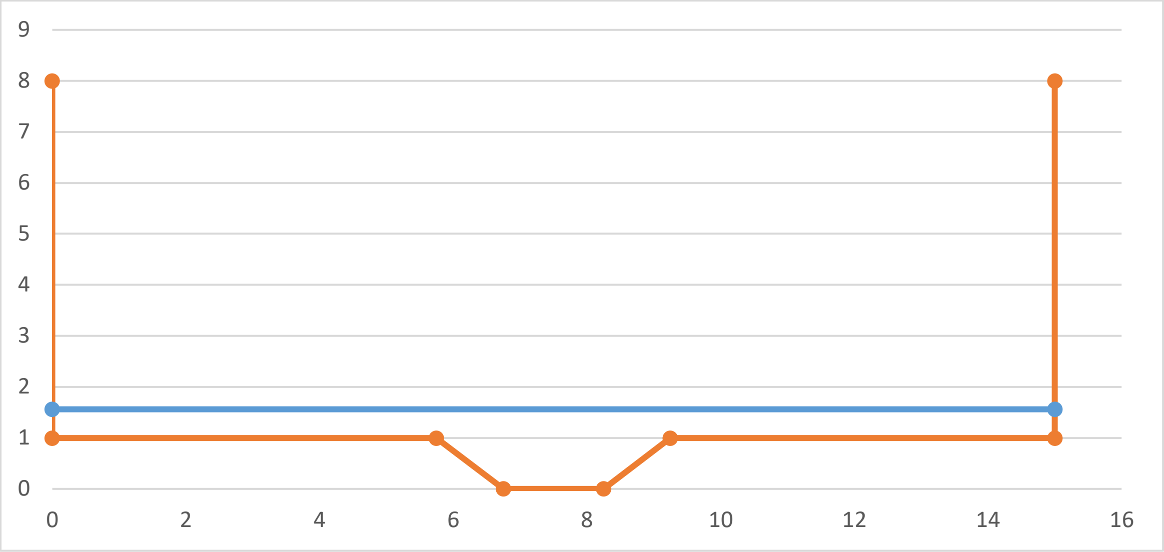
$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

Under the assumption of uniform flow conditions the bottom slope is the same as the slope of the energy grade line and the water surface slope. The Manning's n is a coefficient which represents the roughness or friction applied to the flow by the channel. Manning's n-values are often selected from tables, but can be back calculated from field measurements. In many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results.



Project : Fox Creek Culvert
Date: 9/15/2022
Staff: RCC
QC: CJL
Flow: 95% Exceedance

Location	Station (ft)	Elevation (ft NAVD88)	Wetted Perimeter (ft)	Sectional Area (ft^2)
1	0	8		0
2	0	1	6.38	0.23
3	5.75	1	3.58	0.49
4	6.75	0	1.46	1.01
5	8.25	0	1.46	1.16
6	9.25	1	3.58	0.31
7	15	1	6.38	0.45
8	15	8	0	0

Manning's Parameters

Depth (ft)	1.16
average slope	0.0025
k	1.49
n (selected)	0.08
WP (ft)	22.8
Sectional Area (ft^2)	3.6
Hydraulic Radius (ft)	0.2
Discharge (CFS)	1
Velocity (ft/s)	0.3

Manning's Equation:

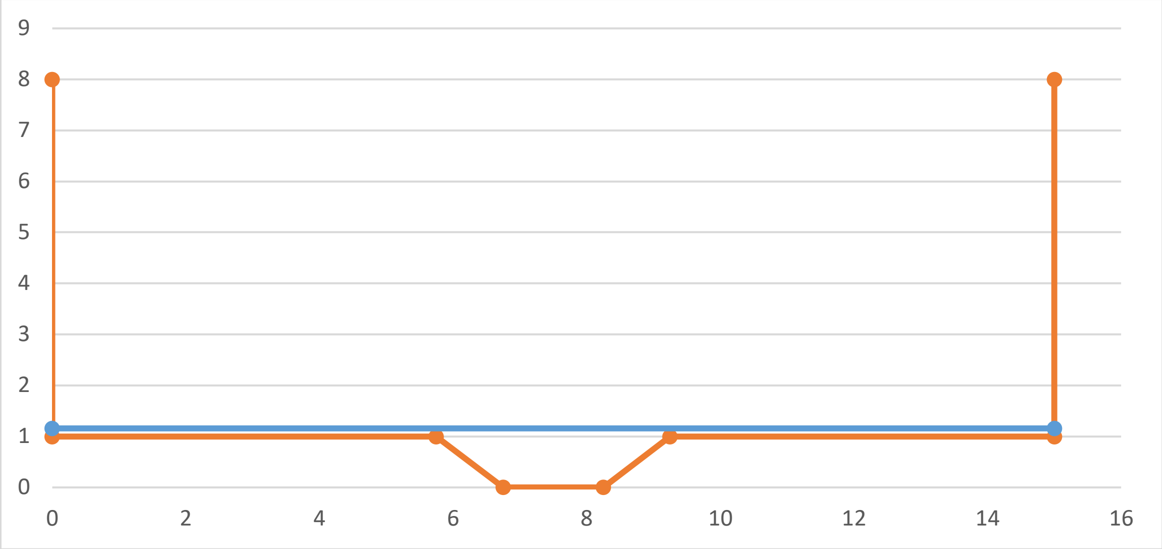
$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [SI]$$

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)
n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

Under the assumption of uniform flow conditions the bottom slope is the same as the slope of the energy grade line and the water surface slope. The Manning's n is a coefficient which represents the roughness or friction applied to the flow by the channel. Manning's n-values are often selected from tables, but can be back calculated from field measurements. In many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results.



Appendix E

Fox Creek Cost Estimate

	Alternative 1A Construction Cost				
Item	Description	Qty	Unit	Unit Cost	Total
1	Mobilization	15%	LS	$ 456,000.00	$456,000
2	Clearing and Grubbing	1	LS	$ 3,500.00	$3,500
3	Excavation	12,000	CY	$ 50.00	$600,000
4	Backfill	420	CY	$ 70.00	$29,400
5	Demolition	1	LS	$ 70,000.00	$70,000
6	Shoring	15,000	SF	$ 40.00	$600,000
7	Subgrade/Foundation Stabilization	1,500	CY	$ 100.00	$150,000
8	Stream Diversion	1	LS	$ 90,000.00	$90,000
9	Utility Relocation	1	LS	$ 20,000.00	$20,000
10	Surface Restoration/ Improvements	1	LS	$ 15,000.00	$15,000
11	Ecoblocks	2,500	EA	$ 95.00	$237,500
12	Precast Box Culvert	320	LF	$ 3,000.00	$960,000
13	Stream Bed Material	1	LS	$ 163,600.00	$163,600
14	Transition piece to ex. ODOT culvert	100	CY	$ 350.00	$35,000
15	Dewatering	90	Day	$ 158.00	$14,300
16	Asphalt Paving	200	SY	$ 30.00	$6,000
17	Traffic Control	90	Day	$ 500.00	$45,000
	Subtotal				**$3,495,300**
	Plus: General Conditions	12%			$419,436
	Plus: Contractor Overhead and Profit	15%			$524,000
	Plus: Escalation to Mid-Point of Construction	20%			$699,000
				Sub-Total	**$5,137,736**
	Contingency	40%			$1,398,000
	Total Construction Cost (Rounded)				**$6,540,000**

Alternative 1B Construction Cost

Item	Description	Qty	Unit	Unit Cost	Total
1	Mobilization	15%	LS	$ 617,000.00	$617,000
2	Clearing and Grubbing	1	LS	$ 3,500.00	$3,500
3	Excavation	8,500	CY	$ 50.00	$425,000
4	Backfill	550	LCY	$ 70.00	$38,500
5	Demolition	1	LS	$ 70,000.00	$70,000
6	Shoring	25,000	SF	$ 40.00	$1,000,000
7	Subgrade/Foundation Stabilization	2,800	CY	$ 100.00	$280,000
7	Stream Diversion	1	LS	$ 90,000.00	$90,000
8	Utility Relocation	1	LS	$ 20,000.00	$20,000
9	Surface Restoration/Improvements	1	LS	$ 15,000.00	$15,000
10	Precast Box Culvert	600	LF	$ 3,000.00	$1,800,000
11	Stream Bed Material	1	LS	$ 275,500.00	$275,500
12	Transition piece to Existing ODOT culvert	100	CY	$ 350.00	$35,000
13	Dewatering	80	Day	$ 158.00	$12,700
14	Asphalt Concrete	200	SY	$ 30.00	$6,000
15	Traffic Control	90	Day	$ 500.00	$45,000
	Subtotal				**$4,733,200**
	Plus: General Conditions		12%		$567,984
	Plus: Contractor Overhead and Profit		15%		$710,000
	Plus: Escalation to Mid-Point of Construction		20%		$947,000
				Sub-Total	**$6,958,184**
	Contingency		40%		$227,000
	Total Construction Cost (Rounded)				**$7,190,000**

	Alternative 2A Construction Cost				
Item	Description	Qty	Unit	Unit Cost	Total
1	Mobilization	15%	LS	$ 525,000	$525,000
2	Clearing and Grubbing	1	LS	$ 3,500.00	$3,500
3	Excavation	16,000	CY	$ 50	$800,000
4	Backfill	450	LCY	$ 70	$31,500
5	Demolition	1	LS	$ 70,000.00	$70,000
6	Shoring	15,000	SF	$ 40	$600,000
7	Subgrade/Foundation Stabilization	2,800	CY	$ 100.00	$280,000
7	Stream Diversion	1	LS	$ 90,000	$90,000
8	Utility Relocation	1	LS	$ 20,000	$20,000
9	Surface Restoration / Improvements	1	LS	$ 15,000	$15,000
10	Precast CMP Culvert	320	LF	$ 3,360	$1,075,200
11	Ecoblocks	2,500	EA	$ 95	$237,500
12	Stream Bed Material	1	LS	$ 175,600	$175,600
13	Transition Piece to Existing ODOT Culvert	100	CY	$ 350	$35,000
14	Dewatering	90	Day	$ 158	$14,300
15	Asphalt Concrete	200	SY	$ 30	$6,000
16	Traffic Control	90	Day	$ 500	$45,000
	Subtotal				**$4,023,600**
	Plus: General Conditions	12%			$482,832
	Plus: Contractor Overhead and Profit	15%			$604,000
	Plus: Escalation to Mid-Point of Construction	20%			$805,000
				Sub-Total	**$5,915,432**
	Contingency	40%			$1,609,000
	Total Construction Cost (Rounded)				**$7,530,000**

	Alternative 2B Construction Cost				
Item	Description	Qty	Unit	Unit Cost	Total
1	Mobilization	15%	LS	$ 771,000	$771,000
2	Clearing and Grubbing	1	LS	$ 3,500.00	$3,500
3	Excavation	15,000	CY	$ 50	$750,000
4	Backfill	350	LCY	$ 70	$24,500
5	Demolition	1	LS	$ 70,000.00	$70,000
6	Shoring	25,000	SF	$ 40	$1,000,000
7	Subgrade/Foundation Stabilization	5,500	CY	$ 100.00	$550,000
7	Stream Diversion	1	LS	$ 90,000	$90,000
8	Utility Relocation	1	LS	$ 20,000	$20,000
9	Surface Restoration/Improvements	1	LS	$ 15,000	$15,000
10	Precast CMP Culvert	600	LF	$ 3,360	$2,016,000
11	Stream Bed Material	1	LS	$ 499,500	$499,500
12	Transition Pieceto Existing ODOT Culvert	100	CY	$ 350	$35,000
13	Dewatering	90	Day	$ 158	$14,300
14	Asphalt Concrete	200	SY	$ 30	$6,000
15	Traffic Control	90	Day	$ 500.00	$45,000
	Subtotal				**$5,909,800**
	Plus: General Conditions		12%		$709,176
	Plus: Contractor Overhead and Profit		15%		$886,000
	Plus: Escalation to Mid-Point of Construction		20%		$1,182,000
				Sub-Total	**$8,686,976**
	Contingency		40%		$284,000
	Total Construction Cost (Rounded)				**$8,980,000**

Alternative 3 Construction Cost

Item	Description	Qty	Unit	Unit Cost	Total
1	Mobilization	15%	LS	$ 473,000	$473,000
2	Clearing and Grubbing	1	LS	$ 3,500.00	$3,500
3	Excavation	20,000	CY	$ 50	$1,000,000
4	Backfill	450	LCY	$ 70	$31,500
5	Demolition	1	LS	$ 70,000.00	$70,000
6	Shoring	10,000	SF	$ 40	$400,000
7	Subgrade/Foundation Stabilization	1,800	CY	$ 100.00	$180,000
8	Stream Diversion	1	LS	$ 80,000	$80,000
9	Utility Relocation	1	LS	$ 20,000	$20,000
10	Surface Restoration / Improvements	1	LS	$ 15,000	$15,000
11	Precast CMP Culvert	200	LF	$ 3,360	$672,000
12	Ecoblocks	4,200	EA	$ 95	$399,000
13	Stream Bed Material	1	LS	$ 199,000	$199,000
14	Transition Piece to Existing ODOT Culvert	100	CY	$ 350	$35,000
15	Dewatering	90	Day	$ 158	$14,300
16	Asphalt Concrete	200	SY	$ 30	$6,000
17	Traffic Control	60	Day	$ 500	$30,000
	Subtotal				**$3,628,300**
	Plus: General Conditions	12%			$435,396
	Plus: Contractor Overhead and Profit	15%			$544,000
	Plus: Escalation to Mid-Point of Construction	20%			$726,000
				Sub-Total	**$5,333,696**
	Contingency	40%			$1,451,000
	Total Construction Cost (Rounded)				**$6,790,000**