



Drainage Assessment Summary – Work Order 17081

Location:

South Branch of Boeing Creek, upstream of M-1 Dam
Near Greenwood Ave N and Carlyle Hall Rd N
Boeing Creek Basin

Issue Description:

During a routine inspection of the M-1 Dam in January 2017, City maintenance crews discovered a downed tree laying perpendicular to the upstream channel and the access road that runs along the channel at the top of the left bank. Otak agrees with the City's assessment that the blockage caused by the tree, and subsequent vegetation and debris build up, has directed flow to the south, causing erosion and a scour hole in the left embankment. The scour has made the access road leading up to the debris rack and sediment bay impassible. The erosion failure has occurred approximately 140 feet upstream of the dam which falls within the dam storage zone. During large storm events, this portion of the channel and access road become completely submerged under the water staging behind the dam. The site was visited in September when the dam storage zone was empty and there was no baseflow in the channel.

Existing Conditions:

Otak has reviewed the GIS information available in Cityworks and two engineering staff visited the site with City staff on 9/10 and 9/11. A desktop review summary is attached. Desktop review also included as-built plans for the channel reconstruction and quarry spall armoring installed in 1973 and dam construction as-built plans dated 8/7/1984.

The drainage basin upstream of the dam is approximately 700 acres in size, and consists of developed residential area, part of Boeing Creek Park, Shoreline Community College grounds, and a section of Aurora Ave N. There is a multitude of small stormwater detention and infiltration facilities in the upstream system (bioretention, permeable pavement, detention vaults, etc.). Two outfalls, from the east and north, enter Boeing Creek upstream of the issue location, and an additional outfall from the South enters the channel within the dam storage zone just downstream of the issue location (see Figure 1).

Upstream of the work order erosion issue, Boeing Creek consists of a 13 feet wide man-made riprap channel with approximately 1% slope. The channel bottom elevation is generally ~4.5 feet below the access road on the south embankment. Approximately 15 feet upstream of the issue location, the channel widens to approximately 20 feet. Approximately 77 feet downstream of the erosion issue

location, the channel continues to widen into a “basin area” upstream of an asphalt spillway (see Figure 2). The spillway leads to a sedimentation zone upstream of the dam face. The dam has a low flow outlet with trash rack at the end of the sedimentation zone, and an overflow structure with bird cage inlet just upstream of the dam crest.

At some point during the winter of 2017-2018, a mature tree fell from the south hillslope into the channel, blocking flow. The tree appears to have caused debris and sediment to build up in the center of the channel, forcing most of the flow to the south, creating a scour hole in the south embankment (see Figure 2). The scour hole is approximately 15 feet long along the channel and 11 feet wide across the access road embankment. A small 3-foot wide low flow channel has scoured down an additional 1-foot depth into left embankment toe at the erosion failure location. It does not appear that the erosion issue is due to a pocket of poor embankment material.

Potential Solution Approaches:

In order to maintain proper function of the dam, the City performs maintenance to remove sediment that collects within the sediment bay just upstream of the low-flow culvert through the dam. The sediment bay appears to be partially full (greater than 1-foot depth) and will need to be cleaned out soon, probably prior to the rainy season starting in 2018. The maintenance road from Greenwood Ave. N will need to be traversable by heavy equipment. Without engineering analysis and design including geotechnical and hydraulic analysis, the scour hole can be stabilized temporarily by partially backfilling the eroded area and protecting the surface with quarry spalls. Temporary improvements should also include reinforcement of the left embankment toe and riprap channel armoring to prevent further erosional downcutting at the current erosion failure location. This temporary stabilization would be similar to the intended rock channel condition from the 1973 design except that the channel is now wider at the recent embankment failure location.

The channel side slopes supporting the maintenance road near the erosion failure location include a mix of rock armoring, blackberry and ivy overgrowth, and some bare soil areas. This portion of the road within the dam storage zone becomes submerged and there is evidence that some sluffing and channel widening has occurred. In order to maintain a stable maintenance road for heavy equipment long-term within the dam storage zone, stabilization could include re-grading the channel horizontally and vertically and reinforcing the left channel embankment with a rock geotextile wrap wall with less steep side slopes. The bottom of the channel would need to be protected with rock and boulder bands would help dissipate energy and step the grade vertically. These improvements would require geotechnical and structural analysis for the maintenance road embankment and hydraulic analysis for the restored channel. For reference, Otak prepared a design for similar improvements nearby at a 48” pipe outfall within Boeing Creek Park. This example location has similar conditions in that scour protection was needed for the first flush flows into a detention pond that fills and later submerges the interior pipe outfall area. This design included large boulder bands with smaller rock surfacing between the bands. The attached Figure 8 includes photos of the outfall condition just after construction around 2008 and the current condition in 2018.

Recommendations:

Solution Concept A - Temporary Stabilization:

This concept includes the following elements which are represented in the attached Figures 3 thru 6:

- Remove and dispose of fallen tree and debris at the scour hole location.
- Clear rock and debris from bottom of channel at scour hole location for full width of channel.
- Install two-man boulders just north of existing left channel embankment toe.
- Backfill behind boulders with drain rock and gravel borrow to partially fill the scour hole and restore a minimum 10' width maintenance road. Install geotextile over gravel borrow and install quarry spall surfacing for erosion protection. Temporary side slopes adjacent to restored roadway should not exceed 2'H:1'V.
- Grade vertical transitions in maintenance road approaching the restored lower road within the scour hole area and surface with quarry spalls.
- Install light loose riprap across the channel bed within the disturbed area.

This solution could likely be performed as an emergency repair with and on-call contractor under the City's general HPA. All of the materials installed with the temporary repair, except the geotextile, could be re-used as part of the long-term stabilization concept. This concept is considered temporary because the maintenance road embankment and channel downstream would still be in an unstable condition and further side slope erosion or downcutting would likely cause the temporary repair area to degrade.

Solution Concept B – Long-term stabilization and channel restoration:

This concept includes the following elements which are represented in the attached Figure 7:

- Remove invasive species and dead trees along the channel within the dam storage zone.
- Re-grade the channel within the dam storage zone to shift the centerline to the north nearer the original location. This will create more room for a stable embankment supporting the maintenance road.
- Install erosion protection on left channel side slope which supports the maintenance road. This may include a geotextile wrap wall that can be vegetated or a rockery wall.
- Install boulder bands across the channel to dissipate energy and step the vertical grade of the channel. Boulders from the temporary repair could be re-used in this phase.
- Install quarry spall size rock protection between the boulder bands. Quarry spalls and light loose riprap from the temporary repair could be re-used in this phase.

This solution is likely a CIP level project. The improvements would require full geotechnical analysis, hydrologic and hydraulic modeling, and environmental review. Site assessment for design

should include the full length of the channel, maintenance road, and ravine area between Greenwood Ave. N and the M-1 dam to determine if there are other instabilities within this reach that should be addressed.

Next Steps for Engineering Analysis

Solution A is recommended as a temporary solution to prevent further scour and erosion during the 2018-2019 wet season. An arborist could also assess unhealthy trees that are at risk of falling into the channel and causing similar erosion problems. We recommend that Otak be on-site part-time during construction of temporary stabilization measures to observe the means and methods and provide field direction if necessary.

If not already available, the City could also collect monitoring data of the dam storage zone that would be useful for analysis and design of long-term stabilization within the dam storage zone.

The scope of engineering for long-term stabilization measures will be discussed separately with the City.

Estimated Planning Level Construction Cost:

See attached cost estimate summary tables. These costs are based on the assumption that the work is performed during the summer and that a stream bypass system is will not be required. It is also assumed that the site will be accessed only along the existing maintenance road from Greenwood Ave N.

Solution Alternative A – Temporary Stabilization: \$40,000

Solution Alternative B – Long-term Stabilization and Restoration: \$180,000

Attachments:

Figure 1-Drainage Assessment Map
Figure 2-Existing Site Photos
Figure 3-Solution A Plan
Figure 4-Solution A Sections
Figure 5-Solution A Sections
Figure 6-Solution A Photos
Figure 7-Solution B Plan
Figure 8-Example Boeing Creek Park Outfall Stabilization Photos
Cost Estimates
Desktop Data Review Memo

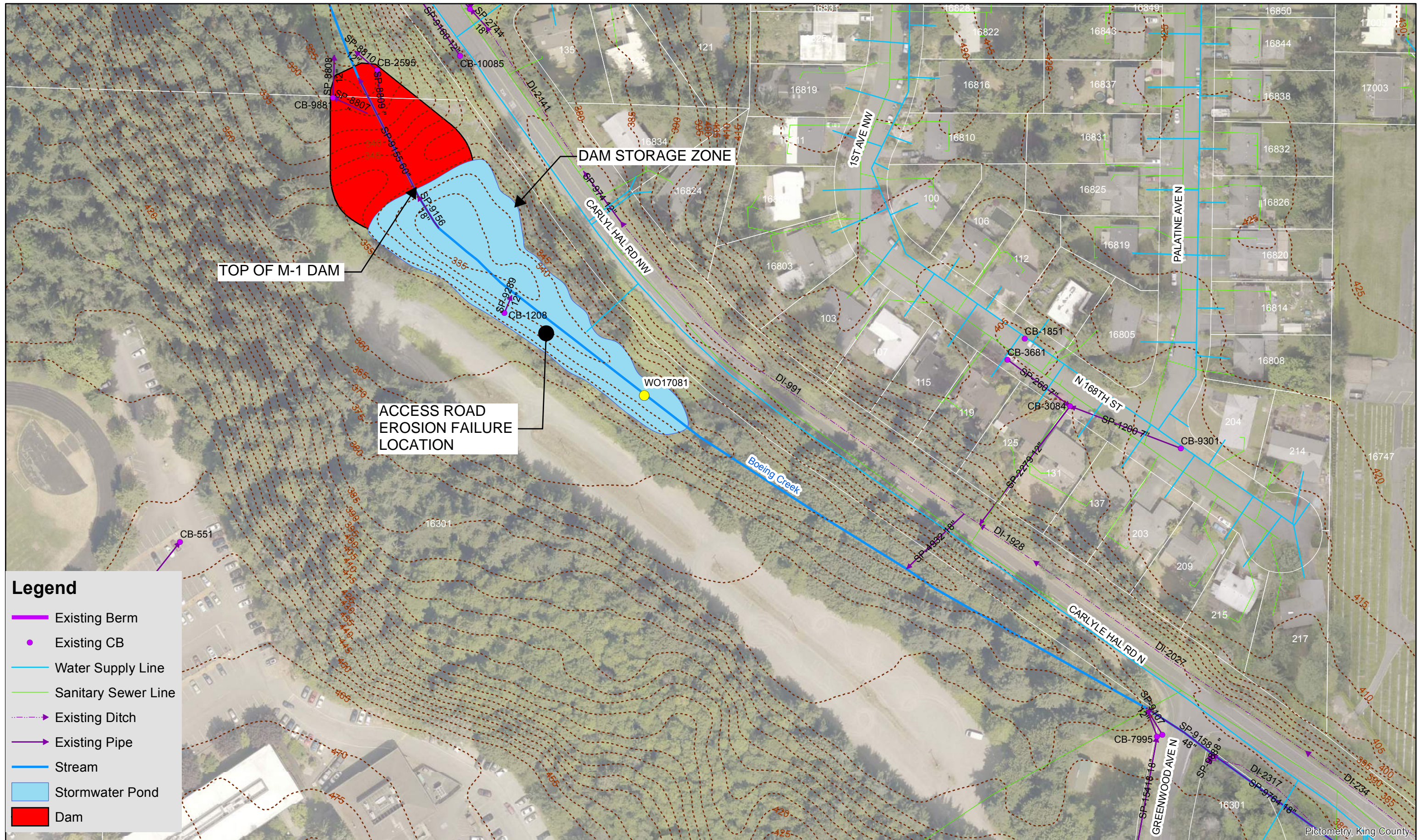


FIGURE 1: CITY OF SHORELINE - WO17081

1 inch = 100 feet





FACING EAST



FACING NORTHWEST, FROM TOP OF EXISTING ACCESS RAMP

FIGURE 2. EXISTING SITE PHOTOS

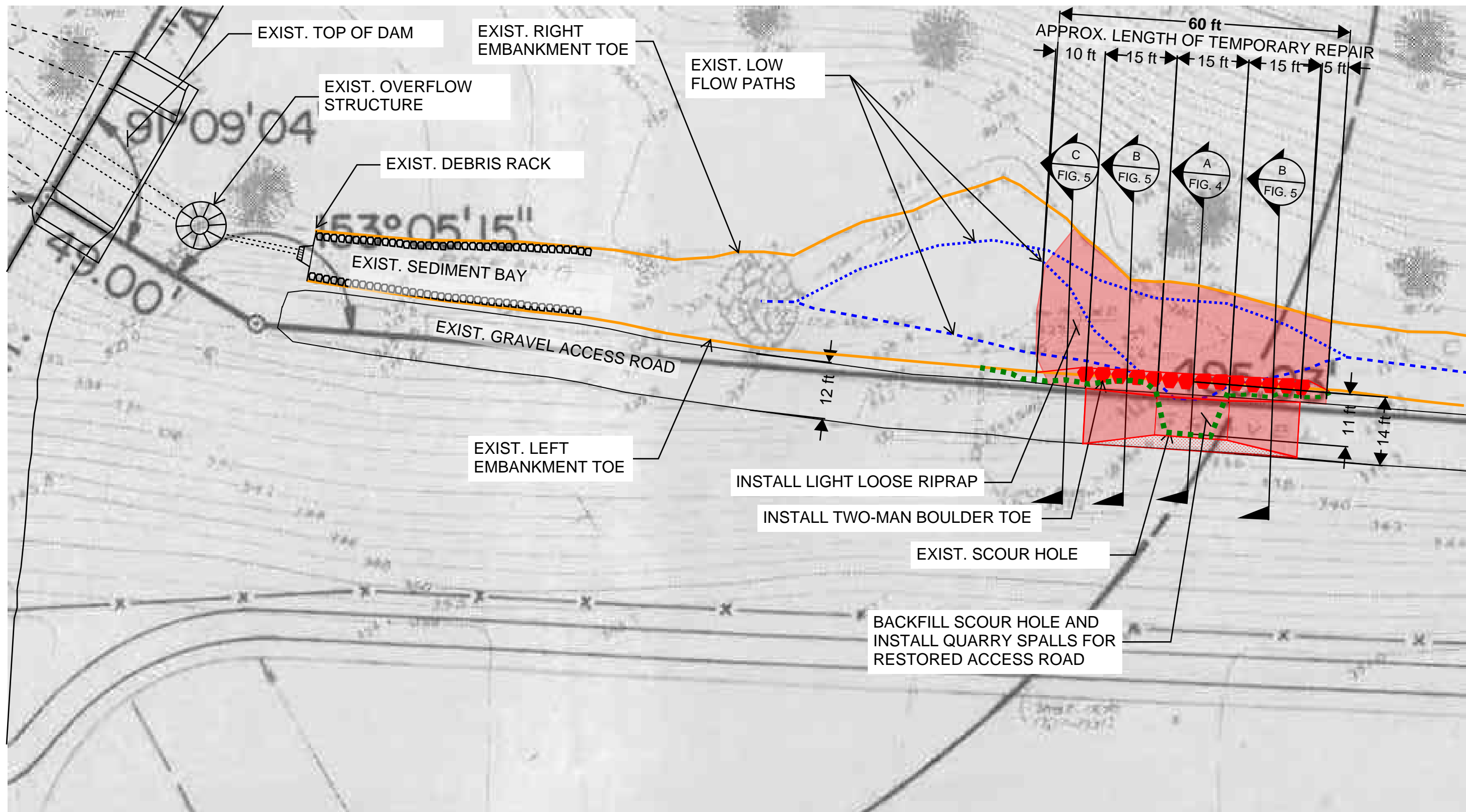
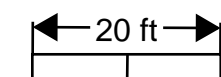
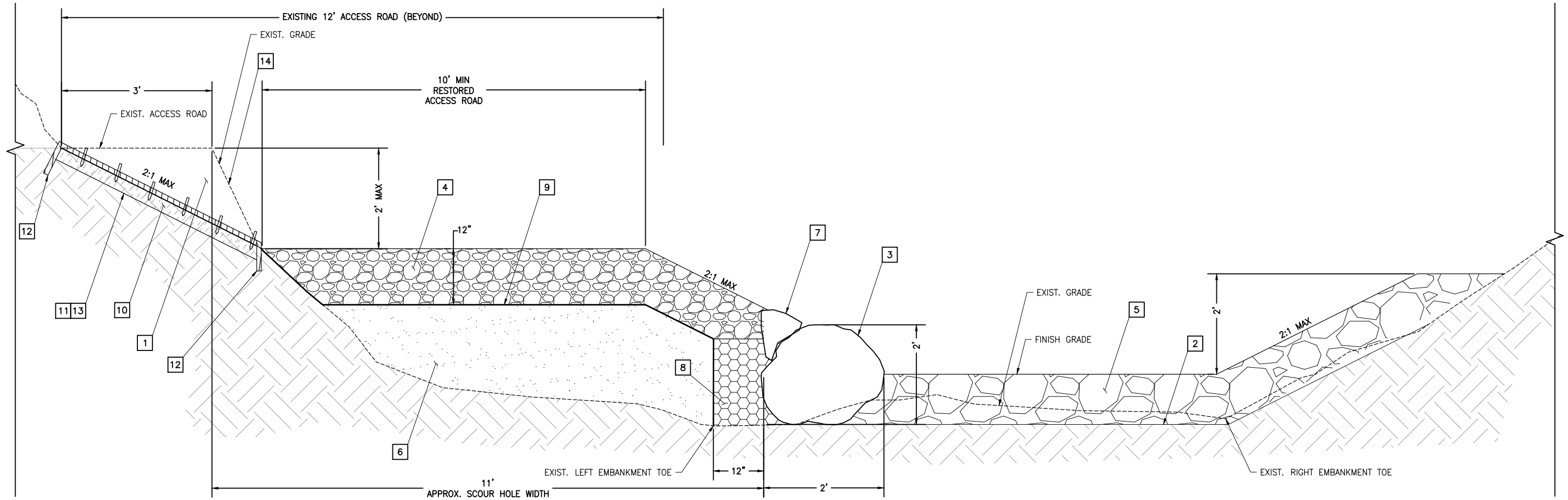


FIGURE 3. CITY OF SHORELINE - WO17081 TEMPORARY STABILIZATION CONCEPT PLAN

1" = 20'





A TYPICAL SECTION A - SCOUR HOLE
 FIG.3 NOT TO SCALE

CONSTRUCTION NOTES

- 1 EXCAVATE EMBANKMENT AND COMPACT SUBGRADE.
- 2 CLEAR AND GRUB AND GRADE CHANNEL BOTTOM TO BE FLAT ACROSS CHANNEL SECTION. SALVAGE EXISTING CHANNEL RIPRAP FOR RE-USE.
- 3 INSTALL 24" MIN. SIZE TWO-MAN STREAMBED BOULDER PER WSDOT STD SPEC 9-03.11(3).
- 4 INSTALL QUARRY SPALLS PER WSDOT STD SPEC 9-13.1(5).
- 5 INSTALL LIGHT LOOSE RIPRAP PER WSDOT STD SPEC 9-12.1(3).
- 6 BACKFILL SCOUR HOLE WITH IMPORT GRAVEL BORROW PER WSDOT STD SPEC 9-13.1 COMPACTED BY METHOD B PER WSDOT STD SPEC 2-03.3(14)C.
- 7 HAND PLACE RIPRAP ROCKS TO FILL GAPS BETWEEN BOULDERS.
- 8 INSTALL GRAVEL BACKFILL FOR DRAINS PER WSDOT STD SPEC 9-03.12(4).
- 9 PLACE NON-WOVEN GEOTEXTILE FOR UNDERGROUND DRAINAGE.
- 10 INSTALL 3" COMPOST BLANKET AND TILL INTO EMBANKMENT.
- 11 INSTALL BIODEGRADABLE EROSION CONTROL BLANKET FOR DITCHES PER WSDOT STD 9-14.5(2)D WITH 1"x2"x12" WOOD STAKES AT 12" O.C.
- 12 KEY END OF EROSION CONTROL BLANKET 6" MIN. BELOW GRADE.
- 13 HYDROSEED BANKS WITH SEED MIX PER THIS SHEET PRIOR TO PLACEMENT OF EROSION CONTROL BLANKET.
- 14 EXCAVATE EMBANKMENT TO TRANSITION TO LOWERED ACCESS ROAD GRADE WITHIN SCOUR BACKFILL AREA.

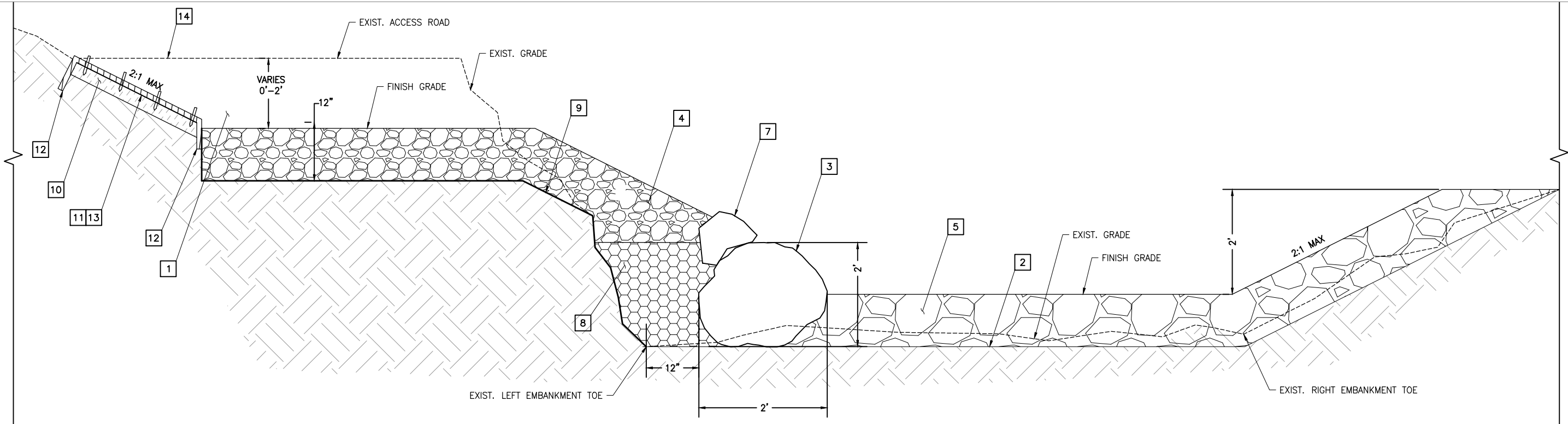
GENERAL NOTES

1. SEE FIGURE 3 FOR APPROXIMATE EXTENTS OF IMPROVEMENTS
2. INSTALL BYPASS SYSTEM FOR DITCH FLOW AS NECESSARY DURING CONSTRUCTION.
3. PREPARE SUBGRADE PER FIELD DIRECTION FROM ENGINEER.
4. INSTALL NECESSARY TEMPORARY EROSION CONTROL MEASURES TO PREVENT SEDIMENT FROM ENTERING DOWNSTREAM CHANNEL SYSTEM.

SEED MIX

- WSDOT STANDARD EROSION:
- 40% Creeping Red Fescue
 - 40% Perennial Ryegrass
 - 10% White Clover
 - 10% Highland Colonial Bentgrass

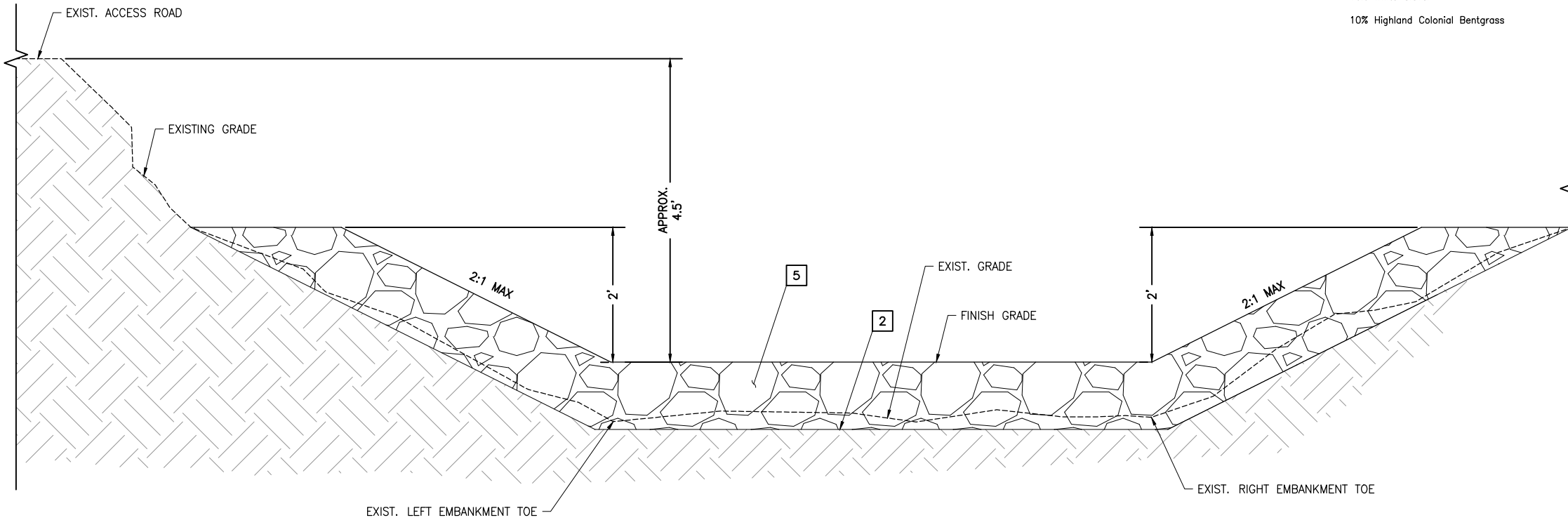
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 Layout Name: SECTION A



B TYPICAL SECTION B - TRANSITION ZONE
 FIG.3 NOT TO SCALE

SEED MIX
 WSDOT STANDARD EROSION:
 40% Creeping Red Fescue
 40% Perennial Ryegrass
 10% White Clover
 10% Highland Colonial Bentgrass

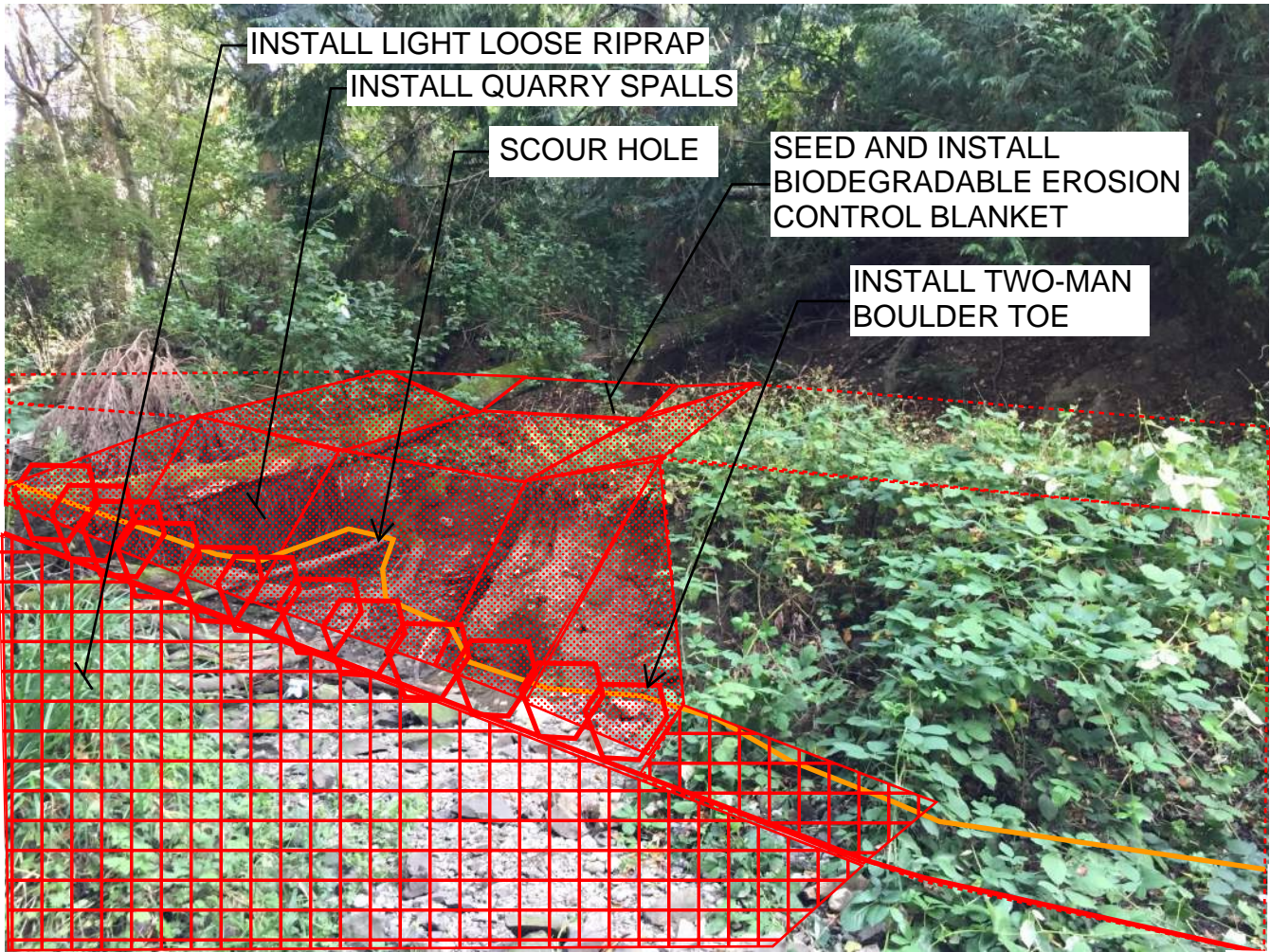
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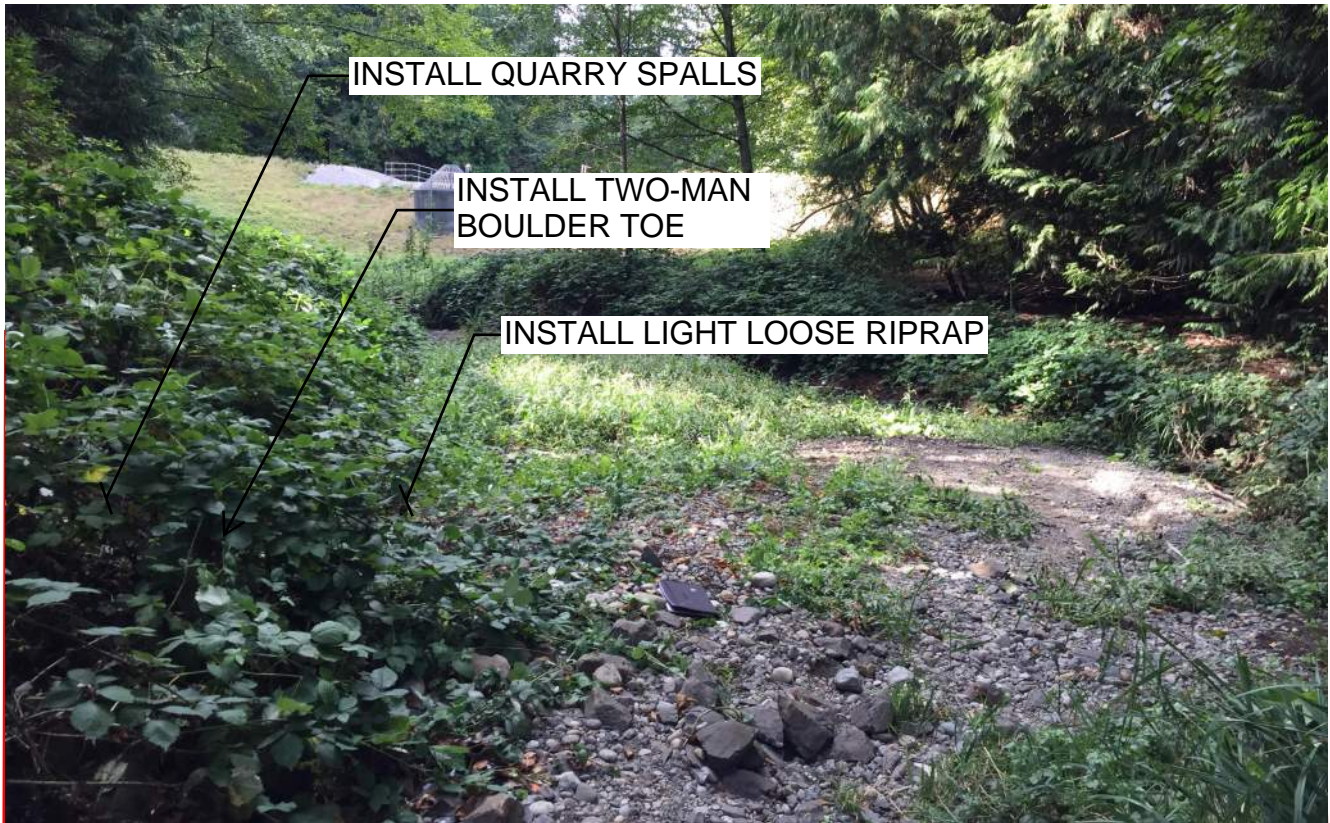
C TYPICAL SECTION C - DOWNSTREAM
 FIG.3 NOT TO SCALE

- GENERAL NOTES**
1. SEE FIGURE 3 FOR APPROXIMATE EXTENTS OF IMPROVEMENTS
 2. INSTALL BYPASS SYSTEM FOR DITCH FLOW AS NECESSARY DURING CONSTRUCTION.
 3. PREPARE SUBGRADE PER FIELD DIRECTION FROM ENGINEER.
 4. INSTALL NECESSARY TEMPORARY EROSION CONTROL MEASURES TO PREVENT SEDIMENT FROM ENTERING DOWNSTREAM CHANNEL SYSTEM.

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FACING EAST



FACING WEST, DOWNSTREAM OF SCOUR HOLE

FIGURE 6. SITE PHOTOS WITH TEMPORARY STABILIZATION CONCEPT

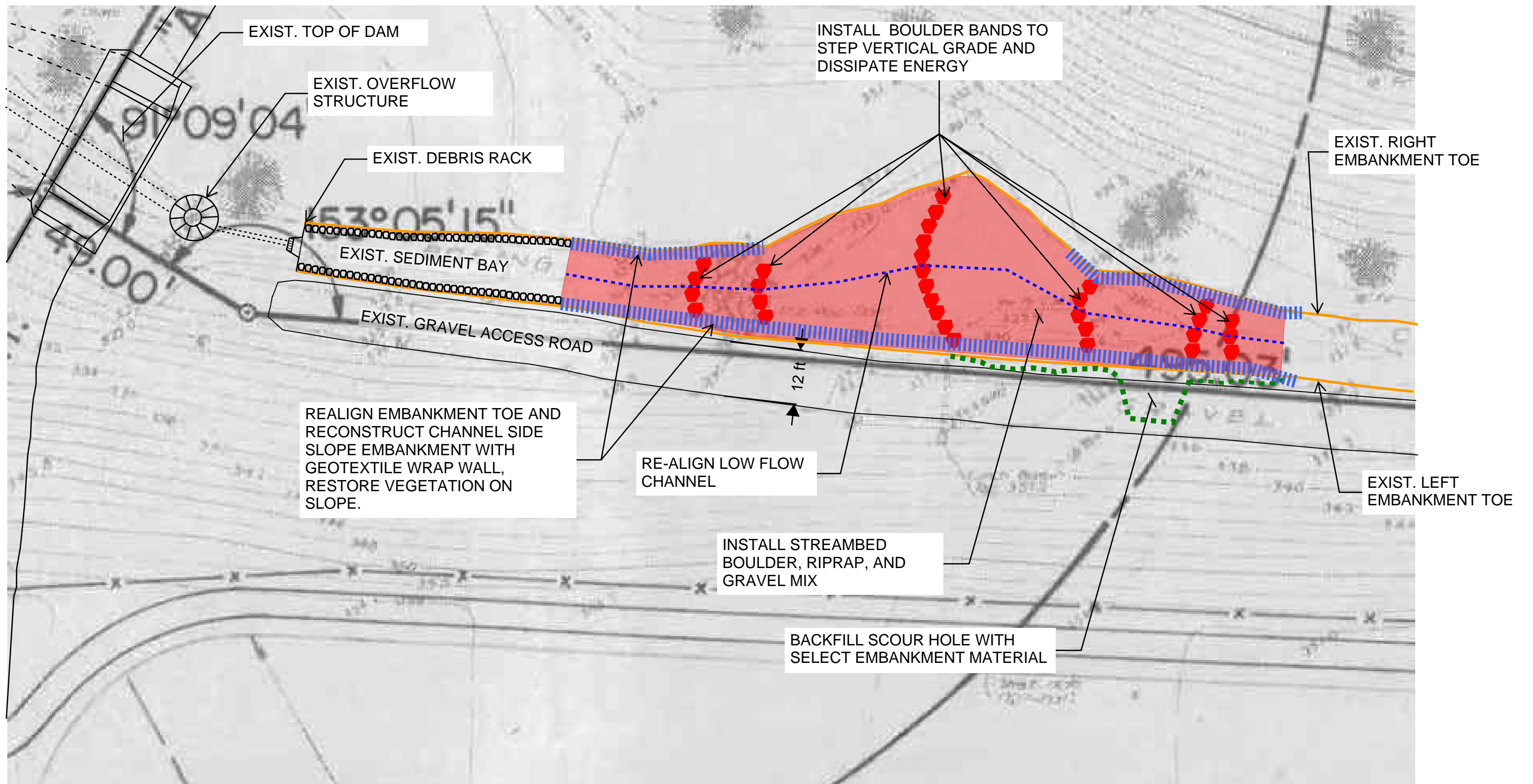
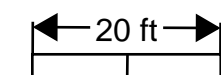


FIGURE 7. CITY OF SHORELINE - WO17081 LONG TERM STABILIZATION CONCEPT PLAN

*THIS IS A PLANNING LEVEL CONCEPT ONLY. THE FINAL STABILIZATION MEASURES WOULD BE BASED UPON GEOTECHNICAL, STRUCTURAL, AND HYDRAULIC ANALYSIS.

1" = 20'





Boeing Creek Park Outfall – 2008, following construction



Boeing Creek Park Outfall – 09/27/2018

FIGURE 8 - EXAMPLE BOEING CREEK PARK OUTFALL STABILIZATION PHOTOS

PLANNING LEVEL CONSTRUCTION COST OPINION					
PROJECT ID: WO 17081		BY: GHP			
LOCATION: Boeing Creek M1 DAM - UPSTREAM DETENTION STORAGE		CHECK BY: TDH			
DESC. AREA		DATE: 9/28/2018			
Alternative A: TEMPORARY SCOUR HOLE STABILIZATION					
ITEM NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
<i>Construction Elements</i>					
1	CHANNEL EXCAVATION INCL. HAUL	50	CY	\$ 40.00	\$ 2,000
2	TWO-MAN BOULDER	23	EA	\$ 350.00	\$ 8,100
3	LIGHT LOOSE RIPRAP	50	CY	\$ 120.00	\$ 6,000
4	QUARRY SPALLS	74	CY	\$ 100.00	\$ 7,400
5	GEOTEXTILE	16	SY	\$ 8.00	\$ 200
6	MOBILIZATION		10%		\$ 2,640
Subtotal Construction Elements					\$ 26,340
<i>Ancillary Items</i>					
7	DEWATERING		3%		\$ 800
8	EROSION & SEDIMENTATION CONTROL		5%		\$ 1,400
9	TRAFFIC CONTROL		3%		\$ 800
10	PLANNING LEVEL CONTINGENCY		40%		\$ 10,600
Subtotal Ancillary					\$ 13,600
Subtotal Construction + Ancillary					\$ 39,940
<i>Tax</i>					
11	STATE SALES TAX		N/A		\$ -
Subtotal					\$ -
Subtotal Construction + Ancillary + Tax					\$ 39,940
2018 Dollars Total Estimated Construction Cost (Rounded)					\$ 40,000
Notes:					
1. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material.					

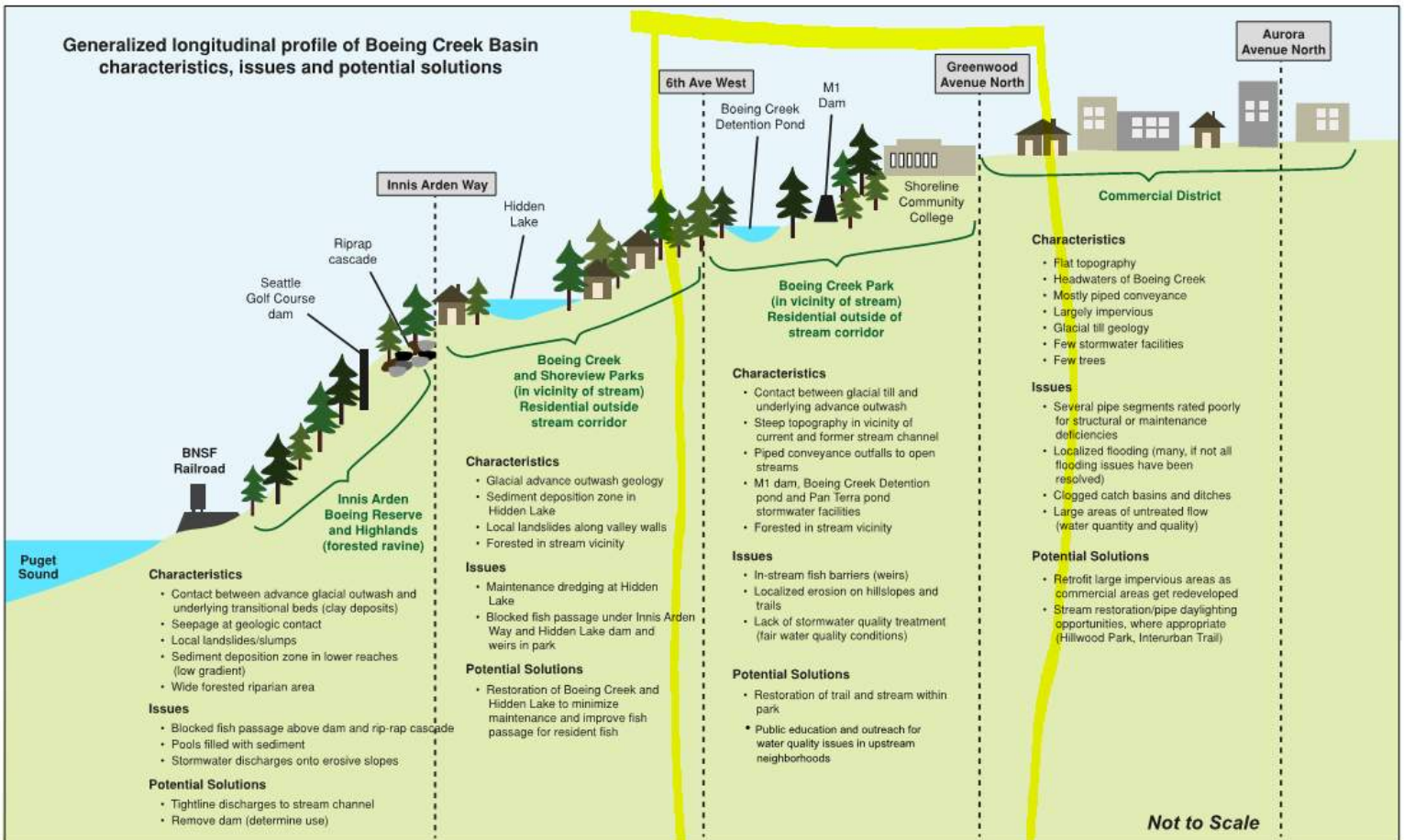
PLANNING LEVEL CONSTRUCTION COST OPINION					
PROJECT ID: WO 17081		BY: GHP			
LOCATION:	Boeing Creek M1 DAM - UPSTREAM DETENTION STORAGE AREA	CHECK BY: TDH			
DESC.	Alternative B: LONG TERM STABILIZATION AND CHANNEL RESTORATION	DATE: 9/28/2018			
ITEM NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
<i>Construction Elements</i>					
1	CHANNEL EXCAVATION INCL. HAUL	143	CY	\$ 60.00	\$ 8,600
2	TWO-MAN BOULDER	75	EA	\$ 350.00	\$ 26,300
3	LIGHT LOOSE RIPRAP	131	CY	\$ 120.00	\$ 15,800
4	LANDSCAPE RESTORATION	222	SY	\$ 15.00	\$ 3,400
5	SELECT EMBANKMENT MATERIAL INCL. HAUL	74	CY	\$ 60.00	\$ 4,500
6	GEOTEXTILE WRAP EMBANKMENT WALL	1000	SF	\$ 40.00	\$ 40,000
7	MOBILIZATION		10%		\$ 10,960
Subtotal Construction Elements					\$ 109,560
<i>Ancillary Items</i>					
8	DEWATERING		3%		\$ 3,300
9	EROSION & SEDIMENTATION CONTROL		5%		\$ 5,500
10	TRAFFIC CONTROL		3%		\$ 3,300
11	PLANNING LEVEL CONTINGENCY		50%		\$ 54,800
Subtotal Ancillary					\$ 66,900
Subtotal Construction + Ancillary					\$ 176,460
<i>Tax</i>					
12	STATE SALES TAX		N/A		\$ -
Subtotal					\$ -
Subtotal Construction + Ancillary + Tax					\$ 176,460
2018 Dollars Total Estimated Construction Cost (Rounded)					\$ 180,000
Notes:					
1. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material.					

Memorandum

To: File
From: Gwyneth Perry
Copies: Tyson Hounsel
Date: August 29, 2018
Subject: Shoreline Task 20 – WO 17081, Desktop Data Review
Project No.: 032713.C20

2013 Boeing Creek Basin Plan

- Referred to as M1 dam
- Within the Boeing Creek Park (in vicinity of stream). Residential outside of stream corridor.



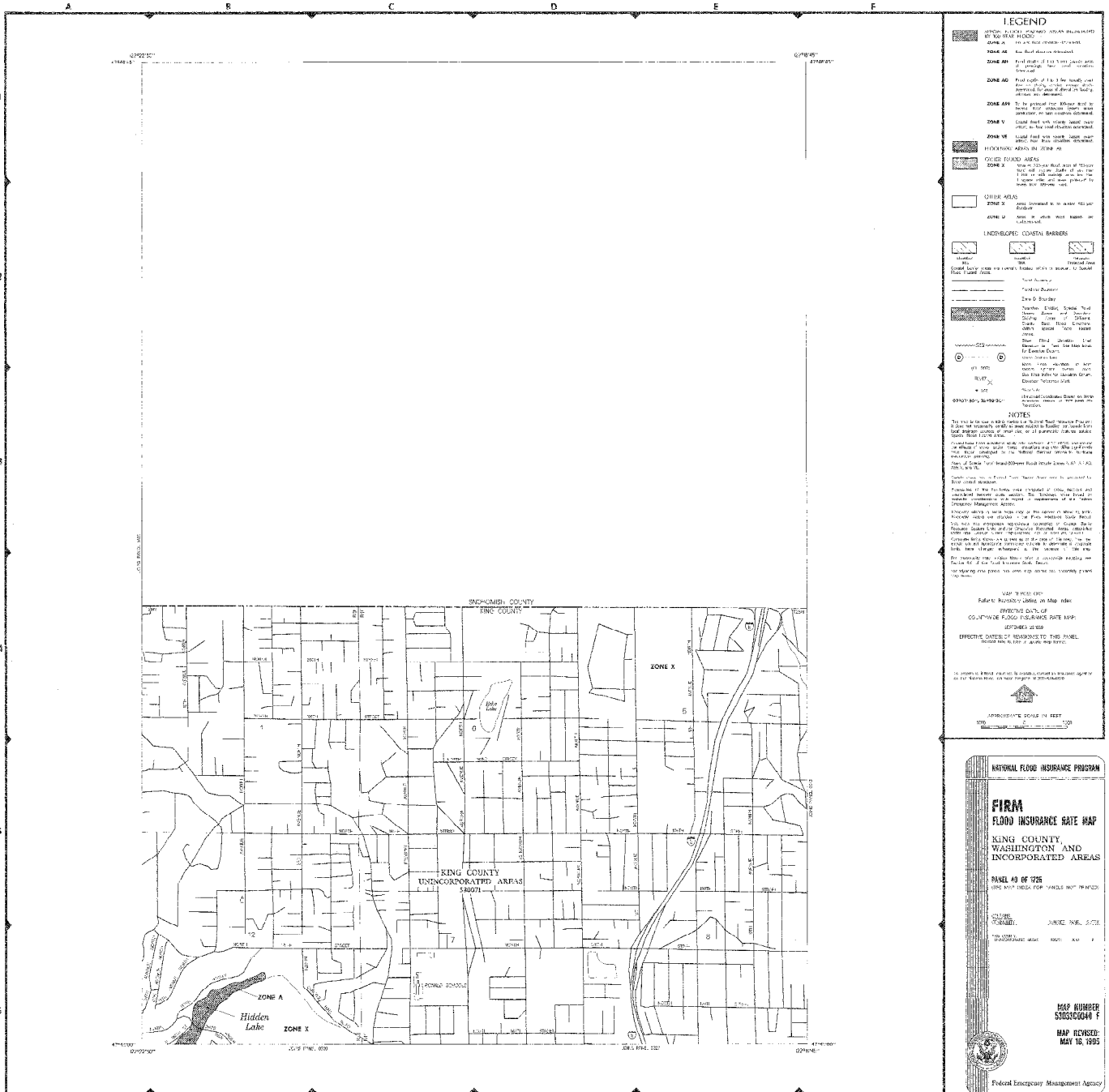
- Issues identified:
 - In-stream fish barriers (weirs). M1 dam described as a definitive migration barrier
 - Localized erosion on hillslopes and trails
 - Lack of stormwater quality treatment (fair water quality conditions)
- M1 dam intended to detain flows to alleviate erosion in Boeing creek
- Near project BC-Ed-4: develop materials and tools to educate owners of large properties in the basin about stormwater retrofit opportunities.
- M1 dam constructed on mainstem of Boeing Creek (1983). Note that downstream Hidden Lake dam fail (1970) washed out Highlands Beach Drive. Current Hidden Lake is maintained through on-going dredging. North Boeing detention pond on North Branch of the Creek also constructed (1991) and renovated through the North Boeing Creek detention facility improvement project (Otak 2008).
- Riprap channel upstream of M1 dam
- A hydrologic model of the basin exists in EPA SWMM (see Appendix A). There is also an HSPF model of the area (Otak 2008)
- South Fork Reach downstream of M1 dam
 - Relatively low gradient
 - Sinuous in pattern
 - Contains some large wood, mostly above the active channel area, and therefore not contributing to the hydraulic diversity and pool formation
 - Seeps observed on right bank
 - HDPE corrugated pipes discharging to channel in several locations
 - Left bank steep through this reach, and consists of many small landslides on the order of 20ft wide by 30ft high
 - Gradient increases toward M1 dam – significant evidence of previous attempts to stabilize this channel section, including large concrete blocks, riprap of various sizes, and asphalt pavement chunks
 - Much of the flow through this section is subsurface
- M1 reach upstream of dam
 - Straight, riprap-constructed channel, with left bank dam access road
 - A few stormwater outfalls discharging water to this reach, including at top of channel

DOE 303d Listing

- WQ standard: core summer salmonid habitat
- No 303d listed waters/sediment issues

FEMA Floodplain Map

- The flood map for this area is number 53033C0040F, effective on 5/16/1995
- The project area is outside of the mapped 500-year floodplain



GIS Data

- Dispersed bioretention along HWY 99 and a few other locations within the basin
- Dispersed stormwater vaults, especially along HWY 99
- Just upstream of dam is considered a stormwater pond. A few other stormwater ponds exist upstream in the basin.
- Dispersed biofiltration swales throughout the basin, especially along HWY 99
- Dispersed permeable pavement: at N 175th St and HWY 99, and few places near Greenwood Ave N and Dayton Ave N and N 160th St

Other Drainage Complaints

- Several upstream drainage complaints related to basement flooding or ponding in residential yard