Risk Assessment

SR 527 MP 2.76 Queensborough Creek (WDFW ID): 993084 Final Hydraulic Design Report

Background

The Washington State Department of Transportation (WSDOT) is proposing a project to provide fish passage at the State Route 527 (SR 527) crossing of Queensborough Creek at milepost (MP) 2.76. The existing culvert has been identified as a fish barrier and will be replaced by a 30-foot-wide bottomless culvert designed using the Stream Simulation methodology.

Purpose

Based on 2-dimensional modelling and other analyses completed during design development, it has been determined that certain elements of the design, Type I Streambed Sediment and mobile woody material (MWM), are unstable during the design flood. Because of this instability, and associated potential risks to existing and proposed habitat and infrastructure, a risk assessment is provided here, per the following guidance document requirements:

- Per the WSDOT *Hydraulics Manual* (2022) 7-4.8.2, because the D_{84} of existing streambed pebble count data is **not** stable at the 100-year event (i.e., design flood) a risk assessment is required.
- Per the WSDOT *Hydraulics Manual* (2022) 10-8.1, if mobile wood is provided in the design, a risk assessment should be provided that shall evaluate downstream infrastructure or constraints.

Guidance Documents

The following is a list of references used to prepare this assessment:

- WSDOT *Hydraulics Manual* (2022),
- US Bureau of Reclamation (USBR; 2014)

Methodology

Following the guidance provided in the WSDOT *Hydraulics Manual* (2022), the risk assessment will first define and identify constraints (infrastructure or features that warrant protection), and then discuss potential impacts to those constraints under natural processes associated with sediment and woody material transport. Finally, a criticality matrix is used to assess the level of risk, and associated risk mitigation is discussed.

The risk assessment is supplemented by guidance from the USBR *Risk-Based Design Guidelines* (2014); particularly the property damage risk matrix.

Constraint Definition and Identification

Constraints are defined in the *Hydraulics Manual* (WSDOT 2022) as infrastructure or land ownership issues that interfere with natural stream processes, and generally include (1) infrastructure, (2) environmental impacts, (3) grade separation, and (4) cultural resources.

1. Infrastructure including culverts, bridges, pipelines, buildings, water intakes, groundwater wells, and roadways are evaluated as part of this risk assessment, as appropriate.
2. Biological goals are considered as part of the stream design. Therefore, environmental impacts of the Project are evaluated as part of this risk assessment.
3. Grade separation at existing culverts is a constraint that has already been evaluated. Vertical stability of the Queensborough Creek longitudinal profile was assessed in Appendix R and potential for long-term degradation was analyzed in Appendix K.1. The results indicate a low probability of channel instability, and associated grade separation constraints are thus disregarded.

4. AECOM recommends that WSDOT, WDFW, and tribes continue to coordinate on potential impacts to cultural resources. They are currently no known cultural resources with the proposed site limits associated with the Queensborough Creek crossing design at I-405 MP 26.90.

Potential Impacts

The potential impacts to constraints described above include the following:

- Collisions
  - Between mobilized sediment and infrastructure
  - Between mobilized woody material and infrastructure
- Erosion
  - Erosion of finish grade may cause over-steepened and bank instability
  - Scour or undercutting of structural elements
- Deposition
  - In the form of log jams or LWM racking,
  - In the form of sediment aggradation,
  - All deposition has the potential to obstruct active flow area and increase flooding.

Criticality Matrix

A criticality matrix categorizes the risk probability and impact significance to qualitatively determine the risk for a given constraint as “low”, “medium”, or “high”. Each constraint identified in this risk assessment uses the criticality matrix shown in Figure 1.

		Impact			
		Minor	Moderate	Major	Extreme
Risk	Unlikely	Low	Low	Medium	Medium
	Moderate	Low	Medium	Medium	High
	Likely	Medium	Medium	High	High
	Very likely	Medium	High	High	High

Table 1. Criticality Matrix. Risk is the probability of an effect on a constraint. Impact is the level of effect that damage to the constraint would have.

Figure 1. Criticality matrix as presented in the WSDOT *Hydraulics Manual* (2022)

Results

The proposed project also includes the replacement of another fish passage barrier, just 750 feet upstream at Interstate 405 (I-405) MP 26.90. The hydraulic modelling analysis and risk assessment considers both fish passage improvements. Therefore, all areas of Queensborough Creek downstream of the I-405 crossing evaluated as part of this risk assessment are referred to as the "potentially affected area." The potentially affected area starts at the most upstream Project regrade limit at I-405 and extends downstream along Queensborough Creek to its confluence with North Creek. The proposed design increases the flow capacity of the crossing sufficiently that backwater effects and areas further upstream of the regrade limits may be disregarded.

The potentially affected area includes the **channel** – defined as the channel and adjacent lands necessary to discharge the base flood (2-year) – and the **floodplain** – defined as the 100-year water surface elevation extents. Because the affected area does not have any Special Flood Hazard Areas as determined by FEMA Flood Insurance Rate Maps (FIRMs), the floodplain for Queensborough Creek is identified using the FHD hydraulic model.

The potentially affected area for this risk assessment is further broken down into the following sections along Queensborough Creek (see Figure 2):

- Reach A – includes all areas within the Project creek grading limits and between the two crossings at I-405 and SR 527, extending approximately 120 feet upstream of the I-405 crossing and 170 feet downstream of the SR 527 crossing.
  - Inside the Project limits, the proposed creek design is coordinated with the stormwater, utilities, roadway, drainage and structural design disciplines (and their associated proposed design elements). All existing conditions inside the Project limits are, therefore, disregarded, and proposed conditions are evaluated instead.
  - In areas outside of the Project limits, existing conditions are evaluated.
- Reach B – includes all areas between the SR 527 crossing downstream grading limit and the existing culvert outlet at 17th Avenue.
  - In areas outside of the Project limits, existing conditions are evaluated.
- Reach C – includes all areas from the 17th Avenue culvert outlet to the confluence of Queensborough and North Creek.
  - In areas outside of the Project limits, existing conditions are evaluated.

Reach A

Transport of undersized streambed sediment has the potential to result in the following risks within Reach A:

- Within the fish passage structure and wingwall extents, the lowered streambed could result in undercutting and/or erosion of structure walls and wingwalls, potentially resulting in structure instability.
- Outside of the fish passage structure extents, the lowered streambed could result in over-steepened creek banks, potentially leading to additional erosion and bank instability, loss of riparian habitat, and undercutting of drainage outfalls.
- Depending on the geometry associated with the reorganized streambed material during and after transport, fish passage barriers could develop during low flow periods.

Transport of MWM has the potential to result in the following risks within Reach A:

- During large flow events, MWM in Reach A has the potential to collide with fish passage structure walls, wingwalls, and drainage outfalls, however, the likelihood of this is low due to the large structure width and design coordination with the drainage design team.
- If all mobile woody material is transported out of Reach A, it could negative impact the habitat complexity associated with the restored creek.
- MWM has the potential to rack against meander bars and LWM structures, which can obstruct and redirect flow, potentially increasing flood risk. This risk was considered and mitigated during the stream crossing design process. LWM is strategically placed to minimize local scour interactions with structures and wing-walls. Inside the structure, meander bars have been designed to prevent entrainment near the soldier pile walls.

The likelihood and level of impact for the potential risks above were determined and are summarized in Table 1, along with associated criticality rating and overall risk rating for Reach A.

Reach B

Transport of undersized streambed sediment from Reach A has the potential to result in the following risks within Reach B:

- Undersized material transported from upstream has the potential to deposit in downstream reaches and culverts, reducing the channel or culvert capacity and increasing flood risk adjacent to the channel (e.g. Canyon Park Park-and-Ride and Canyon Park Office Center).
- Depending on the geometry associated with the reorganized streambed material during and after transport, fish passage barriers could develop during low flow periods.

Transport of MWM has the potential to result in the following risks within Reach B:

- During large flow events, MWM from Reach A has the potential to collide with drainage outfalls and culverts (38-inch culvert at 17th Avenue SE) in Reach B, which could lead to blockage and an increase in flood risk for adjacent properties (e.g. Canyon Park Park-and-Ride and Canyon Park Office Center).

The likelihood and level of impact for the potential risks above were determined and are summarized in Table 1, along with associated criticality rating and overall risk rating for Reach B.

Reach C

Transport of undersized streambed sediment from Reach A has the potential to result in the following risks within Reach C:

- Undersized material transported from upstream has the potential to deposit in downstream reaches and culverts, reducing the channel or culvert capacity and increasing flood risk adjacent to the channel (e.g. commercial developments at 22121 17th Avenue SE and residential development at 18th and 19th Avenue SE).
- Depending on the geometry associated with the reorganized streambed material during and after transport, fish passage barriers could develop during low flow periods.

Transport of MWM has the potential to result in the following risks within Reach C, although this is unlikely due to the upstream 17th Street culvert preventing MWM from reaching Reach C:

- During large flow events, MWM from Reach A has the potential to collide with drainage outfalls and culverts in Reach C, which could lead to blockage and an increase in flood risk for adjacent properties (e.g. commercial developments at 22121 17th Avenue SE and residential development at 18th and 19th Avenue SE).

The likelihood and level of impact for the potential risks above were determined and are summarized in Table 1, along with associated criticality rating and overall risk rating for Reach C.

Based on the results summarized in Table 1, the risk assessment concludes that there is a Medium risk associated with the undersized streambed sediment sizing and mobile wood material placement. For the one high risk identified in Table 1, mitigation measures could include a wood maintenance program to clear out wood at or within culverts or other infrastructure, or development of additional design measure to limit transport in areas of key constraints.

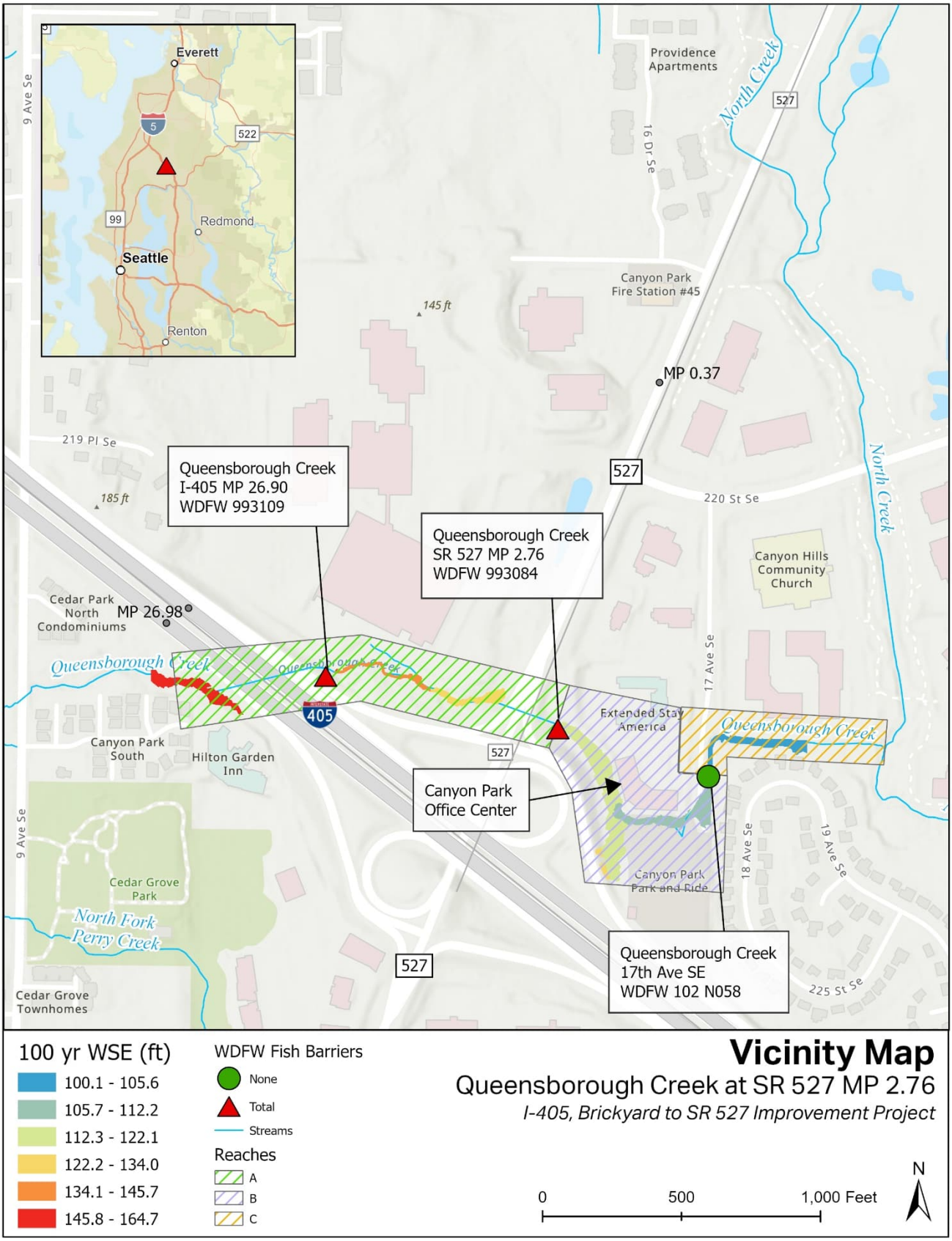

Figure 2. Potentially affected areas

Table 1. Risk Results Summary

Reach	Constraint	Existing or Proposed	Type of Risk	Description of Risk	Likelihood	Impact	Criticality Rating
A	FP structure & wingwalls	Proposed	Sediment	Sediment transport of undersized material could lead to undercutting	Likely	Moderate	Medium
			MWM	Transport of MWM could lead to collision and/or blockage	Unlikely	Moderate	Low
A	Creek banks outside structure	Both	Sediment	Sediment transport of undersized material could lead to undercutting, slope failure, and or loss of riparian habitat	Likely	Moderate	Medium
A	Reach fish passage	Proposed	Sediment	Sediment transport of undersized material could lead to passage blockage	Unlikely	Moderate	Low
A	Utilities and drainage	Both	Sediment	Sediment transport of undersized material could lead to undercutting	Likely	Moderate	Medium
			MWM	Transport of MWM could lead to collision and/or blockage	Unlikely	Moderate	Low
B	Creek banks	Existing	Sediment	Sediment transport of undersized material could lead to deposition and increased risk of flooding	Likely	Moderate	Medium
B	Reach fish passage	Existing	Sediment	Sediment transport of undersized material from Reach A could lead to passage blockage in Reach B	Likely	Moderate	Medium
B	Infrastructure above banks	Existing	Sediment	Sediment deposition and lowered channel capacity could lead to increased flooding on private property	Moderate	Major	Medium
B	Road culvert(s)	Existing	Sediment	Sediment transport of undersized material could lead to deposition and culvert blockage	Likely	Moderate	Medium
			MWM	Collision and/or blockage could lead to backup and associated flooding	Likely	Major	High
C	Creek banks	Existing	Sediment	Sediment transport of undersized material could lead to deposition and increased risk of flooding	Likely	Moderate	Medium
C	Reach fish passage	Existing	Sediment	Sediment transport of undersized material from Reach A could lead to passage blockage in Reach C	Likely	Moderate	Medium
C	Infrastructure above banks	Existing	Sediment	Sediment deposition and lowered channel capacity could lead to increased flooding on private property	Moderate	Major	Medium
C	Road culvert(s)	Existing	Sediment	Sediment transport of undersized material could lead to deposition and culvert blockage	Likely	Moderate	Medium
			MWM	Collision and/or blockage could lead to backup and associated flooding, although since the 17th Street culvert blocks material from begin transported to Reach C, the likelihood is low	Unlikely	Major	Medium
					Overall Rating		**Medium**

(1) MWM = Mobile Woody Material

References

USBR (United States Bureau of Reclamation). 2014. Large Woody Material—Risk-Based Design Guidelines. Knutson, P.E., and Fealko, P.E., co-authors, USBR Pacific Northwest Region Boise, Idaho. 115 p.

WSDOT. 2022. *Hydraulics Manual*. Olympia, Washington. Publication M 23-03.07.