TECHNICAL MEMORANDUM

DATE:	January 17, 2017
TO:	Seth Boettcher, Public Works Director
FROM:	Craig Buitrago, P.E.
SUBJECT:	Covington Creek at 224th Avenue SE Fish Passage Culvert Basis of Design
CC:	Scott Hanis (City), Austin Fisher (Parametrix)
PROJECT NUMBER:	213-3043-025
PROJECT NAME:	Covington Creek Culvert Replacement

Covington Creek is conveyed beneath 224th Avenue SE through three parallel 70-foot-long, 72-inch-diameter corrugated metal culverts. These culverts were inspected in October 2012, and were found to have holes forming in the bottoms of the culverts, including major corrosion in the lower one-third of the culverts. These findings indicate that the culverts are nearing the end of service life and need to be replaced. The purpose of this technical memorandum is to describe the basis of design for replacing the three deteriorating metal culverts, with a fish passable culvert crossing Covington Creek at 224th Avenue SE. The proposed culvert design follows the guidelines presented in the 2013 Water Crossing Design Guidelines (Barnard et al. 2013).

STREAM CHARACTERISTICS

A field investigation was performed to collect stream characteristics: long profile, cross sections, and pebble counts (Attachment A).

The stream profile was taken from the weir to the inlet of the center culvert (approximately 100 feet), and from the culvert outlet to approximately 161 feet downstream. The measured profile of the reach downstream of the culvert crossing is approximately 0.5 percent. The profile slope is approximately negative 2 percent for the upstream reach from the stream bottom at the weir base to the culvert inlet. The stream channel inside the new culvert will tie into the existing stream channel using a positive 0.5 percent slope.

Two cross-sections were taken: one at 41 feet upstream of the center culvert inlet, and the other at 72 feet downstream of the center culvert outlet. Upstream of the culverts, the stream channel narrows from a wide pool (approximately 80 feet wide) at the lake weir to a channel with steep embankments and a bankfull width (BFW) approximately 31 feet, starting about 50 feet upstream of the culvert inlets. The narrow channel section is confined by a right bank at 1.5H:1V slope, made up of gravelly soils, shrubs, grasses, and trees with diameters ranging from 6 to 34 inches. The left bank consists of a rock wall 3.5 feet in height, followed by a grassy bench and a vegetated slope. The BFW was measured at 31.5 feet. Downstream of the culverts, the narrowed channel section continues for approximately 50 feet from the culvert ends. The narrow channel section is defined by a U-shaped channel bottom, with left and right banks at 3H:1V slopes. The right bank is well vegetated with grasses, shrubs, and trees, and the left embankment is vegetated with shrubs and trees to the top of the bank (approximately 8 feet horizontal). The remainder of the left bank is part of a private property owner's lawn. The BFW in the narrow reach was measured at 35 feet. After the first 50 feet downstream of the culverts, the stream widens and a cross section was measured at 72 feet downstream of the culverts. The BFW at this location was measured at 46.5 feet; however, this wider section of stream was not used as the BFW for determining the

culvert size because it does not represent the existing channel that is present for approximately 100 lineal feet through the 224th Avenue SE crossing. As described, the channel is confined through this roadway crossing; therefore, the design used 31.5 feet as the BFW.

One pebble count was taken at each stream cross section. The streambed material consists of a well-graded mixture of sediments and cobbles, and the D_{84} was found to be 3 inches at the upstream section and 1.9 inches at the downstream section, for an average of 2.5 inches. D_{84} is the intermediate axis of the 84th percentile particle in sediment distribution.

CULVERT SIZING AND DESIGN CONSTRAINTS

The purpose of this project is to replace three parallel culverts that are deteriorating with an open-bottom culvert crossing. The upstream end of the channel is controlled by the Lake Sawyer weir that controls the lake stage. Covington Creek forms a channel with a BFW of 31.5 feet starting 50 feet upstream of the 224th Avenue SE crossing. The channel continues with a similar channel section until approximately 50 feet downstream of the 224th Avenue SE crossing, where the channel widens out. Therefore, using the Stream Simulation Method Equation (Culvert Bed Width = 1.2 x BFW + 2 feet) with A BFW of 31.5 feet, the minimum culvert design width is 39.8 feet, or rounded to 40 feet. The Washington Department of Fish and Wildlife (WDFW) design manual requires crossings with a span greater than 20 feet to be a bridge. The design team spoke with local precast culvert manufacturers, and they do not produce precast box culverts over 35 feet wide. Further investigation resulted in the design team identifying that Contech Engineered Solutions® has precast bridge structure systems with spans greater than 40 feet wide. The design proposes using the CON/SPAN® O-Series® O-740 structure that has a rise of 9.79 feet and span of 40 feet.

One goal of the proposed design is to minimize disturbed area with respect to the roadway reconstruction and surrounding properties. To minimize impacts, the proposed design matches the existing roadway grades, while extending the east side of the roadway prism to include enough space for adding a 6-foot-wide sidewalk in the future. Additional site constraints that contributed to the proposed design include stream BFW, roadway elevation, existing underground utilities (water, gas, communication, and sewer), right-of-way, private property boundaries, and stream elevation. To accommodate site constraints and match the existing roadway grades, the design proposes to use the CON/SPAN O-Series O-740 structure with a minimum design cover of 24 inches from the top of the structure to the finished road grade. However, these site constraints do not allow for the full 40-foot-wide open span to be utilized; rather, the design buries the structure to provide an effective rise of 5.78 feet and effective width (span) of 32 feet. The effective span is equivalent to the BFW upstream and downstream of the culvert crossing. A hydraulic analysis was performed using the U.S. Army Corps of Engineers' HEC-RAS program to verify that the proposed open channel bottom and structure dimensions would convey stream flows.

FLOW RATES AND HYDRAULIC ANALYSIS

Covington Creek begins at the western outlet of Lake Sawyer, and the culvert crossing at 224th Avenue SE is located approximately 100 feet downstream of a concrete weir that regulates the outlet of Lake Sawyer. The concrete weir is approximately 80 feet in total width, and includes a fish ladder (approximately 6 to 8 feet wide) in the middle of the weir to allow fish migration through Lake Sawyer to other tributary streams. To perform the hydraulic analysis, stream flows needed to be established.

King County iMap identifies a Stream Gauge ID 9, Site Code 09e, that was installed on June 15, 1994, but it is currently inactive, and gauge data could not be accessed via the King County website. The U.S. Geological Survey (USGS) StreamStats interactive map also identifies a stream gauge, USGS Station Number 12111500, which is a station named Covington Creek Near Black Diamond, WA. The station type is a stream gauge with continuous record (http://streamstatsags.cr.usgs.gov/gagepages/html/12111500.htm). The gauge data are over 50 years old (February 1, 1953 to October 31, 1959). There has been significant land use development in the Lake Sawyer drainage basin since that time; therefore, the project will not use the flow rates from this stream gauge. King

County also manages Stream Gauge 9a on Covington Creek near the mouth of Soos Creek (http://green2.kingcounty.gov/hydrology/DataDownload.aspx?G_ID=5&Parameter=Stream Flow), and has collected data from 1988 to the present (about 28 years). While this gauge cannot be used directly to estimate flows at the project site, relationships can be developed that may inform flows at the site. The Covington Creek culvert crossing at 224th Avenue SE is located immediately downstream at the outlet of Lake Sawyer. The lake level is managed by a weir at the outlet, and all of the water flowing over the weir becomes Covington Creek. Consequently, lake stage data will define flow rates over the weir and can be used to predict flow rates at the culvert for design purposes. However, lake level data were only collected for 1 year (1994-1995) in support of the Lake Sawyer Management Plan (King County Surface Water Management 2000), but data have been collected more recently by a lake resident since the summer of 2010 (http://www.lakesawyerweather.com/). A relationship between the longer record at King County Gauge 9a and the weir flows can be used to "extend" the flow record at the culvert, if a meaningful relationship is found.

Several peak flow rates at Gauge 9a and the Lake Sawyer weir were compared. The flow rates at the weir stage (assuming an 80-foot weir and no consideration of the fish ladder) are very similar (usually within 5 percent or less). Therefore, the flow record at this gauge will be used as a guide for flow rates at the culvert. Additional refinement of the weir and gauge reading is recommended, but unlikely to return significantly different results. Table 1 shows a series of peak flows at key dates, estimated return frequency using the simple return frequency formula, and correlated Lake Sawyer stages over the weir and resultant flows using the weir formula. The peak reported stage at the weir, 26 inches, was used as the100-year flow, and the historical mean high water stage at the weir, 10 inches, was used as the 2-year flow (http://www.lakesawyerweather.com/LevelMeasurement.htm).

Table 1. Peak Flow Rates Compared to Weir Flows at Lake Stage Depths above Weir

Date	Return Frequency	Peak Hourly Flow at Gauge 9a (cfs)	Lake Stage at Weir (inches)	Flow for 80 foot Weir (cfs)	Notes
2/9/96	29	810	26	851	Reported stage of record at Lake Sawyer, applied as the 100-year peak
1/8/09	14	591			
1/3/97	9+	467			
1/13/06	7+	503			
11/26/90	5+	459			
12/9-11/15	4+	411	16	408	
12/14/10		193	10.0	201	Reported stage at Lake Sawyer, applied as the 2-year peak
3/10/14		238	10.5	216	

As a verification of the design flow rates, the design team calculated flows from the Washington State Hydrology USGS Regression Equation for Region 2. The drainage basin area used for the USGS Equation was the Lake Sawyer watershed area of 8,120 acres. When converted, this contributing area equals about 12.7 square miles (the area unit used in the USGS Regression Equation). To determine the Mean Area Precipitation (MAP), the stream gauge latitude (47.3359) and longitude (-122.0457) were entered in the MGSFlood Hydrologic Model program, which calculates the MAP to be 49.7 inches, or 50 inches, when rounded to the nearest inch.

Table 2 compares the peak flow rates from the USGS Regression Equation for Region 2 with the estimated flow rates from the King County Gauge 9a. The estimated flows at the Lake Sawyer weir were used for design. The return frequencies, when estimated and shown on Table 1, were plotted and the return frequency in years was extrapolated. As an additional analysis, the existing culverts were evaluated for capacity and were estimated

between 590 and 650 cubic feet per second (cfs), with the upstream stage at the 224th Avenue SE roadway edge. This corresponds to the estimated approximate 25-year flow rate.

Table 2. Covington Creek Flow Rates (USGS Regression Equation for Region 2) and Estimates from King County Gauge 9a Relationship

Return Frequency	USGS Regression Flow Rate (cfs)	Estimated flows at the Lake Sawyer Weir (cfs)
2-year	314	201
10-year	556	411
25-year	682	591
100-year	895	851

A hydraulic analysis of Covington Creek with the proposed stream channel and CON/SPAN structure was performed using HEC-RAS (Attachment B). Using the flows rates described above, the model results indicate that the proposed stream crossing will convey the 2-year, 10-year, and 25-year peak flows with at least 1 foot of clearance from the water surface elevation to the top of the CON/SPAN structure. The proposed design will also convey the 100-year peak flow under inlet control conditions, where the inlet will be submerged approximately 12 to 16 inches above the crown of the CON/SPAN structure. Model results indicate that the backwater that is projected to occur during the 100-year peak flow would be able to flow through the proposed CON/SPAN crossing, and would not create roadway over-topping.

STREAMBED GRAVEL

The design of the streambed gravel mix is based on the pebble count and verified with the Bathurst Equation for Unit-Discharge Bed Design, as described in the 2013 Water Crossing Design Guidelines. A longitudinal stream slope of 0.5 percent was used in the Bathurst Equation to estimate the D_{84} particle size. The flow rates were derived using the flow rate analysis, as previously described.

Bathurst Equation:

$$D_{84} = 3.45S^{0.747}(1.25q_c)^{2/3} / g^{1/3}$$

where: D_{84} = intermediate axis of the 84th percentile particle in sediment distribution, in feet

S = energy slope of the proposed channel, ft/ft

q_c = critical unit discharge (total design discharge divided by width of bankfull channel) at which incipient motion of D_{84} occurs, in cubic feet per second per foot

g = gravity, 32.2 feet/sec^2

The D_{84} from the pebble counts were found to be 3 inches upstream and 1.9 inches downstream. From the Bathurst Equation, the resulting D_{84} particle sizes are 2.59 inches for the 100-year flow upstream, and 2.01 inches at the 100-year flow downstream. A D_{84} particle size of 2.5 inches will be used for streambed gradation because it is a rounded value between the average D_{84} from the pebble count and D_{84} calculated using the Bathurst Equation in the measured reach upstream of the culverts.

The streambed mix design will be 18 inches deep, using a mix of 70 percent streambed sediment and 30 percent 6-inch streambed cobbles, both of which are standard specifications from the Washington State Department of Transportation (WSDOT). Table 3 shows a comparison of the calculated gradation versus the streambed cobbles.

Table 3. Comparison of Calculated Streambed Gradation versus Streambed Cobbles

Calculated Grain Size		6-inch Streambed Cobbles	
Percentile	Size (inch)	Approximate Size (inch)	Percentile Passing
D_{100} =	6¼	6	100
D_{84} =	2½	5	70-90
D_{50} =	1	2	30-60
D_{16} =	5/16	¾	10 max.

The D_{100} will be approximately the same size as the calculated value (6¼ inches vs. 6 inches). The 6-inch cobbles will consist of approximately 10 to 30 percent cobbles 5 inches and larger. This is larger than the 16 percent of cobbles 2½ inches or larger retained according to the D_{84} calculation. In accordance with the calculated grain size distribution, approximately half the cobbles should be 1 inch or larger; the streambed cobbles have a range of 40 to 70 percent of cobbles 2 inches or larger. The smaller sized particles will consist of the 10 percent maximum passing the ¾ sieve. The 6-inch streambed cobbles are meant to provide larger streambed material that will not likely be transported during typical flows. Therefore, even though the cobbles are larger than the calculated grain sizes for the D_{84} and D_{50}, this material will be mixed with streambed sediment, which has up to 35 percent of material between 2 and 2½ inches in diameter, and half of the material at 1 inch in diameter. The remainder of the streambed sediment is small in diameter and fines, which is designed to solidify the bed and prevent the stream from running subsurface.

The pebble counts and Bathurst Equation for Unit-Discharge Bed Design calculations are provided in Attachment A.

OUTSTANDING DESIGN ITEMS AND PERMIT APPROVAL

Moving forward to final design, the project team needs input on several items from the City, including utilities, traffic control, tree preservation plan, temporary and permanent construction easements, and construction sequencing. Each item is discussed below.

Utilities

It is the understanding of the design team that the City will coordinate with the utility companies for underground gas, communication, water, and sewer, and for the overhead power and telephone lines. At this stage, the project plans note that utilities are to be done "By Others." This is assuming that the City has a franchise agreement with the utility companies, and that they are responsible for making changes to their systems at the stream crossings. We are assuming that the utility companies will be able to construct their installations over the precast CON/SPAN structure. Conversations with CON/SPAN confirm that they can accommodate the sewer with a block-out structure wall for the sanitary sewer main. They could also allow the utility companies to punch holes through the structure walls, if necessary, but would rather the utilities be designed and installed over the CON/SPAN structure.

Additionally, the CON/SPAN O-series comes in 6-foot-long precast sections, and will require the use of a 300-ton crane to lift the precast sections into place. There are overhead power and telephone lines crossing the project area; it is possible that the utility pole and transformer box at the northeast end of the existing culverts will need to be relocated. If the utilities were underground, that would alleviate concerns of a crane damaging the overhead lines.

Tree Preservation

The environmental permitting team indicated that the City's code requires a tree preservation plan for specific species of trees that are 6 inches in diameter or greater. The final design scope did not include tree evaluation or

preparation of a tree preservation plan. The City needs to decide if they will be doing this, or if the design team needs to prepare a contract amendment to address the tree preservation plan.

Traffic Control

Traffic control during construction will be addressed with final design. At this time, the Site Preparation Plan is assuming that the road will be closed, and the project staging area will be the parking lot at the Lake Sawyer Park at the end of SE 296th Street (approximately 0.25 mile from the project site). The design team needs input from the City regarding closure of 224th Avenue SE (allowable construction hours, weekend work times, etc.).

Construction Sequence

A construction sequence is proposed in the Site Preparation Plan; however, it is possible for the Contractor to design a different stream bypass approach than what is proposed. The City needs to indicate if they would be open to the idea of preparing a specification that requires the Contractor to submit a Construction Sequence Plan along with their bid for evaluation and approval by the City. This may be an area where the Contractor will be able to save money; therefore, it would be efficient to evaluate the stream bypass and construction sequencing with the bid proposals.

WDFW Approval

The design described above assumes that based on our hydraulic analysis, the proposed design will provide fish passage through the 224th Avenue SE structure crossing. The design approach is a deviation from the WDFW Stream Simulation design method because it does not provide for the full span as required by the Stream Simulation design equation. If the design reviewers do not approve of this design approach, then the project would be forced to design a bridge to accommodate site constraints of matching existing road grade and stream profile elevation, minimizing impacts to adjacent properties and underground utilities. Our structural design team reviewed the proposed design and geotechnical report, and developed a preliminary bridge design as a round comparison to the proposed CON/SPAN design. This design alternative uses pre-stressed concrete girders with foundation shafts and soil nail walls (see Attachment C). Included in the preliminary design evaluation is a rough cost estimate of construction costs. This design alternative estimates the installed cost to be around $396,000 (which includes the foundations). The cost is based on $150/square foot for a 44-foot-long x 60-foot-wide bridge deck. This design approach would require the design team to prepare the structural sheets, including wingwalls at the four corners of the bridge. Design costs are not included in the estimate.

In comparison, the CON/SPAN structure was quoted at $225,000 delivered to the site for the structure and four wingwalls. The installation was estimated to be 0.75 times the CON/SPAN quote, bringing the estimated installed cost to about $394,000. It is anticipated that the other costs (construction of the streambed, temporary bypass, traffic control, underground utilities, etc.) would be roughly the same for the construction of either structure system; therefore, although design costs would increase if a bridge is required, the construction costs would be similar to that of the proposed design with the CON/SPAN structure.

REFERENCES

Barnard, R.J., J. Johnson, P. Brooks, K.M. Bates, B. Heiner, J.P. Klavas, D.C. Ponder, P.D. Smith, and P.D. Powers. 2013. Water Crossings Design Guidelines, Washington Department of Fish and Wildlife, Olympia, Washington. Accessed at: http://wdfw.wa.gov/hab/ahg/culverts.htm.

King County Surface Water Management. 2000. Lake Sawyer Management Plan. Prepared by King County Surface Water Management, with assistance from Entranco. Seattle, Washington. July 2000.

Attachment A

Stream Characteristics

King County

Lake Sawyer
King County, Washington

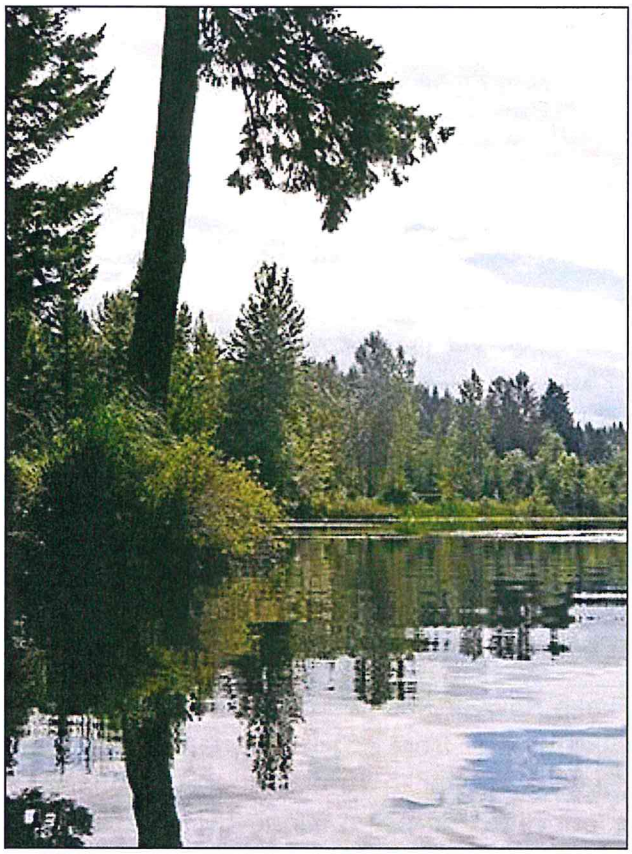
Lake Sawyer is the fourth largest natural lake in King County with a surface area of 286.1 acres. The lake is located two miles northwest of Black Diamond and lies within the Big Soos Creek Basin of the Green River Watershed. The lake is used extensively for boating, water skiing, swimming and fishing. Public access is provided at the King County Lake Sawyer Park on the northwest side of the lake, and the newly acquired County Park in the southern part of the lake. The City of Black Diamond annexed the lake and surrounding homes in 1998. The City of Black Diamond is on the verge of significant expansion and growth which could have significant impacts on the water quality of Lake Sawyer.

Lake Sawyer has had historical water quality problems related to the discharge of wastewater from a failed wetland treatment system. The wastewater was diverted to the sanitary sewer in 1992. A draft lake management plan was developed in 1996 by King County to address the long-term water quality protection of the lake and watershed. The City and County have been conducting additional stormwater monitoring in the watershed to better identify sources of phosphorus to the lake.

The management approach for Lake Sawyer and its watershed as stated in the Draft Management Plan is to address the nutrient loading from the watershed to maintain its existing conditions. In-lake treatments such as alum and/or hypolimnetic aeration, are recommended as contingency measures in the event that monitoring results reveal that watershed controls are insufficient.

Lake Sawyer has been part of the Lake Stewardship Volunteer Monitoring Program since 1994. Twice a month from May through September, volunteers collect total phosphorus, chlorophyll a, total nitrogen, and phytoplankton samples to send to the County lab. Additional measurements, such as

temperature, Secchi depth, precipitation, and lake level are collected by volunteers weekly throughout the year.



Lake Sawyer

Lake Sawyer Recreation

- Lake Sawyer recreation information from King County's Small Lakes Recreation Guide (1.05 Mb Acrobat file)
- City of Black Diamond Parks (external) - provides information about Lake Sawyer Park and boat launch
- Lake Sawyer boat launch access/ shoreline habitat improvement project (902 Kb Acrobat file)
- Lake Sawyer fishing (external, WDFW)
- Lake Sawyer park plan (external, 23 Mb Acrobat)
- Lake Sawyer Community Club (external link)

Lake Sawyer and watershed data

- Watershed area: 8,120 acres
- Lake surface area: 279 acres
- Maximum depth: 58 feet
- Mean depth: 26 feet
- Lake Sawyer water quality data
- Lake Sawyer Management Plan

Lake Sawyer drainage area and park location map

Lake Sawyer bathymetric contour map

For more information about Lake Sawyer, contact the City of Black Diamond at 253-631-0351.

For questions about Lake Sawyer and other small lakes in King County, please contact Rachael Gravon, Water Quality Planner or Chris Knutson, Project Manager, Lake Stewardship Program.

Related information

- Lake stewardship program
- Lake services and information
- Green River watershed
- Environmental services

Related agencies

- Water and Land Resources Division
- Wastewater Treatment Division
- Parks and Recreation Division

Last Updated February 26, 2016

StreamStats Data-Collection Station Report

USGS Station Number 12111500
Station Name COVINGTON CREEK NEAR BLACK DIAMOND, WA

Click here to link to available data on NWIS-Web for this site.

Descriptive Information

Station Type	Streamgage, continuous record
Location	
Gage	
Regulation and Diversions	
Regulated?	Unknown
Period of Record	
Remarks	
Latitude (degrees NAD83)	47.3359343
Longitude (degrees NAD83)	-122.04567092
Hydrologic unit code	17110013
County	033-King
HCDN2009	No

Physical Characteristics

Characteristic Name	Value	Units	Citation Number
Descriptive Information			
Datum_of_Latitude_Longitude	NAD83	dimensionless	30
District_Code	53	dimensionless	30
Begin_date_of_record	2/1/1953	days	41
End_date_of_record	10/31/1959	days	41
Number_of_days_of_record	2464	days	41
Number_of_days_GT_0	1978	days	41
Basin Dimensional Characteristics			
Drainage_Area	13	square miles	30

Streamflow Statistics

Statistic Name	Value	Units	Citation Number	Preferred?	Years of Record	Standard Error, percent	Variance log-10	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Start Date	End Date	Remarks
Flow-Duration Statistics												
1_Percent_Duration	127	cubic feet per second	41	Y	6							
5_Percent_Duration	84	cubic feet per second	41	Y	6							
10_Percent_Duration	64	cubic feet per second	41	Y	6							
20_Percent_Duration	46	cubic feet per second	41	Y	6							
25_Percent_Duration	40	cubic feet per second	41	Y	6							

30_Percent_Duration	34	cubic feet per second	41	Y	6
40_Percent_Duration	25	cubic feet per second	41	Y	6
50_Percent_Duration	16	cubic feet per second	41	Y	6
60_Percent_Duration	9.9	cubic feet per second	41	Y	6
70_Percent_Duration	3.3	cubic feet per second	41	Y	6
75_Percent_Duration	1.05	cubic feet per second	41	Y	6
80_Percent_Duration	0.1	cubic feet per second	41	Y	6
90_Percent_Duration	0	cubic feet per second	41	Y	6
95_Percent_Duration	0	cubic feet per second	41	Y	6
99_Percent_Duration	0	cubic feet per second	41	Y	6
General Flow Statistics					
Minimum_daily_flow	0	cubic feet per second	41	Y	6
Maximum_daily_flow	198	cubic feet per second	41	Y	6
Std_Dev_of_daily_flows	28.824	cubic feet per second	41	Y	6
Average_daily_streamflow	25.342	cubic feet per second	41	Y	6
Base Flow Statistics					
Number_of_years_to_compute_BFI	6	years	42	Y	6
Average_BFI_value	0.705	dimensionless	42	Y	6
Std_dev_of_annual_BFI_values	0.019	dimensionless	42	Y	6

Citations

Citation Number	*Citation Name and URL*
30	Imported from NWIS file
41	Wolock, D.M., 2003, Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States: U.S. Geological Survey Open-File Report 03-146, digital data set
42	Wolock, D.M., 2003, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03-263, digital data set

WASHINGTON STATE HYDROLOGY
USGS REGRESSION EQUATIONS
Region 2- 202 stations

SR:	224th Ave	Date:	8/16/2016
Project:	Covington Creek Culvert Replacement		
Made By:	C. Buitrago		

Equations:

Q2yr	=	0.09 x A^0.877 x (MAP)^1.51	(Standard Error = 56%)
Q10yr	=	0.129 x A^0.868 x (MAP)^1.57	(Standard Error = 53%)
Q25yr	=	0.148 x A^0.864 x (MAP)^1.59	(Standard Error = 53%)
Q50yr	=	0.161 x A^0.862 x (MAP)^1.61	(Standard Error = 53%)
Q100yr	=	0.174 x A^0.861 x (MAP)^1.62	(Standard Error = 54%)

Legend

Q = Flow (cfs)
A = Drainage Basin Area (miles^2)
MAP = Mean Annual Precipitation (inches)

Limits

(0.08 sq. miles $\leq$ A $\leq$ 3,020 sq. miles)
(23.0 in $\leq$ MAP $\leq$ 170 in)

Input Values Into Columns With Red Headings

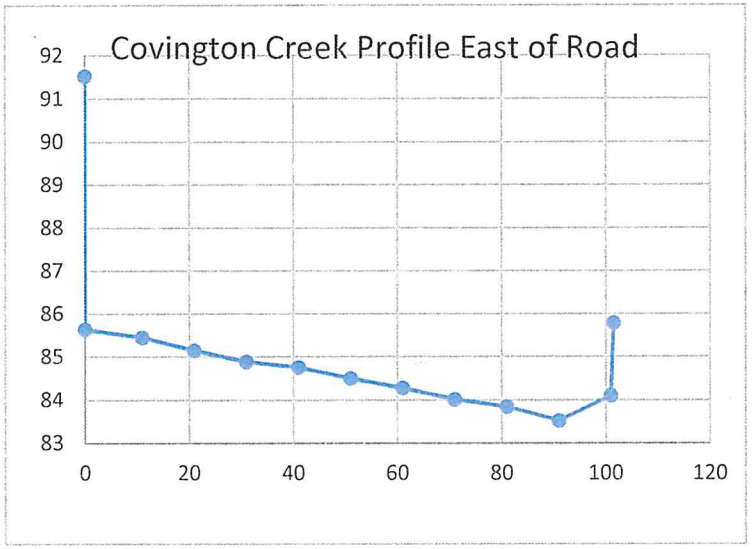
	Return			**Q**	**+1 Std Dev**	**-1 Std Dev**
Description of Area	**Frequency**	**A**	**MAP**	(cfs)	(cfs)	(cfs)
Lake Sawyer Drainage Area	2	13	50	314	489	138
	10	13	50	556	850	261
	25	13	50	682	1,044	321
	50	13	50	799	1,222	375
	100	13	50	895	1,379	412

Upstream Long Profile

100 feet, *Arbitrary 100' elevation start point

STA	Rod Height	*Elevation	Notes
0	8.47	91.53	Culvert Crown - middle Culvert
0	14.36	85.64	Culvert IE - middle Culvert
11	14.55	85.45	
21	14.85	85.15	
31	15.11	84.89	
41	15.24	84.76	Water depth: 1.79'
51	15.5	84.5	
61	15.72	84.28	
71	15.99	84.01	
81	16.16	83.84	
91	16.48	83.52	Water depth: 2.73'
101	15.9	84.1	Stream bottom after weir
101.5	14.21	85.79	Edge of weir

slope = -2.1%

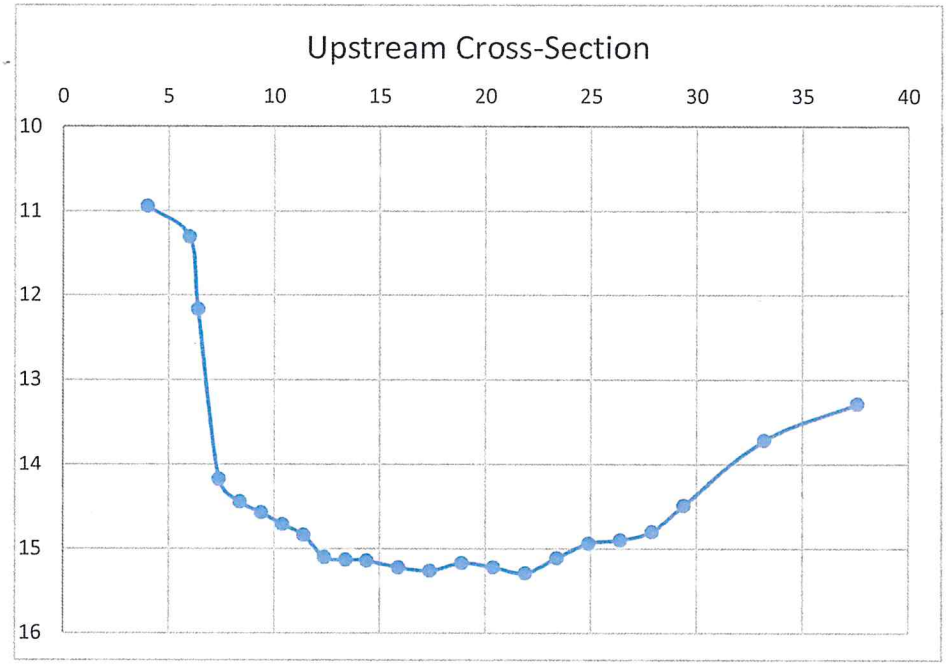


Upstream Cross-Section

*Measured at STA 41' upstream of center culvert

100 feet, *Arbitrary 100' elevation start point

STA	Rod Height	*Elevation	Notes	
4	10.94	89.06		
6	11.31	88.69	Top Bank	
6.4	12.17	87.83	OHWM	
7.4	14.18	85.82	TOE	WD=0.48'
8.4	14.44	85.56		
9.4	14.57	85.43		
10.4	14.71	85.29		
11.4	14.84	85.16		
12.4	15.1	84.9		
13.4	15.13	84.87		
14.4	15.14	84.86		
15.9	15.22	84.78		
17.4	15.26	84.74		
18.9	15.17	84.83		
20.4	15.22	84.78		
21.9	15.29	84.71		
23.4	15.11	84.89		
24.9	14.94	85.06		WD=1.46'
26.4	14.9	85.1		WD: 1.21'
27.9	14.8	85.2		
29.4	14.49	85.51		
33.2	13.72	86.28	Water Edge	
37.6	13.29	86.71	OHWM	



31.6 BFW (feet)

39.92 W_{culv} = 1.2*BFW+2 WDFW Stream Simulation Design Equation

40 W_{culv}, Round to nearest 10 foot

Upstream Pebble Count

*Zig-zag method started at upstream STA 41' and worked down stream towards culverts

Total Particals
100

Analysis

D_{100} (in)=	5.67		
D_{16} (in)=	0.31	D_{50} (in)=	0.83
D_{84} (in)=	**3.06**	D_{95} (in)=	4.14
D_{84} (ft)=	**0.26**		

Data

Pebble #	Size (mm)	Size (in)
1	20	0.79
2	24	0.94
3	9	0.35
4	43	1.69
5	4	0.16
6	67	2.64
7	18	0.71
8	32	1.26
9	12	0.47
10	89	3.50
11	97	3.82
12	144	5.67
13	126	4.96
14	45	1.77
15	23	0.91
16	39	1.54
17	42	1.65
18	89	3.50
19	43	1.69
20	6	0.24
21	10	0.39
22	99	3.90
23	51	2.01
24	56	2.20
25	112	4.41
26	12	0.47
27	4	0.16
28	104	4.09
29	14	0.55
30	9	0.35
31	16	0.63
32	13	0.51
33	14	0.55
34	23	0.91
35	87	3.43
36	8	0.31
37	22	0.87
38	10	0.39
39	40	1.57
40	59	2.32
41	4	0.16
42	8	0.31
43	122	4.80
44	47	1.85

Pebble #	Size (in)	Rank	Cumulative %
81	0.08	1	1%
61	0.12	2	2%
62	0.12	2	2%
5	0.16	4	4%
27	0.16	4	4%
41	0.16	4	4%
54	0.20	7	7%
98	0.20	7	7%
20	0.24	9	9%
71	0.24	9	9%
89	0.28	11	11%
36	0.31	12	12%
42	0.31	12	12%
64	0.31	12	12%
82	0.31	12	12%
88	0.31	12	12%
93	0.31	12	12%
3	0.35	18	18%
30	0.35	18	18%
66	0.35	18	18%
90	0.35	18	18%
94	0.35	18	18%
21	0.39	23	23%
38	0.39	23	23%
51	0.39	23	23%
70	0.39	23	23%
80	0.39	23	23%
96	0.39	23	23%
99	0.39	23	23%
58	0.43	30	30%
9	0.47	31	31%
26	0.47	31	31%
72	0.47	31	31%
32	0.51	34	34%
29	0.55	35	35%
33	0.55	35	35%
91	0.55	35	35%
53	0.59	38	38%
67	0.59	38	38%
69	0.59	38	38%
84	0.59	38	38%
31	0.63	42	42%
63	0.63	42	42%
83	0.63	42	42%

45	51	2.01
46	37	1.46
47	77	3.03
48	54	2.13
49	41	1.61
50	18	0.71
51	10	0.39
52	110	4.33
53	15	0.59
54	5	0.20
55	100	3.94
56	35	1.38
57	26	1.02
58	11	0.43
59	20	0.79
60	105	4.13
61	3	0.12
62	3	0.12
63	16	0.63
64	8	0.31
65	18	0.71
66	9	0.35
67	15	0.59
68	28	1.10
69	15	0.59
70	10	0.39
71	6	0.24
72	12	0.47
73	95	3.74
74	84	3.31
75	24	0.94
76	56	2.20
77	27	1.06
78	28	1.10
79	82	3.23
80	10	0.39
81	2	0.08
82	8	0.31
83	16	0.63
84	15	0.59
85	30	1.18
86	32	1.26
87	53	2.09
88	8	0.31
89	7	0.28
90	9	0.35
91	14	0.55
92	18	0.71
93	8	0.31
94	9	0.35
95	70	2.76
96	10	0.39
97	54	2.13
98	5	0.20
99	10	0.39
100	36	1.42

7	0.71	45	45%
50	0.71	45	45%
65	0.71	45	45%
92	0.71	45	45%
1	0.79	49	49%
59	0.79	49	49%
37	0.87	51	51%
15	0.91	52	52%
34	0.91	52	52%
2	0.94	54	54%
75	0.94	54	54%
57	1.02	56	56%
77	1.06	57	57%
68	1.10	58	58%
78	1.10	58	58%
85	1.18	60	60%
8	1.26	61	61%
86	1.26	61	61%
56	1.38	63	63%
100	1.42	64	64%
46	1.46	65	65%
16	1.54	66	66%
39	1.57	67	67%
49	1.61	68	68%
17	1.65	69	69%
4	1.69	70	70%
19	1.69	70	70%
14	1.77	72	72%
44	1.85	73	73%
23	2.01	74	74%
45	2.01	74	74%
87	2.09	76	76%
48	2.13	77	77%
97	2.13	77	77%
24	2.20	79	79%
76	2.20	79	79%
40	2.32	81	81%
6	2.64	82	82%
95	2.76	83	83%
47	3.03	84	84%
79	3.23	85	85%
74	3.31	86	86%
35	3.43	87	87%
10	3.50	88	88%
18	3.50	88	88%
73	3.74	90	90%
11	3.82	91	91%
22	3.90	92	92%
55	3.94	93	93%
28	4.09	94	94%
60	4.13	95	95%
52	4.33	96	96%
25	4.41	97	97%
43	4.80	98	98%
13	4.96	99	99%
12	5.67	100	100%

Bathurst Equation

$D_{84} = 3.45S^{0.747}(1.25q_c)^{2/3} / g^{1/3}$

where, D_{84} = intermediate axis of the 84th percentile particle in sediment distribution, in feet

S = energy slope of the proposed channel, ft/ft

q_c = critical unit discharge (total design discharge divided by width of bankfull channel) at which incipient motion of D84 occurs, in cubic feet per second per foot.

g = gravity, 32.2 feet/sec^2

S = 0.005 ft/ft

g = 32.2 ft/s^2

q =				
	6.36	cfs/ft	2 yr (Q=201 cfs)	Estimated with King County
	18.70	cfs/ft	25 yr (Q=591 cfs)	Stream Gauge 9a and Lake
	26.93	cfs/ft	100 yr (Q=851 cfs)	Sayer Weir Stage relationship.

Sediment Transport Particle Size,D_{84}, in feet based of Slope and flow rate

	Q_{2yr} = 201 cfs	Q_{25yr} = 591 cfs	Q_{100yr} = 851 cfs
S = 0.005	0.0825	0.1694	0.2160

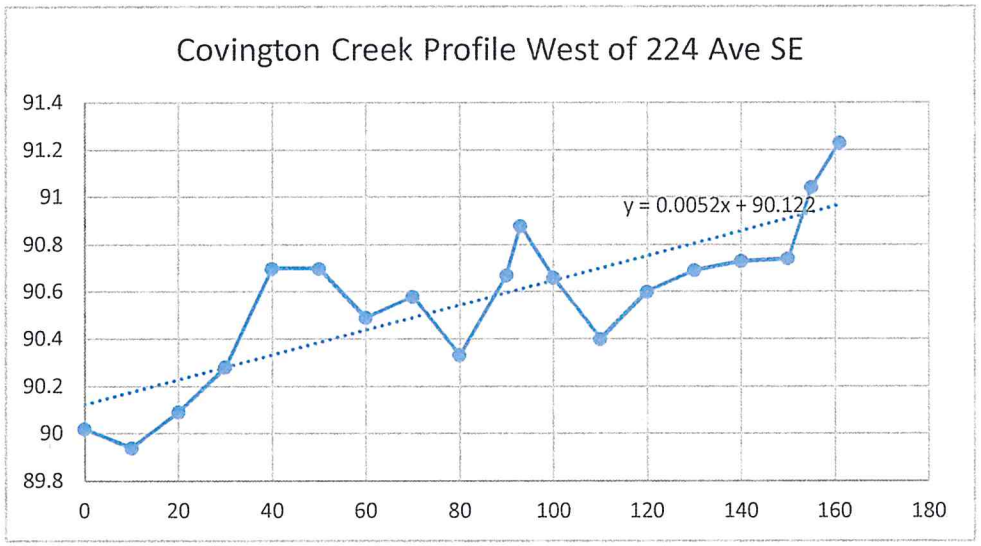
Sediment Transport Particle Size,D_{84}, in inches based of Slope and flow rate

	Q_{2yr} = 201 cfs	Q_{25yr} = 591 cfs	Q_{100yr} = 851 cfs
S = 0.005	0.99	2.03	2.59

Downstream Long profile

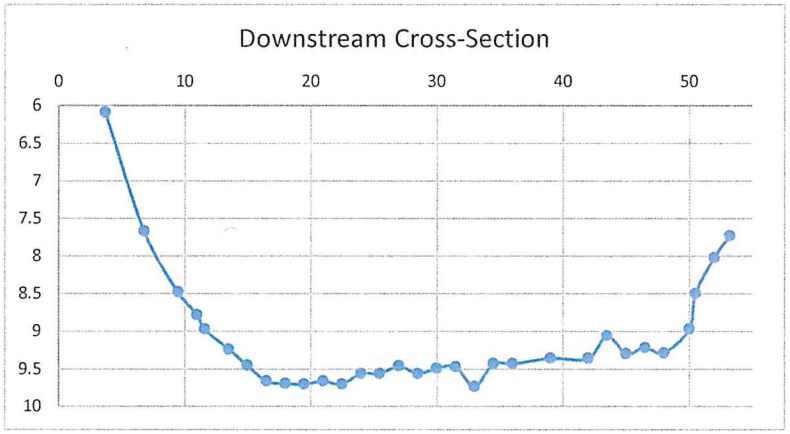
100 feet, *Arbitrary 100' elevation start point

STA	Rod Height	*Elevation	Notes
0	9.98	90.02	
10	10.06	89.94	
20	9.91	90.09	
30	9.72	90.28	
40	9.3	90.7	
50	9.3	90.7	
60	9.51	90.49	
70	9.42	90.58	
80	9.67	90.33	
90	9.33	90.67	
93	9.12	90.88	Gravel Bar
100	9.34	90.66	
110	9.6	90.4	
120	9.4	90.6	
130	9.31	90.69	
140	9.27	90.73	
150	9.26	90.74	
155	8.96	91.04	
161	8.77	91.23	Culvert IE Middle Culvert



*Measured at STA 72'

STA	Rod Height			Notes	Channel Depth
3.7	6.09			Top of left bank	3.64
6.8	7.67			OHWM LB	2.06
9.5	8.48				1.25
11	8.78				0.95
11.6	8.97			Left edge of water	0.76
13.5	9.24				0.49
15	9.45				0.28
16.5	9.66				0.07
18	9.69				0.04
19.5	9.7				0.03
21	9.66				0.07
22.5	9.7				0.03
24	9.56				0.17
25.5	9.56				0.17
27	9.46				0.27
28.5	9.56				0.17
30	9.49				0.24
31.5	9.47				0.26
33	9.73	Height after		Moved the sensor	0
34.5	9.43	sensor move	Difference	due to line of site	0.3
36	9.43	8.59	0.84	restrictions	0.3
39	9.36	8.52	0.84		0.37
42	9.36	8.52	0.84	WD: 0.38'	0.37
43.5	9.06	8.22	0.84		0.67
45	9.3	8.46	0.84		0.43
46.5	9.22	8.38	0.84		0.51
48	9.29	8.45	0.84		0.44
50	8.97	8.13	0.84	Right edge of water	0.76
50.5	8.5	7.66	0.84		1.23
52	8.02	7.18	0.84		1.71
53.2	7.73	6.89	0.84	OHWM RB	2



Note that the two edges of water are exactly the same. Therefore, moving the surveyor had no effect on the data.

46.4 BFW (feet)

57.68 W_{culv} = 1.2*BFW+2

60 W_{culv}, Round to nearest 10 foot

Downstream Pebble Count

*Zig-zag method started near downstream STA 76' and worked upstream

Total Particals
100

Analysis

D_{100} (in)=	5.51		
D_{16} (in)=	0.31	D_{50} (in)=	0.71
D_{84} (in)=	**1.86**	D_{95} (in)=	3.74
D_{84} (ft)=	**0.16**		

Data

Number	Size (mm)	Size (in)
1	14	0.55
2	69	2.72
3	21	0.83
4	82	3.23
5	18	0.71
6	15	0.59
7	32	1.26
8	94	3.70
9	6	0.24
10	71	2.80
11	112	4.41
12	25	0.98
13	26	1.02
14	27	1.06
15	49	1.93
16	15	0.59
17	13	0.51
18	7	0.28
19	12	0.47
20	13	0.51
21	16	0.63
22	5	0.20
23	6	0.24
24	10	0.39
25	8	0.31
26	15	0.59
27	9	0.35
28	44	1.73
29	54	2.13
30	12	0.47
31	47	1.85
32	124	4.88
33	119	4.69
34	25	0.98
35	47	1.85
36	9	0.35
37	12	0.47
38	30	1.18
39	34	1.34
40	36	1.42
41	12	0.47
42	5	0.20
43	8	0.31

Pebble #	Size (in)	Rank	Cumulative %
89	0.08	1	1%
65	0.12	2	2%
44	0.16	3	3%
63	0.16	3	3%
22	0.20	5	5%
42	0.20	5	5%
45	0.20	5	5%
9	0.24	8	8%
23	0.24	8	8%
46	0.24	8	8%
90	0.24	8	8%
100	0.24	8	8%
18	0.28	13	13%
48	0.28	13	13%
25	0.31	15	15%
43	0.31	15	15%
47	0.31	15	15%
64	0.31	15	15%
99	0.31	15	15%
27	0.35	20	20%
36	0.35	20	20%
70	0.35	20	20%
86	0.35	20	20%
24	0.39	24	24%
54	0.39	24	24%
87	0.39	24	24%
67	0.43	27	27%
19	0.47	28	28%
30	0.47	28	28%
37	0.47	28	28%
41	0.47	28	28%
60	0.47	28	28%
73	0.47	28	28%
77	0.47	28	28%
88	0.47	28	28%
17	0.51	36	36%
20	0.51	36	36%
61	0.51	36	36%
66	0.51	36	36%
1	0.55	40	40%
71	0.55	40	40%
6	0.59	42	42%
16	0.59	42	42%

44	4	0.16
45	5	0.20
46	6	0.24
47	8	0.31
48	7	0.28
49	19	0.75
50	50	1.97
51	20	0.79
52	50	1.97
53	60	2.36
54	10	0.39
55	15	0.59
56	30	1.18
57	18	0.71
58	50	1.97
59	30	1.18
60	12	0.47
61	13	0.51
62	19	0.75
63	4	0.16
64	8	0.31
65	3	0.12
66	13	0.51
67	11	0.43
68	18	0.71
69	38	1.50
70	9	0.35
71	14	0.55
72	30	1.18
73	12	0.47
74	15	0.59
75	118	4.65
76	140	5.51
77	12	0.47
78	50	1.97
79	40	1.57
80	24	0.94
81	15	0.59
82	44	1.73
83	36	1.42
84	24	0.94
85	20	0.79
86	9	0.35
87	10	0.39
88	12	0.47
89	2	0.08
90	6	0.24
91	35	1.38
92	40	1.57
93	19	0.75
94	32	1.26
95	35	1.38
96	38	1.50
97	30	1.18
98	18	0.71
99	8	0.31
100	6	0.24

26	0.59	42	42%
55	0.59	42	42%
74	0.59	42	42%
81	0.59	42	42%
21	0.63	48	48%
5	0.71	49	49%
57	0.71	49	49%
68	0.71	49	49%
98	0.71	49	49%
49	0.75	53	53%
62	0.75	53	53%
93	0.75	53	53%
51	0.79	56	56%
85	0.79	56	56%
3	0.83	58	58%
80	0.94	59	59%
84	0.94	59	59%
12	0.98	61	61%
34	0.98	61	61%
13	1.02	63	63%
14	1.06	64	64%
38	1.18	65	65%
56	1.18	65	65%
59	1.18	65	65%
72	1.18	65	65%
97	1.18	65	65%
7	1.26	70	70%
94	1.26	70	70%
39	1.34	72	72%
91	1.38	73	73%
95	1.38	73	73%
40	1.42	75	75%
83	1.42	75	75%
69	1.50	77	77%
96	1.50	77	77%
79	1.57	79	79%
92	1.57	79	79%
28	1.73	81	81%
82	1.73	81	81%
31	1.85	83	83%
35	1.85	83	83%
15	1.93	85	85%
50	1.97	86	86%
52	1.97	86	86%
58	1.97	86	86%
78	1.97	86	86%
29	2.13	90	90%
53	2.36	91	91%
2	2.72	92	92%
10	2.80	93	93%
4	3.23	94	94%
8	3.70	95	95%
11	4.41	96	96%
75	4.65	97	97%
33	4.69	98	98%
32	4.88	99	99%
76	5.51	100	100%

Bathurst Equation

$D_{84} = 3.45S^{0.747}(1.25q_c)^{2/3} / g^{1/3}$

where, D_{84} = intermediate axis of the 84th percentile particle in sediment distribution, in feet

S = energy slope of the proposed channel, ft/ft

q_c = critical unit discharge (total design discharge divided by width of bankfull channel) at which incipient motion of D84 occurs, in cubic feet per second per foot.

g = gravity, 32.2 feet/sec^2

S = 0.005

g = 32.2 ft/s^2

q =	4.33	cfs/ft	2 yr (Q=201 cfs)	Estimated with King County
	12.74	cfs/ft	25 yr (Q=591 cfs)	Stream Gauge 9a and Lake
	18.34	cfs/ft	100 yr (Q=851 cfs)	Sayer Weir Stage relationship.

Sediment Transport Particle Size,D_{84}, in feet based of Slope and flow rate

	Q_{2yr} = 201 cfs	Q_{25yr} = 591 cfs	Q_{100yr} = 851 cfs
S = 0.005	0.0639	0.1311	0.1672

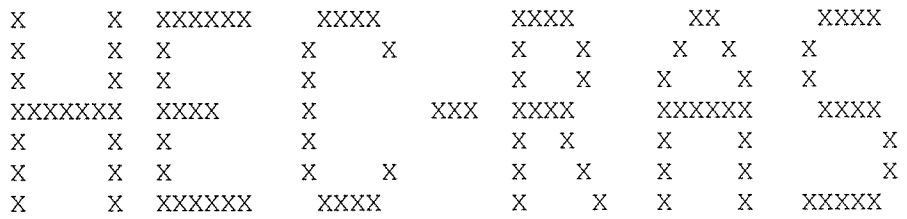
Sediment Transport Particle Size,D_{84}, in inches based of Slope and flow rate

	Q_{2yr} = 201 cfs	Q_{25yr} = 591 cfs	Q_{100yr} = 851 cfs
S = 0.005	0.77	1.57	2.01

Attachment B

HEC-RAS Model Output

HEC-RAS HEC-RAS 5.0.1 April 2016
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California



PROJECT DATA
Project Title: CovingtonCreek
Project File : CovingtonCreek2.prj
Run Date and Time: 12/19/2016 1:42:06 PM

Project in English units

PLAN DATA

Plan Title: Plan 02
Plan File : u:\PSO\Projects\Clients\3043-BlackDiamondCityof\213-3043-025
CovingtonCreekCulvert\02WBS\T5-PrelimDsn\Hydro\HEC-RAS\CovingtonCreek2.p02

Geometry Title: CovingtonCreek
Geometry File : u:\PSO\Projects\Clients\3043-BlackDiamondCityof\213-3043-025
CovingtonCreekCulvert\02WBS\T5-PrelimDsn\Hydro\HEC-RAS\CovingtonCreek2.g04

```
          Flow Title    : CovingtonCreek
          Flow File     : u:\PSO\Projects\Clients\3043-BlackDiamondCityof\213-3043-025
CovingtonCreekCulvert\02WBS\T5-PrelimDsn\Hydro\HEC-RAS\CovingtonCreek2.f04

Plan Summary Information:
Number of:  Cross Sections =    6    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    1    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow



FLOW DATA

Flow Title: CovingtonCreek
Flow File : u:\PSO\Projects\Clients\3043-BlackDiamondCityof\213-3043-025
CovingtonCreekCulvert\02WBS\T5-PrelimDsn\Hydro\HEC-RAS\CovingtonCreek2.f04

Flow Data (cfs)

  River           Reach           RS                    2-yr           10-yr           25-yr
100-yr
  CovingtonCreek  1               175.73                 200             411             591
851
```

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
CovingtonCreek	1	2-yr	Critical	Critical
CovingtonCreek	1	10-yr	Critical	Critical
CovingtonCreek	1	25-yr	Critical	Critical

GEOMETRY DATA

Geometry Title: CovingtonCreek
Geometry File : u:\PSO\Projects\Clients\3043-BlackDiamondCityof\213-3043-025 CovingtonCreekCulvert\02WBS\T5-PrelimDsn\Hydro\HEC-RAS\CovingtonCreek2.g04

CROSS SECTION

RIVER: CovingtonCreek
REACH: 1 RS: 175.73

INPUT
Description:
Station Elevation Data num= 9

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-45.39	525.32	-39.12	524.99	-33.46	521.14	-18.94	520.7	-18.35	517.57
-5.64	517.29	8.33	518.27	11.88	522.33	17.77	523.42		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-45.39	.1	-33.46	.05	11.88	.1

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-33.46	11.88	27.31	27.31	.1	.3

CROSS SECTION OUTPUT Profile #2-yr

E.G. Elev (ft)	521.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.05	Wt. n-Val.	0.100	0.050	
W.S. Elev (ft)	521.26	Reach Len. (ft)	27.31	27.31	27.31
Crit W.S. (ft)		Flow Area (sq ft)	0.01	107.39	
E.G. Slope (ft/ft)	0.001357	Area (sq ft)	0.01	107.39	
Q Total (cfs)	200.00	Flow (cfs)	0.00	200.00	
Top Width (ft)	44.58	Top Width (ft)	0.18	44.40	
Vel Total (ft/s)	1.86	Avg. Vel. (ft/s)	0.07	1.86	
Max Chl Dpth (ft)	3.97	Hydr. Depth (ft)	0.06	2.42	
Conv. Total (cfs)	5429.3	Conv. (cfs)	0.0	5429.3	
Length Wtd. (ft)	27.31	Wetted Per. (ft)	0.21	48.40	
Min Ch El (ft)	517.29	Shear (lb/sq ft)	0.00	0.19	
Alpha	1.00	Stream Power (lb/ft s)	0.00	0.35	
Frctn Loss (ft)	0.04	Cum Volume (acre-ft)	0.00	0.24	0.00
C & E Loss (ft)	0.00	Cum SA (acres)	0.00	0.14	0.00

CROSS SECTION OUTPUT Profile #10-yr

E.G. Elev (ft)	522.58	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.10	Wt. n-Val.	0.100	0.050	0.100
W.S. Elev (ft)	522.48	Reach Len. (ft)	27.31	27.31	27.31
Crit W.S. (ft)		Flow Area (sq ft)	1.31	162.06	0.06
E.G. Slope (ft/ft)	0.001507	Area (sq ft)	1.31	162.06	0.06
Q Total (cfs)	411.00	Flow (cfs)	0.51	410.48	0.01
Top Width (ft)	48.10	Top Width (ft)	1.97	45.34	0.79
Vel Total (ft/s)	2.51	Avg. Vel. (ft/s)	0.39	2.53	0.10
Max Chl Dpth (ft)	5.19	Hydr. Depth (ft)	0.67	3.57	0.07
Conv. Total (cfs)	10586.8	Conv. (cfs)	13.1	10573.5	0.1
Length Wtd. (ft)	27.31	Wetted Per. (ft)	2.38	49.82	0.81
Min Ch El (ft)	517.29	Shear (lb/sq ft)	0.05	0.31	0.01
Alpha	1.01	Stream Power (lb/ft s)	0.02	0.78	0.00
Frctn Loss (ft)	0.04	Cum Volume (acre-ft)	0.00	0.37	0.00
C & E Loss (ft)	0.00	Cum SA (acres)	0.00	0.14	0.00

CROSS SECTION OUTPUT Profile #25-yr

E.G. Elev (ft)	523.59	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.12	Wt. n-Val.	0.100	0.050	0.100
W.S. Elev (ft)	523.47	Reach Len. (ft)	27.31	27.31	27.31
Crit W.S. (ft)		Flow Area (sq ft)	3.99	207.07	3.50
E.G. Slope (ft/ft)	0.001364	Area (sq ft)	3.99	207.07	3.50
Q Total (cfs)	591.00	Flow (cfs)	2.13	587.53	1.34
Top Width (ft)	54.65	Top Width (ft)	3.42	45.34	5.89
Vel Total (ft/s)	2.75	Avg. Vel. (ft/s)	0.54	2.84	0.38
Max Chl Dpth (ft)	6.18	Hydr. Depth (ft)	1.16	4.57	0.59
Conv. Total (cfs)	16001.7	Conv. (cfs)	57.8	15907.8	36.2
Length Wtd. (ft)	27.31	Wetted Per. (ft)	4.14	49.82	6.04
Min Ch El (ft)	517.29	Shear (lb/sq ft)	0.08	0.35	0.05
Alpha	1.06	Stream Power (lb/ft s)	0.04	1.00	0.02
Frctn Loss (ft)	0.04	Cum Volume (acre-ft)	0.00	0.46	0.01
C & E Loss (ft)	0.00	Cum SA (acres)	0.00	0.14	0.01

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #100-yr

E.G. Elev (ft)	525.57	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.12	Wt. n-Val.	0.100	0.050	0.100
W.S. Elev (ft)	525.45	Reach Len. (ft)	27.31	27.31	27.31
Crit W.S. (ft)		Flow Area (sq ft)	15.35	296.86	15.17
E.G. Slope (ft/ft)	0.000827	Area (sq ft)	15.35	296.86	15.17
Q Total (cfs)	851.00	Flow (cfs)	7.23	833.86	9.91
Top Width (ft)	63.16	Top Width (ft)	11.93	45.34	5.89
Vel Total (ft/s)	2.60	Avg. Vel. (ft/s)	0.47	2.81	0.65
Max Chl Dpth (ft)	8.16	Hydr. Depth (ft)	1.29	6.55	2.57
Conv. Total (cfs)	29591.9	Conv. (cfs)	251.5	28995.9	344.6
Length Wtd. (ft)	27.31	Wetted Per. (ft)	13.25	49.82	8.02
Min Ch El (ft)	517.29	Shear (lb/sq ft)	0.06	0.31	0.10
Alpha	1.15	Stream Power (lb/ft s)	0.03	0.86	0.06
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.01	0.58	0.02
C & E Loss (ft)	0.00	Cum SA (acres)	0.01	0.13	0.01

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION

RIVER: CovingtonCreek
REACH: 1 RS: 148.42

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-32.25	526.85	-18.7	521.77	-13.48	519.32	1.29	517.73	16.05	518.19
18.33	520.46	35.4	525.2						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-32.25	.1	-18.7	.05	18.33	.1

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-18.7	18.33	8.6	8.6	.1	.3

CROSS SECTION OUTPUT Profile #2-yr

			Left OB	Channel	Right OB
E.G. Elev (ft)	521.27	Element			
Vel Head (ft)	0.07	Wt. n-Val.		0.050	0.100
W.S. Elev (ft)	521.21	Reach Len. (ft)	8.60	8.60	8.60
Crit W.S. (ft)		Flow Area (sq ft)		95.62	1.00
E.G. Slope (ft/ft)	0.001407	Area (sq ft)		95.62	1.00
Q Total (cfs)	200.00	Flow (cfs)		199.72	0.28
Top Width (ft)	38.52	Top Width (ft)		35.83	2.69
Vel Total (ft/s)	2.07	Avg. Vel. (ft/s)		2.09	0.28
Max Chl Dpth (ft)	3.48	Hydr. Depth (ft)		2.67	0.37
Conv. Total (cfs)	5332.1	Conv. (cfs)		5324.5	7.6
Length Wtd. (ft)	8.60	Wetted Per. (ft)		37.28	2.79
Min Ch El (ft)	517.73	Shear (lb/sq ft)		0.23	0.03

Alpha	1.02	Stream Power (lb/ft s)	0.47	0.01
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.18	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.11	0.00

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #10-yr

E.G. Elev (ft)	522.53	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.13	Wt. n-Val.	0.100	0.050	0.100
W.S. Elev (ft)	522.40	Reach Len. (ft)	8.60	8.60	8.60
Crit W.S. (ft)		Flow Area (sq ft)	0.53	139.39	6.76
E.G. Slope (ft/ft)	0.001741	Area (sq ft)	0.53	139.39	6.76
Q Total (cfs)	411.00	Flow (cfs)	0.14	406.85	4.01
Top Width (ft)	45.68	Top Width (ft)	1.68	37.03	6.98
Vel Total (ft/s)	2.80	Avg. Vel. (ft/s)	0.27	2.92	0.59
Max Chl Dpth (ft)	4.67	Hydr. Depth (ft)	0.31	3.76	0.97
Conv. Total (cfs)	9848.9	Conv. (cfs)	3.5	9749.4	96.0
Length Wtd. (ft)	8.60	Wetted Per. (ft)	1.79	38.61	7.24
Min Ch El (ft)	517.73	Shear (lb/sq ft)	0.03	0.39	0.10
Alpha	1.07	Stream Power (lb/ft s)	0.01	1.15	0.06
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.00	0.27	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.00	0.11	0.00

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #25-yr

E.G. Elev (ft)	523.55	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.16	Wt. n-Val.	0.100	0.050	0.100
W.S. Elev (ft)	523.39	Reach Len. (ft)	8.60	8.60	8.60
Crit W.S. (ft)		Flow Area (sq ft)	3.48	175.97	15.41

E.G. Slope (ft/ft)	0.001615	Area (sq ft)	3.48	175.97	15.41
Q Total (cfs)	591.00	Flow (cfs)	1.73	577.70	11.57
Top Width (ft)	51.88	Top Width (ft)	4.31	37.03	10.54
Vel Total (ft/s)	3.03	Avg. Vel. (ft/s)	0.50	3.28	0.75
Max Chl Dpth (ft)	5.66	Hydr. Depth (ft)	0.81	4.75	1.46
Conv. Total (cfs)	14707.2	Conv. (cfs)	43.0	14376.3	288.0
Length Wtd. (ft)	8.60	Wetted Per. (ft)	4.60	38.61	10.94
Min Ch El (ft)	517.73	Shear (lb/sq ft)	0.08	0.46	0.14
Alpha	1.15	Stream Power (lb/ft s)	0.04	1.51	0.11
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.00	0.34	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.00	0.11	0.00

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #100-yr

E.G. Elev (ft)	525.54	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.15	Wt. n-Val.	0.100	0.050	0.100
W.S. Elev (ft)	525.39	Reach Len. (ft)	8.60	8.60	8.60
Crit W.S. (ft)		Flow Area (sq ft)	17.49	250.23	43.72
E.G. Slope (ft/ft)	0.000965	Area (sq ft)	17.49	250.23	43.72
Q Total (cfs)	851.00	Flow (cfs)	11.48	802.94	36.59
Top Width (ft)	63.76	Top Width (ft)	9.66	37.03	17.07
Vel Total (ft/s)	2.73	Avg. Vel. (ft/s)	0.66	3.21	0.84
Max Chl Dpth (ft)	7.66	Hydr. Depth (ft)	1.81	6.76	2.56
Conv. Total (cfs)	27399.0	Conv. (cfs)	369.5	25851.5	1178.0
Length Wtd. (ft)	8.60	Wetted Per. (ft)	10.32	38.61	17.91
Min Ch El (ft)	517.73	Shear (lb/sq ft)	0.10	0.39	0.15
Alpha	1.31	Stream Power (lb/ft s)	0.07	1.25	0.12
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.41	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.00	0.10	0.00

Warning: The cross-section end points had to be extended vertically for the computed water surface.

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: CovingtonCreek
REACH: 1 RS: 135

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-6.25	520.5	3.17	518.95	9.8	518.46	16.54	518.97	23.17	518.93
25.06	519.65	26.3	519.43						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-6.25	.1	-6.25	.05	26.3	.1

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-6.25	26.3	78	78	.1	.3

CROSS SECTION OUTPUT Profile #2-yr

			Left OB	Channel	Right OB
E.G. Elev (ft)	521.25	Element			
Vel Head (ft)	0.15	Wt. n-Val.		0.050	
W.S. Elev (ft)	521.10	Reach Len. (ft)	4.00	4.00	4.00
Crit W.S. (ft)	520.13	Flow Area (sq ft)		64.38	
E.G. Slope (ft/ft)	0.004871	Area (sq ft)		64.38	
Q Total (cfs)	200.00	Flow (cfs)		200.00	
Top Width (ft)	32.55	Top Width (ft)		32.55	
Vel Total (ft/s)	3.11	Avg. Vel. (ft/s)		3.11	
Max Chl Dpth (ft)	2.64	Hydr. Depth (ft)		1.98	
Conv. Total (cfs)	2865.6	Conv. (cfs)		2865.6	
Length Wtd. (ft)	4.00	Wetted Per. (ft)		35.13	
Min Ch El (ft)	518.46	Shear (lb/sq ft)		0.56	

Alpha	1.00	Stream Power (lb/ft s)	1.73
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.16
C & E Loss (ft)	0.00	Cum SA (acres)	0.10

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #10-yr

E.G. Elev (ft)	522.49	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.25	Wt. n-Val.		0.050	
W.S. Elev (ft)	522.24	Reach Len. (ft)	4.00	4.00	4.00
Crit W.S. (ft)	520.83	Flow Area (sq ft)		101.59	
E.G. Slope (ft/ft)	0.004892	Area (sq ft)		101.59	
Q Total (cfs)	411.00	Flow (cfs)		411.00	
Top Width (ft)	32.55	Top Width (ft)		32.55	
Vel Total (ft/s)	4.05	Avg. Vel. (ft/s)		4.05	
Max Chl Dpth (ft)	3.78	Hydr. Depth (ft)		3.12	
Conv. Total (cfs)	5876.0	Conv. (cfs)		5876.0	
Length Wtd. (ft)	4.00	Wetted Per. (ft)		37.41	
Min Ch El (ft)	518.46	Shear (lb/sq ft)		0.83	
Alpha	1.00	Stream Power (lb/ft s)		3.36	
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)		0.25	
C & E Loss (ft)	0.01	Cum SA (acres)		0.11	

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #25-yr

E.G. Elev (ft)	523.51	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.31	Wt. n-Val.		0.050	
W.S. Elev (ft)	523.21	Reach Len. (ft)	4.00	4.00	4.00
Crit W.S. (ft)	521.29	Flow Area (sq ft)		133.12	

E.G. Slope (ft/ft)	0.004395	Area (sq ft)	133.12
Q Total (cfs)	591.00	Flow (cfs)	591.00
Top Width (ft)	32.55	Top Width (ft)	32.55
Vel Total (ft/s)	4.44	Avg. Vel. (ft/s)	4.44
Max Chl Dpth (ft)	4.75	Hydr. Depth (ft)	4.09
Conv. Total (cfs)	8915.0	Conv. (cfs)	8915.0
Length Wtd. (ft)	4.00	Wetted Per. (ft)	39.35
Min Ch El (ft)	518.46	Shear (lb/sq ft)	0.93
Alpha	1.00	Stream Power (lb/ft s)	4.12
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)	0.31
C & E Loss (ft)	0.02	Cum SA (acres)	0.11

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #100-yr

E.G. Elev (ft)	525.52	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.28	Wt. n-Val.		0.050	
W.S. Elev (ft)	525.23	Reach Len. (ft)	4.00	4.00	4.00
Crit W.S. (ft)	521.88	Flow Area (sq ft)		199.03	
E.G. Slope (ft/ft)	0.002717	Area (sq ft)		199.03	
Q Total (cfs)	851.00	Flow (cfs)		851.00	
Top Width (ft)	32.55	Top Width (ft)		32.55	
Vel Total (ft/s)	4.28	Avg. Vel. (ft/s)		4.28	
Max Chl Dpth (ft)	6.77	Hydr. Depth (ft)		6.11	
Conv. Total (cfs)	16325.9	Conv. (cfs)		16325.9	
Length Wtd. (ft)	4.00	Wetted Per. (ft)		43.40	
Min Ch El (ft)	518.46	Shear (lb/sq ft)		0.78	
Alpha	1.00	Stream Power (lb/ft s)		3.33	
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)		0.37	

C & E Loss (ft) 0.05 Cum SA (acres) 0.10

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

BRIDGE

RIVER: CovingtonCreek
REACH: 1 RS: 131.88

INPUT
Description:
Distance from Upstream XS = 4
Deck/Roadway Width = 72
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 12

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
-11.37	525.83	514.21	-10.54	525.83	514.21	-7.37	525.83	519.43
-4.03	525.83	521.64	2	525.83	523.3	9.46	525.83	524
13.95	525.83	523.75	20	525.83	522.59	23.85	525.83	521.23
26.28	525.83	519.48	29.46	525.83	514.21	30.3	525.83	514.21

Upstream Bridge Cross Section Data
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-6.25	520.5	3.17	518.95	9.8	518.46	16.54	518.97	23.17	518.93

```
   25.06  519.65    26.3  519.43

Manning's n Values          num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   -6.25      .1   -6.25     .05    26.3      .1

Bank Sta: Left   Right    Coeff Contr.   Expan.
         -6.25    26.3             .1       .3

Downstream  Deck/Roadway Coordinates
    num=      12
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
  -11.37  525.26  514.21  -10.54  525.27  514.21   -7.37  525.37  518.51
   -4.03   525.4  520.99       2  525.52  523.02    9.46  525.67  523.98
   13.95  525.76  523.86      20  525.88  522.89   23.85  525.96   521.8
   26.28  526.01  520.56   29.46  526.07  514.21    30.3  526.09  514.21

Downstream Bridge Cross Section Data
Station Elevation Data    num=       7
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    -4.9  520.41       0  519.45      10  518.43   15.44  518.02      20  518.53
   25.53  518.77   27.73  519.32

Manning's n Values          num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    -4.9      .1    -4.9     .05   27.73      .1

Bank Sta: Left   Right    Coeff Contr.   Expan.
          -4.9   27.73             .1       .3

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested
```

Number of Bridge Coefficient Sets = 1

Low Flow Methods and Data
Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Energy Only

Additional Bridge Parameters
Add Friction component to Momentum
Do not add Weight component to Momentum
Class B flow critical depth computations use critical depth
inside the bridge at the upstream end
Criteria to check for pressure flow = Upstream energy grade line

BRIDGE OUTPUT Profile #2-yr

E.G. US. (ft)	521.25	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	521.10	E.G. Elev (ft)	521.22	520.61
Q Total (cfs)	200.00	W.S. Elev (ft)	521.05	520.33
Q Bridge (cfs)	200.00	Crit W.S. (ft)	520.14	519.83
Q Weir (cfs)		Max Chl Dpth (ft)	2.59	2.31
Weir Sta Lft (ft)		Vel Total (ft/s)	3.29	4.19
Weir Sta Rgt (ft)		Flow Area (sq ft)	60.77	47.74
Weir Submerg		Froude # Chl	0.36	0.49
Weir Max Depth (ft)		Specif Force (cu ft)	84.67	67.70
Min El Weir Flow (ft)	525.84	Hydr Depth (ft)	2.09	1.54
Min El Prs (ft)	524.00	W.P. Total (ft)	36.34	33.07
Delta EG (ft)	0.67	Conv. Total (cfs)	2544.5	1812.1
Delta WS (ft)	0.78	Top Width (ft)	29.01	30.90
BR Open Area (sq ft)	117.69	Frctn Loss (ft)	0.61	0.02
BR Open Vel (ft/s)	4.19	C & E Loss (ft)	0.01	0.00
BR Sluice Coef		Shear Total (lb/sq ft)	0.65	1.10
BR Sel Method	Energy only	Power Total (lb/ft s)	2.12	4.60

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

BRIDGE OUTPUT Profile #10-yr

E.G. US. (ft)	522.49	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	522.24	E.G. Elev (ft)	522.46	521.61
Q Total (cfs)	411.00	W.S. Elev (ft)	522.13	521.08
Q Bridge (cfs)	411.00	Crit W.S. (ft)	520.82	520.54
Q Weir (cfs)		Max Chl Dpth (ft)	3.67	3.06
Weir Sta Lft (ft)		Vel Total (ft/s)	4.59	5.84
Weir Sta Rgt (ft)		Flow Area (sq ft)	89.50	70.35
Weir Submerg		Froude # Chl	0.42	0.59
Weir Max Depth (ft)		Specif Force (cu ft)	204.38	160.40
Min El Weir Flow (ft)	525.84	Hydr Depth (ft)	3.80	2.42
Min El Prs (ft)	524.00	W.P. Total (ft)	42.26	36.07
Delta EG (ft)	0.93	Conv. Total (cfs)	4386.3	3263.6
Delta WS (ft)	1.17	Top Width (ft)	23.54	29.03
BR Open Area (sq ft)	117.69	Frctn Loss (ft)	0.83	0.03
BR Open Vel (ft/s)	5.84	C & E Loss (ft)	0.02	0.01
BR Sluice Coef		Shear Total (lb/sq ft)	1.16	1.93
BR Sel Method	Energy only	Power Total (lb/ft s)	5.33	11.28

BRIDGE OUTPUT Profile #25-yr

E.G. US. (ft)	523.51	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	523.21	E.G. Elev (ft)	523.47	522.30
Q Total (cfs)	591.00	W.S. Elev (ft)	523.00	521.48
Q Bridge (cfs)	591.00	Crit W.S. (ft)	521.29	521.00
Q Weir (cfs)		Max Chl Dpth (ft)	4.54	3.46
Weir Sta Lft (ft)		Vel Total (ft/s)	5.51	7.24
Weir Sta Rgt (ft)		Flow Area (sq ft)	107.25	81.63
Weir Submerg		Froude # Chl	0.46	0.69
Weir Max Depth (ft)		Specif Force (cu ft)	332.49	249.36
Min El Weir Flow (ft)	525.84	Hydr Depth (ft)	6.32	3.02
Min El Prs (ft)	524.00	W.P. Total (ft)	49.06	38.21

Delta EG (ft)	1.29	Conv. Total (cfs)	5368.5	4023.5
Delta WS (ft)	1.69	Top Width (ft)	16.97	27.05
BR Open Area (sq ft)	117.69	Frctn Loss (ft)	1.14	0.04
BR Open Vel (ft/s)	7.24	C & E Loss (ft)	0.03	0.03
BR Sluice Coef		Shear Total (lb/sq ft)	1.65	2.88
BR Sel Method	Energy only	Power Total (lb/ft s)	9.11	20.83

Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

BRIDGE OUTPUT Profile #100-yr

E.G. US. (ft)	525.52	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	525.23	E.G. Elev (ft)	525.44	523.19
Q Total (cfs)	851.00	W.S. Elev (ft)	524.63	521.82
Q Bridge (cfs)	851.00	Crit W.S. (ft)	521.86	521.57
Q Weir (cfs)		Max Chl Dpth (ft)	6.17	3.80
Weir Sta Lft (ft)		Vel Total (ft/s)	7.23	9.41
Weir Sta Rgt (ft)		Flow Area (sq ft)	117.69	90.43
Weir Submerg		Froude # Chl	0.51	0.85
Weir Max Depth (ft)		Specif Force (cu ft)	610.23	394.16
Min El Weir Flow (ft)	525.84	Hydr Depth (ft)		3.56
Min El Prs (ft)	524.00	W.P. Total (ft)	66.18	40.03
Delta EG (ft)	2.47	Conv. Total (cfs)	5133.8	4626.8
Delta WS (ft)	3.26	Top Width (ft)		25.37
BR Open Area (sq ft)	117.69	Frctn Loss (ft)	2.19	0.05
BR Open Vel (ft/s)	9.41	C & E Loss (ft)	0.06	0.09
BR Sluice Coef		Shear Total (lb/sq ft)	3.05	4.77
BR Sel Method	Energy only	Power Total (lb/ft s)	22.06	44.90

Note: Momentum answer is not valid if the water surface is above the low chord or if there is weir flow. The momentum
answer has been disregarded.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross

sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION

RIVER: CovingtonCreek
REACH: 1 RS: 65

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-4.9	520.41	0	519.45	10	518.43	15.44	518.02	20	518.53
25.53	518.77	27.73	519.32						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-4.9	.1	-4.9	.05	27.73	.1

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-4.9	27.73	.78	.78	.1	.3

CROSS SECTION OUTPUT Profile #2-yr

E.G. Elev (ft)	520.58	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.27	Wt. n-Val.		0.050	
W.S. Elev (ft)	520.31	Reach Len. (ft)	0.78	0.78	0.78
Crit W.S. (ft)		Flow Area (sq ft)		48.26	
E.G. Slope (ft/ft)	0.011891	Area (sq ft)		48.26	
Q Total (cfs)	200.00	Flow (cfs)		200.00	
Top Width (ft)	32.13	Top Width (ft)		32.13	
Vel Total (ft/s)	4.14	Avg. Vel. (ft/s)		4.14	
Max Chl Dpth (ft)	2.29	Hydr. Depth (ft)		1.50	
Conv. Total (cfs)	1834.1	Conv. (cfs)		1834.1	
Length Wtd. (ft)	0.78	Wetted Per. (ft)		33.38	

Min Ch El (ft)	518.02	Shear (lb/sq ft)	1.07
Alpha	1.00	Stream Power (lb/ft s)	4.45
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.06
C & E Loss (ft)	0.02	Cum SA (acres)	0.05

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #10-yr

E.G. Elev (ft)	521.57	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.49	Wt. n-Val.		0.050	
W.S. Elev (ft)	521.07	Reach Len. (ft)	0.78	0.78	0.78
Crit W.S. (ft)		Flow Area (sq ft)		73.07	
E.G. Slope (ft/ft)	0.013582	Area (sq ft)		73.07	
Q Total (cfs)	411.00	Flow (cfs)		411.00	
Top Width (ft)	32.63	Top Width (ft)		32.63	
Vel Total (ft/s)	5.62	Avg. Vel. (ft/s)		5.62	
Max Chl Dpth (ft)	3.05	Hydr. Depth (ft)		2.24	
Conv. Total (cfs)	3526.6	Conv. (cfs)		3526.6	
Length Wtd. (ft)	0.78	Wetted Per. (ft)		35.31	
Min Ch El (ft)	518.02	Shear (lb/sq ft)		1.75	
Alpha	1.00	Stream Power (lb/ft s)		9.87	
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)		0.10	
C & E Loss (ft)	0.04	Cum SA (acres)		0.06	

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #25-yr

E.G. Elev (ft)	522.23	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.71	Wt. n-Val.		0.050	
W.S. Elev (ft)	521.52	Reach Len. (ft)	0.78	0.78	0.78
Crit W.S. (ft)		Flow Area (sq ft)		87.58	
E.G. Slope (ft/ft)	0.015872	Area (sq ft)		87.58	
Q Total (cfs)	591.00	Flow (cfs)		591.00	
Top Width (ft)	32.63	Top Width (ft)		32.63	

Vel Total (ft/s)	6.75	Avg. Vel. (ft/s)	6.75
Max Chl Dpth (ft)	3.50	Hydr. Depth (ft)	2.68
Conv. Total (cfs)	4691.0	Conv. (cfs)	4691.0
Length Wtd. (ft)	0.78	Wetted Per. (ft)	36.20
Min Ch El (ft)	518.02	Shear (lb/sq ft)	2.40
Alpha	1.00	Stream Power (lb/ft s)	16.18
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.13
C & E Loss (ft)	0.09	Cum SA (acres)	0.07

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #100-yr

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	523.05	Wt. n-Val.		0.050	
Vel Head (ft)	1.07	Reach Len. (ft)	0.78	0.78	0.78
W.S. Elev (ft)	521.98	Flow Area (sq ft)		102.50	
Crit W.S. (ft)		Area (sq ft)		102.50	
E.G. Slope (ft/ft)	0.020140	Flow (cfs)		851.00	
Q Total (cfs)	851.00	Top Width (ft)		32.63	
Top Width (ft)	32.63	Avg. Vel. (ft/s)		8.30	
Vel Total (ft/s)	8.30	Hydr. Depth (ft)		3.14	
Max Chl Dpth (ft)	3.96	Conv. (cfs)		5996.5	
Conv. Total (cfs)	5996.5	Wetted Per. (ft)		37.11	
Length Wtd. (ft)	0.78	Shear (lb/sq ft)		3.47	
Min Ch El (ft)	518.02	Stream Power (lb/ft s)		28.83	
Alpha	1.00	Cum Volume (acre-ft)		0.18	
Frctn Loss (ft)	0.01	Cum SA (acres)		0.07	
C & E Loss (ft)	0.17				

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.

CROSS SECTION

RIVER: CovingtonCreek
REACH: 1 RS: 61.05

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-39.64	522.75	-12.31	519.76	-6.41	518.61	4.73	518.02	16.03	518.91
23.97	523.49	40.84	528.2						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-39.64	.05	-39.64	.05	23.97	.05

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-39.64	23.97	65.32	61.05	54.41	.1	.3

CROSS SECTION OUTPUT Profile #2-yr

			Left OB	Channel	Right OB
E.G. Elev (ft)	520.56	Element			
Vel Head (ft)	0.21	Wt. n-Val.		0.050	
W.S. Elev (ft)	520.34	Reach Len. (ft)	65.32	61.05	54.41
Crit W.S. (ft)	519.70	Flow Area (sq ft)		53.94	
E.G. Slope (ft/ft)	0.009321	Area (sq ft)		53.94	
Q Total (cfs)	200.00	Flow (cfs)		200.00	
Top Width (ft)	36.14	Top Width (ft)		36.14	
Vel Total (ft/s)	3.71	Avg. Vel. (ft/s)		3.71	
Max Chl Dpth (ft)	2.32	Hydr. Depth (ft)		1.49	
Conv. Total (cfs)	2071.5	Conv. (cfs)		2071.5	
Length Wtd. (ft)	61.05	Wetted Per. (ft)		36.72	
Min Ch El (ft)	518.02	Shear (lb/sq ft)		0.85	
Alpha	1.00	Stream Power (lb/ft s)		3.17	
Frctn Loss (ft)	1.01	Cum Volume (acre-ft)		0.06	
C & E Loss (ft)	0.03	Cum SA (acres)		0.05	

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION OUTPUT Profile #10-yr

E.G. Elev (ft)	521.51	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.34	Wt. n-Val.		0.050	
W.S. Elev (ft)	521.17	Reach Len. (ft)	65.32	61.05	54.41
Crit W.S. (ft)	520.45	Flow Area (sq ft)		87.53	
E.G. Slope (ft/ft)	0.010578	Area (sq ft)		87.53	
Q Total (cfs)	411.00	Flow (cfs)		411.00	
Top Width (ft)	45.13	Top Width (ft)		45.13	
Vel Total (ft/s)	4.70	Avg. Vel. (ft/s)		4.70	
Max Chl Dpth (ft)	3.15	Hydr. Depth (ft)		1.94	
Conv. Total (cfs)	3996.2	Conv. (cfs)		3996.2	
Length Wtd. (ft)	61.05	Wetted Per. (ft)		45.97	
Min Ch El (ft)	518.02	Shear (lb/sq ft)		1.26	
Alpha	1.00	Stream Power (lb/ft s)		5.90	
Frctn Loss (ft)	1.05	Cum Volume (acre-ft)		0.10	
C & E Loss (ft)	0.04	Cum SA (acres)		0.06	

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION OUTPUT Profile #25-yr

E.G. Elev (ft)	522.13	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.42	Wt. n-Val.		0.050	
W.S. Elev (ft)	521.71	Reach Len. (ft)	65.32	61.05	54.41

Crit W.S. (ft)	520.92	Flow Area (sq ft)	113.41
E.G. Slope (ft/ft)	0.010872	Area (sq ft)	113.41
Q Total (cfs)	591.00	Flow (cfs)	591.00
Top Width (ft)	50.99	Top Width (ft)	50.99
Vel Total (ft/s)	5.21	Avg. Vel. (ft/s)	5.21
Max Chl Dpth (ft)	3.69	Hydr. Depth (ft)	2.22
Conv. Total (cfs)	5668.1	Conv. (cfs)	5668.1
Length Wtd. (ft)	61.05	Wetted Per. (ft)	52.00
Min Ch El (ft)	518.02	Shear (lb/sq ft)	1.48
Alpha	1.00	Stream Power (lb/ft s)	7.71
Frctn Loss (ft)	1.04	Cum Volume (acre-ft)	0.13
C & E Loss (ft)	0.05	Cum SA (acres)	0.06

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION OUTPUT Profile #100-yr

E.G. Elev (ft)	522.87	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.51	Wt. n-Val.		0.050	
W.S. Elev (ft)	522.36	Reach Len. (ft)	65.32	61.05	54.41
Crit W.S. (ft)	521.49	Flow Area (sq ft)		148.95	
E.G. Slope (ft/ft)	0.010824	Area (sq ft)		148.95	
Q Total (cfs)	851.00	Flow (cfs)		851.00	
Top Width (ft)	58.07	Top Width (ft)		58.07	
Vel Total (ft/s)	5.71	Avg. Vel. (ft/s)		5.71	
Max Chl Dpth (ft)	4.34	Hydr. Depth (ft)		2.56	
Conv. Total (cfs)	8179.5	Conv. (cfs)		8179.5	
Length Wtd. (ft)	61.05	Wetted Per. (ft)		59.30	
Min Ch El (ft)	518.02	Shear (lb/sq ft)		1.70	

Alpha	1.00	Stream Power (lb/ft s)	9.70
Frctn Loss (ft)	1.02	Cum Volume (acre-ft)	0.17
C & E Loss (ft)	0.06	Cum SA (acres)	0.07

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION

RIVER: CovingtonCreek
REACH: 1 RS: 0

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-37.56	521.4	-23.16	521.06	-16.09	518.07	1.53	517.61	13.94	518.35
24	521.29	54.53	530.22						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-37.56	.1	-23.16	.05	24	.1

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-23.16	24	0	0	.1	.3

CROSS SECTION OUTPUT Profile #2-yr

E.G. Elev (ft)	519.51	Element	Left OB	Channel	Right OB

Vel Head (ft)	0.51	Wt. n-Val.	0.050
W.S. Elev (ft)	519.00	Reach Len. (ft)	
Crit W.S. (ft)	519.00	Flow Area (sq ft)	34.91
E.G. Slope (ft/ft)	0.036983	Area (sq ft)	34.91
Q Total (cfs)	200.00	Flow (cfs)	200.00
Top Width (ft)	34.46	Top Width (ft)	34.46
Vel Total (ft/s)	5.73	Avg. Vel. (ft/s)	5.73
Max Chl Dpth (ft)	1.39	Hydr. Depth (ft)	1.01
Conv. Total (cfs)	1040.0	Conv. (cfs)	1040.0
Length Wtd. (ft)		Wetted Per. (ft)	34.77
Min Ch El (ft)	517.61	Shear (lb/sq ft)	2.32
Alpha	1.00	Stream Power (lb/ft s)	13.28
Frctn Loss (ft)		Cum Volume (acre-ft)	
C & E Loss (ft)		Cum SA (acres)	

CROSS SECTION OUTPUT Profile #10-yr

E.G. Elev (ft)	520.42	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.77	Wt. n-Val.		0.050	
W.S. Elev (ft)	519.64	Reach Len. (ft)			
Crit W.S. (ft)	519.64	Flow Area (sq ft)		58.23	
E.G. Slope (ft/ft)	0.032721	Area (sq ft)		58.23	
Q Total (cfs)	411.00	Flow (cfs)		411.00	
Top Width (ft)	38.18	Top Width (ft)		38.18	
Vel Total (ft/s)	7.06	Avg. Vel. (ft/s)		7.06	
Max Chl Dpth (ft)	2.03	Hydr. Depth (ft)		1.53	
Conv. Total (cfs)	2272.1	Conv. (cfs)		2272.1	
Length Wtd. (ft)		Wetted Per. (ft)		38.71	
Min Ch El (ft)	517.61	Shear (lb/sq ft)		3.07	
Alpha	1.00	Stream Power (lb/ft s)		21.69	
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

CROSS SECTION OUTPUT Profile #25-yr

E.G. Elev (ft)	521.03	Element	Left OB	Channel	Right OB

Vel Head (ft)	0.94	Wt. n-Val.	0.050
W.S. Elev (ft)	520.09	Reach Len. (ft)	
Crit W.S. (ft)	520.09	Flow Area (sq ft)	75.87
E.G. Slope (ft/ft)	0.030693	Area (sq ft)	75.87
Q Total (cfs)	591.00	Flow (cfs)	591.00
Top Width (ft)	40.76	Top Width (ft)	40.76
Vel Total (ft/s)	7.79	Avg. Vel. (ft/s)	7.79
Max Chl Dpth (ft)	2.48	Hydr. Depth (ft)	1.86
Conv. Total (cfs)	3373.4	Conv. (cfs)	3373.4
Length Wtd. (ft)		Wetted Per. (ft)	41.45
Min Ch El (ft)	517.61	Shear (lb/sq ft)	3.51
Alpha	1.00	Stream Power (lb/ft s)	27.32
Frctn Loss (ft)		Cum Volume (acre-ft)	
C & E Loss (ft)		Cum SA (acres)	

CROSS SECTION OUTPUT Profile #100-yr

E.G. Elev (ft)	521.79	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.15	Wt. n-Val.		0.050	
W.S. Elev (ft)	520.64	Reach Len. (ft)			
Crit W.S. (ft)	520.64	Flow Area (sq ft)		99.13	
E.G. Slope (ft/ft)	0.028954	Area (sq ft)		99.13	
Q Total (cfs)	851.00	Flow (cfs)		851.00	
Top Width (ft)	43.94	Top Width (ft)		43.94	
Vel Total (ft/s)	8.58	Avg. Vel. (ft/s)		8.58	
Max Chl Dpth (ft)	3.03	Hydr. Depth (ft)		2.26	
Conv. Total (cfs)	5001.2	Conv. (cfs)		5001.2	
Length Wtd. (ft)		Wetted Per. (ft)		44.82	
Min Ch El (ft)	517.61	Shear (lb/sq ft)		4.00	
Alpha	1.00	Stream Power (lb/ft s)		34.32	
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

SUMMARY OF MANNING'S N VALUES

River:CovingtonCreek

Reach	River Sta.	n1	n2	n3
1	175.73	.1	.05	.1
1	148.42	.1	.05	.1
1	135	.1	.05	.1
1	131.88	Bridge		
1	65	.1	.05	.1
1	61.05	.05	.05	.05
1	0	.1	.05	.1

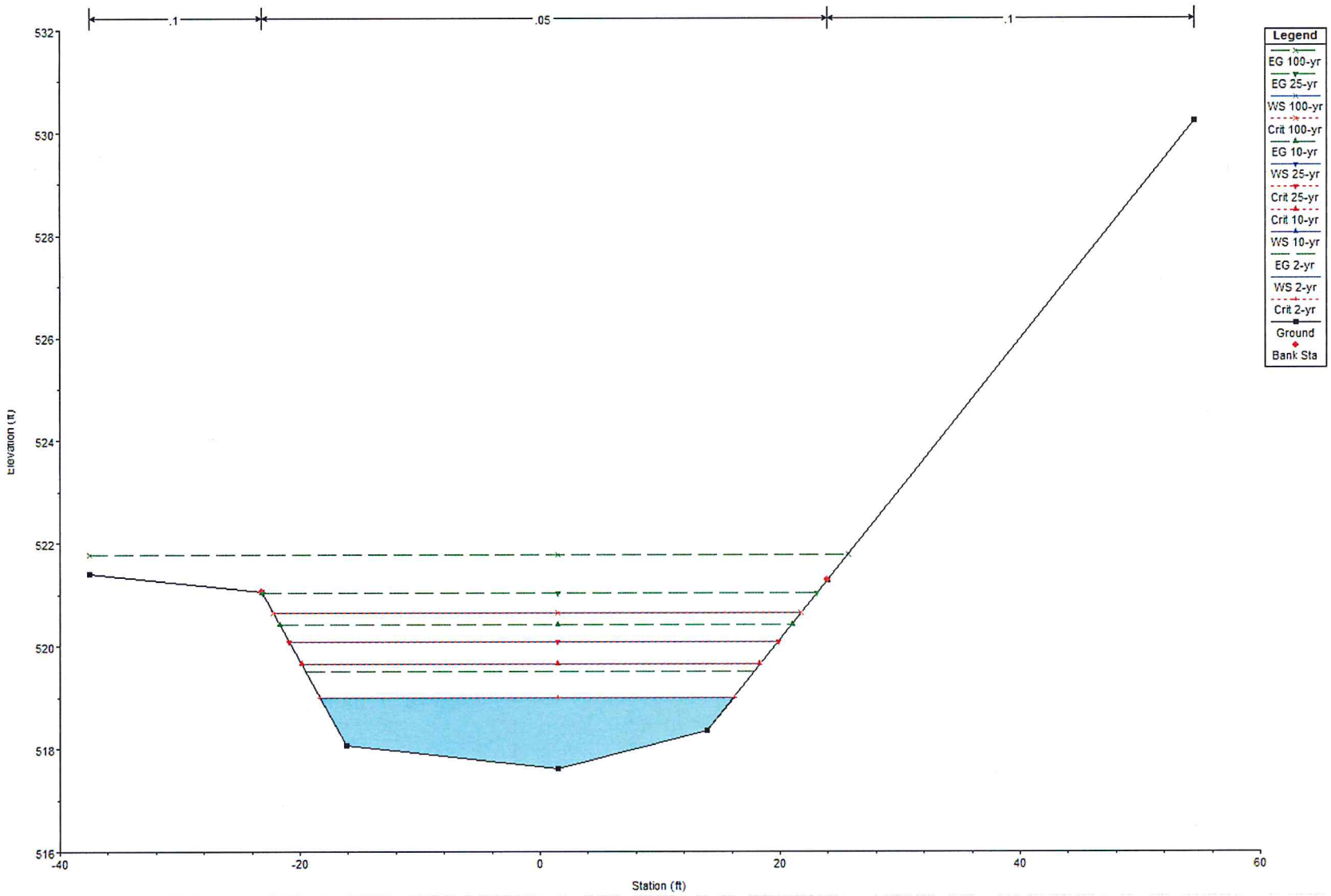
SUMMARY OF REACH LENGTHS

River: CovingtonCreek

Reach	River Sta.	Left	Channel	Right
1	175.73	27.31	27.31	27.31
1	148.42	8.6	8.6	8.6
1	135	78	78	78
1	131.88	Bridge		
1	65	.78	.78	.78
1	61.05	65.32	61.05	54.41
1	0	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: CovingtonCreek

Reach	River Sta.		Contr.	Expan.
1	175.73		.1	.3
1	148.42		.1	.3
1	135		.1	.3
1	131.88	Bridge		
1	65		.1	.3
1	61.05		.1	.3
1	0		.1	.3



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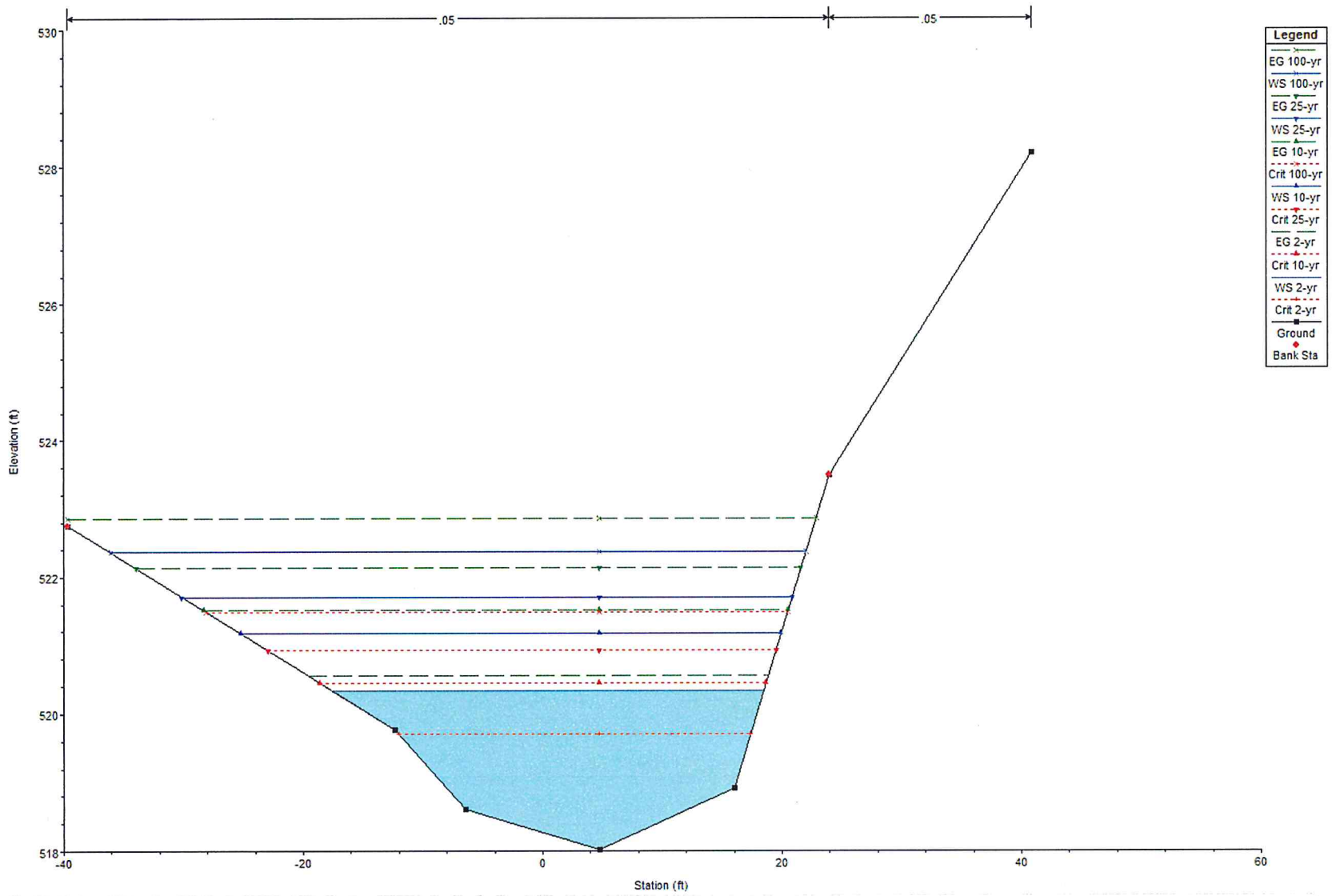
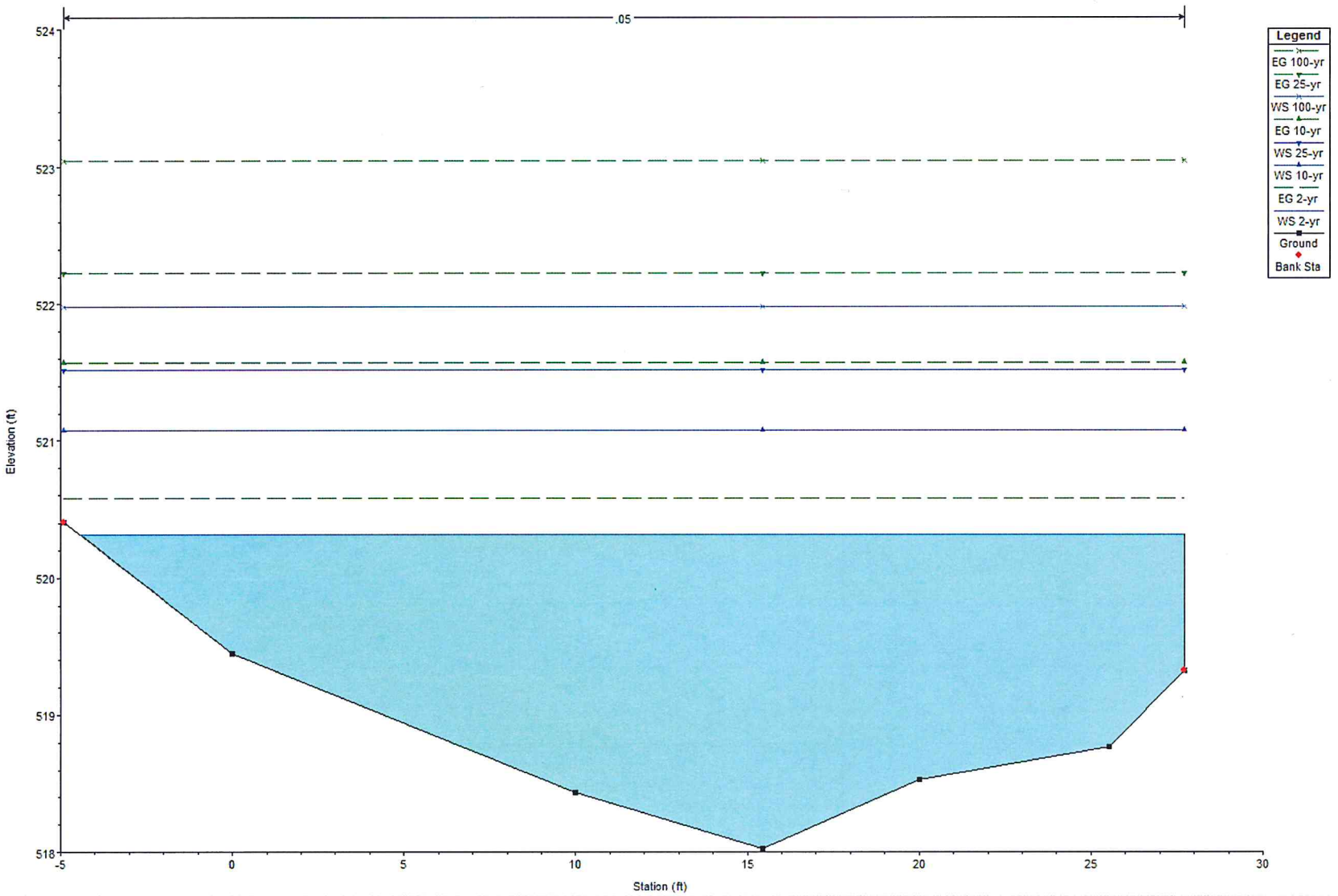
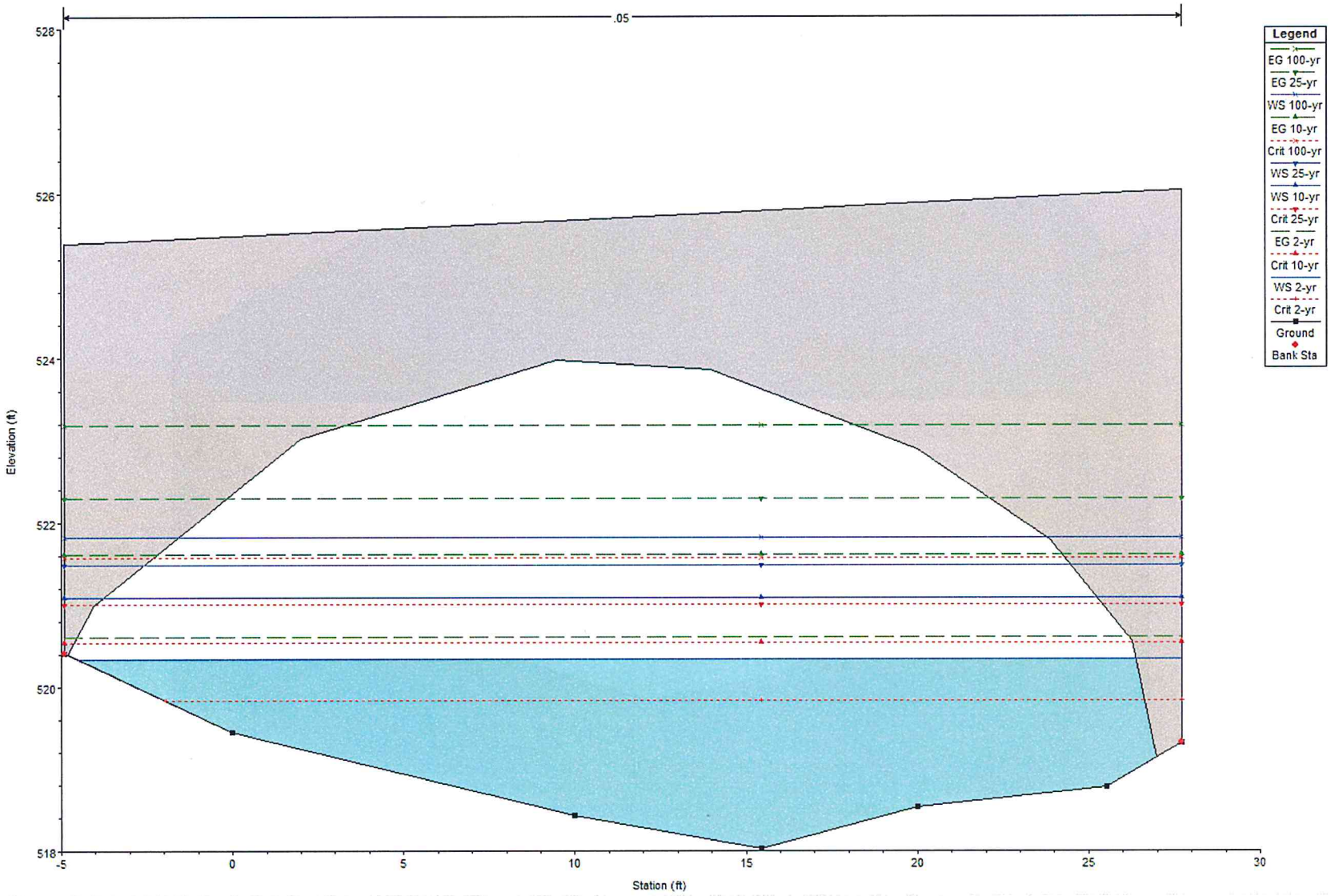


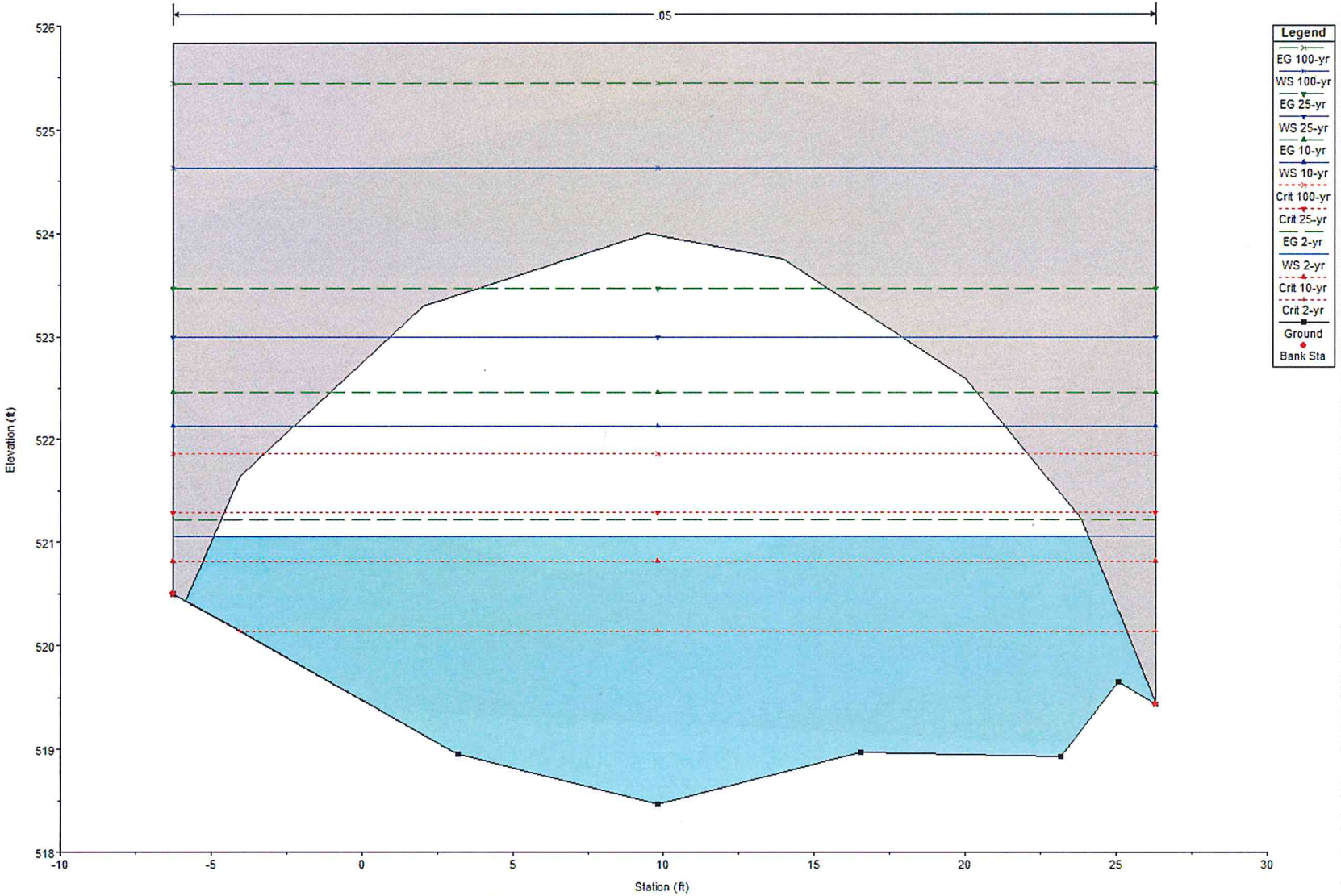
River Station: 61.05



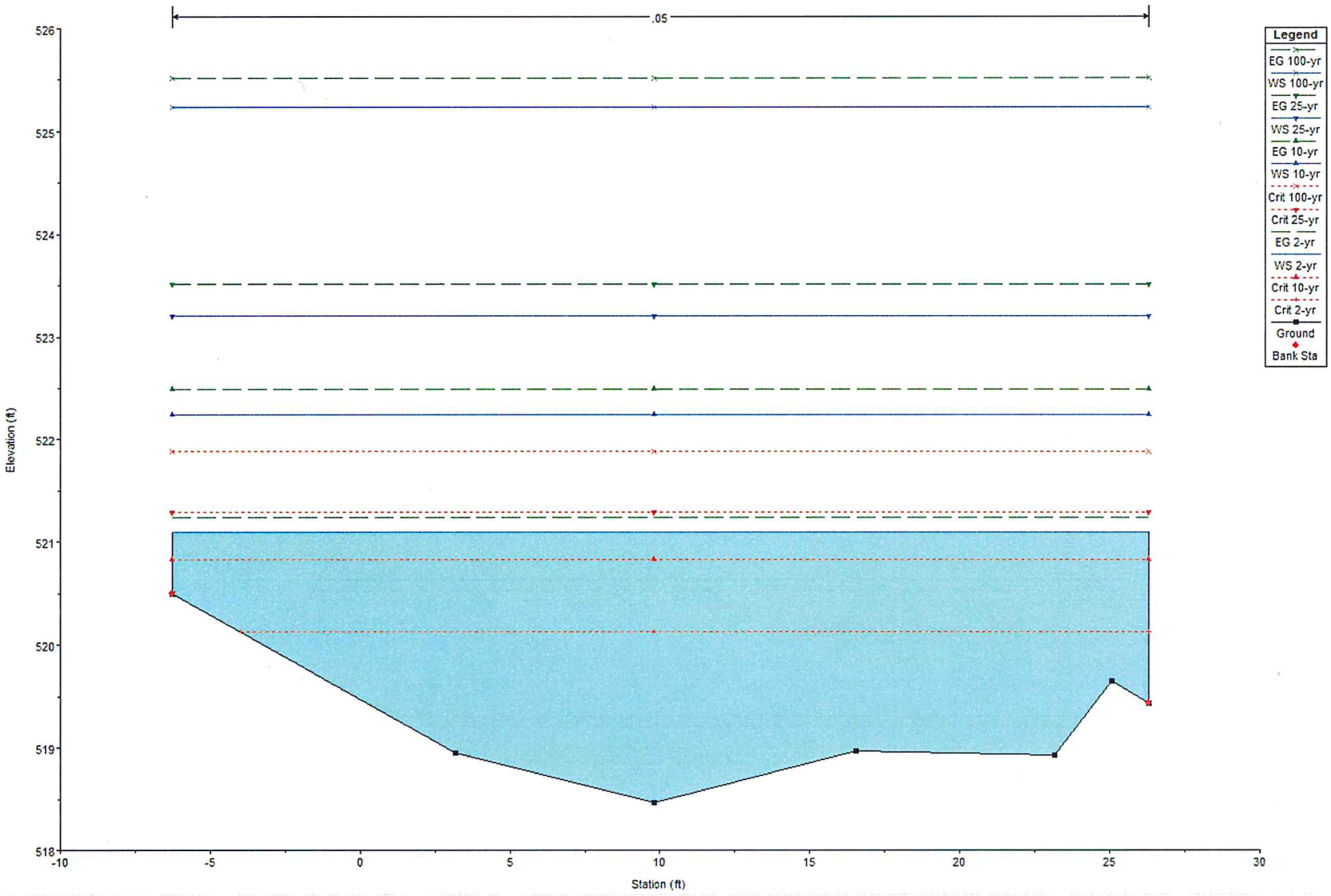
River Station: 65 (Cross section exiting culvert)



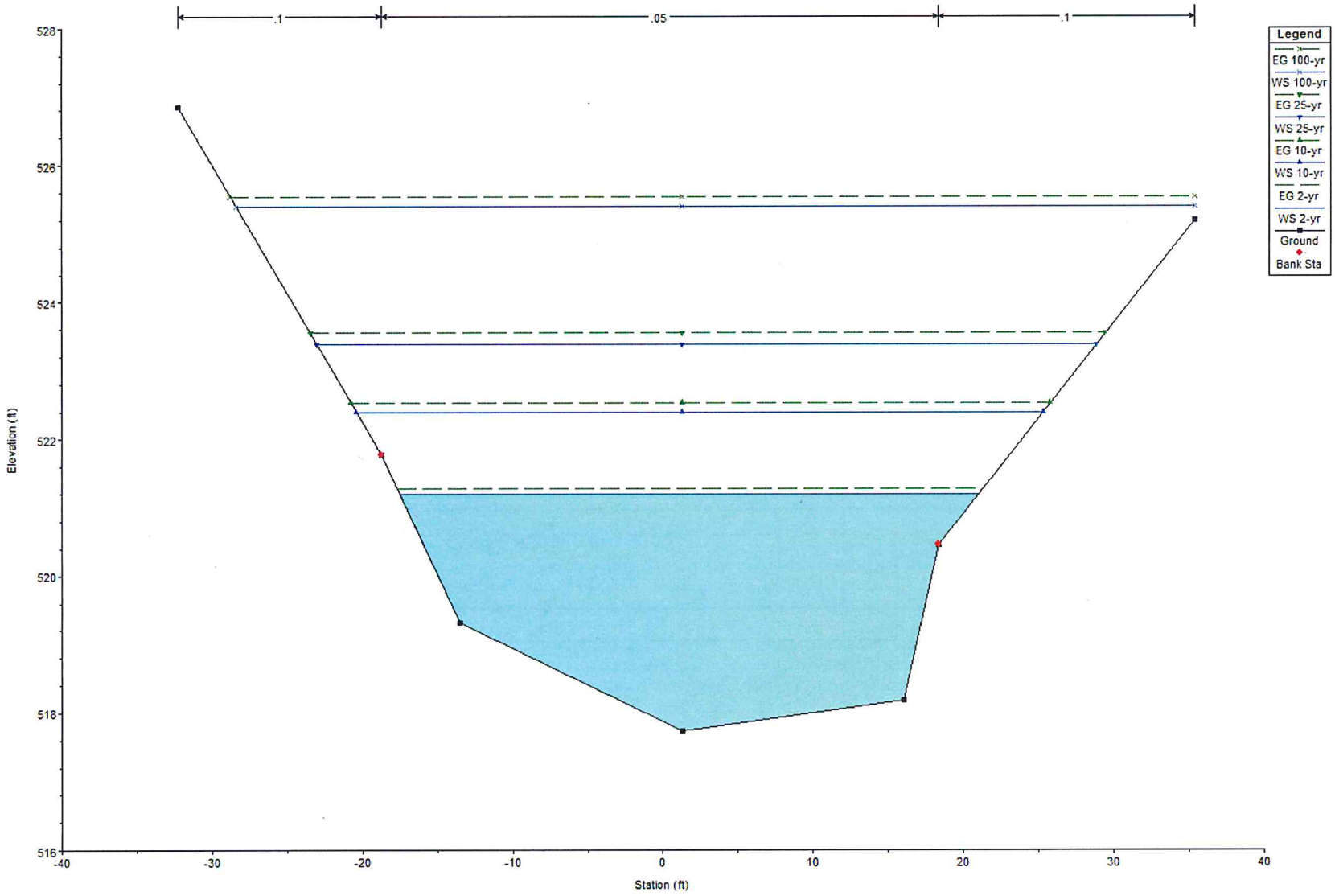
River Station: 131.88 BR D (Culvert Downstream)



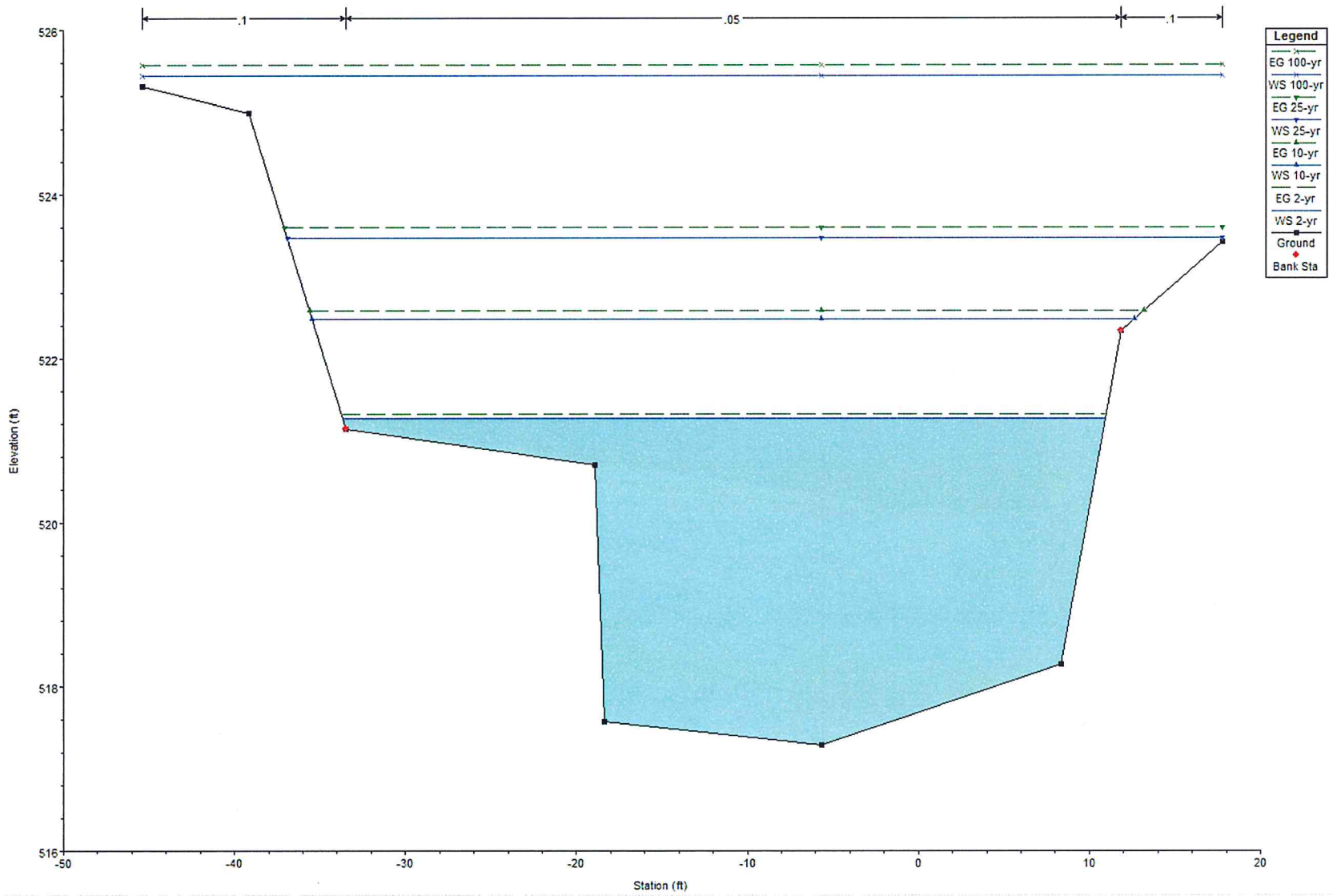
River Station: 131.88 BR U (Culvert Upstream)



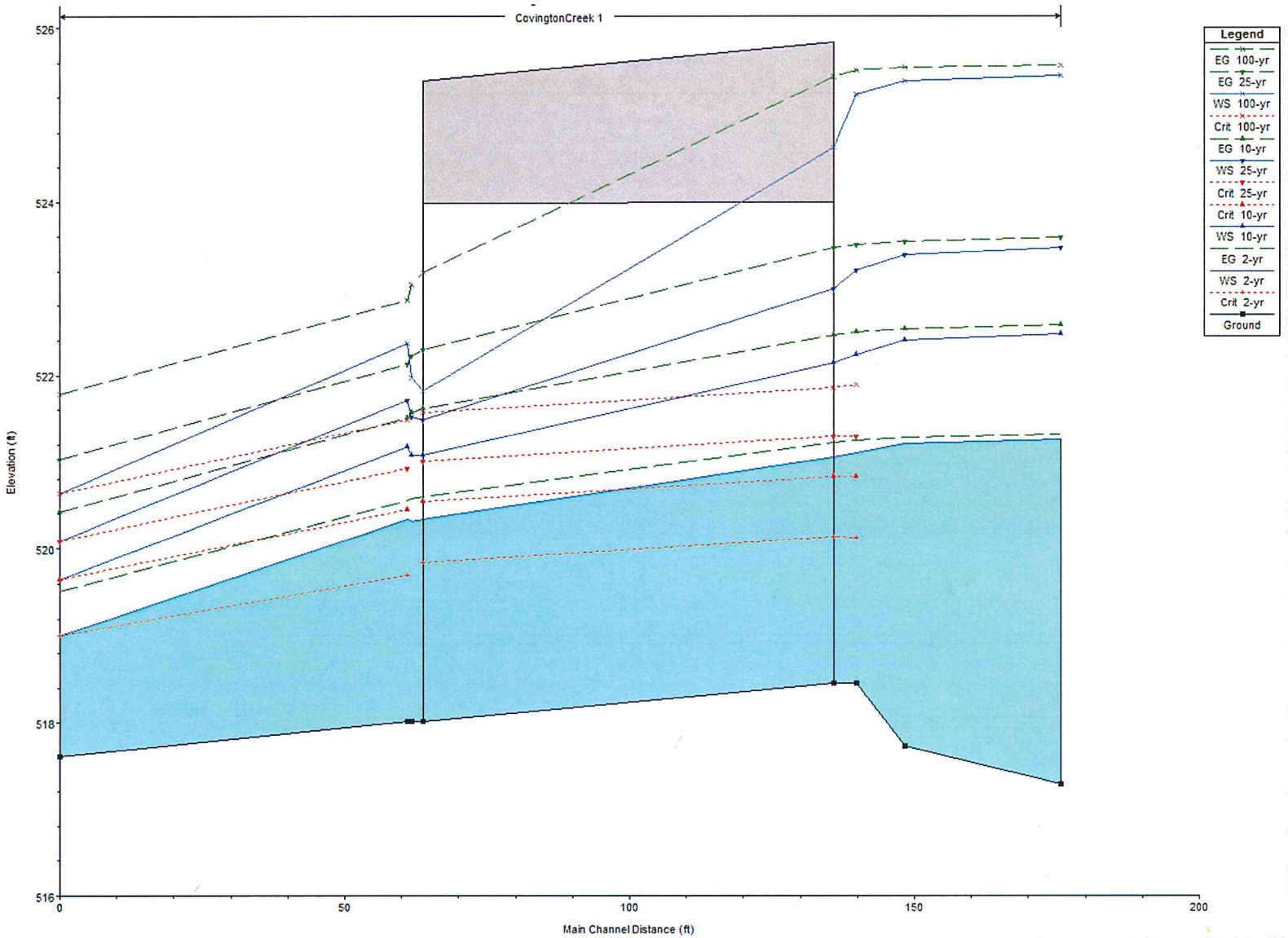
River Station: 135 (Cross section entering culvert)



River Station: 148.42



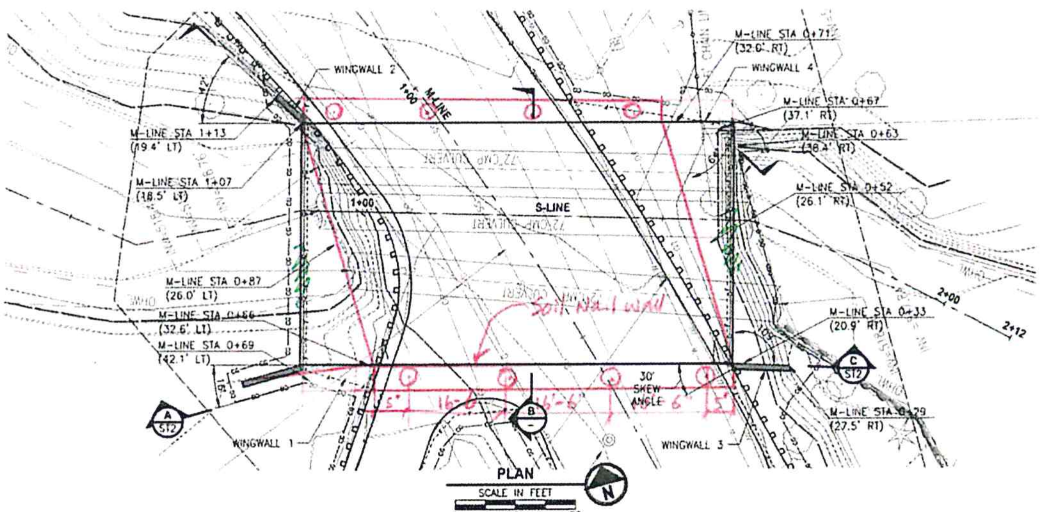
River Station: 175.73


CovingtonCreek 1
Legend
EG 100-yr
EG 25-yr
WS 100-yr
Crit 100-yr
EG 10-yr
WS 25-yr
Crit 25-yr
Crit 10-yr
WS 10-yr
EG 2-yr
WS 2-yr
Crit 2-yr
Ground
Elevation (ft)
526
524
522
520
518
516
0
50
100
150
200
Main Channel Distance (ft)

Profile

Attachment C

Bridge Design Alternative



GENERAL NOTES:

1. CONSPAN O-740 IS A PROPRIETARY PRECAST REINFORCED CONCRETE BRIDGE STRUCTURE. CONSPAN O-740 PRECAST STRUCTURE AND ASSOCIATED PRECAST WINGWALLS AND HEADWALLS ARE TO BE DESIGNED BY CONTRACTOR. SEE SPECIAL PROVISIONS FOR SUBMITTAL AND APPROVAL REQUIREMENTS. NO WORK SHALL BEGIN UNTIL STRUCTURAL DESIGN IS APPROVED BY STRUCTURAL ENGINEER.

   shaft foundations

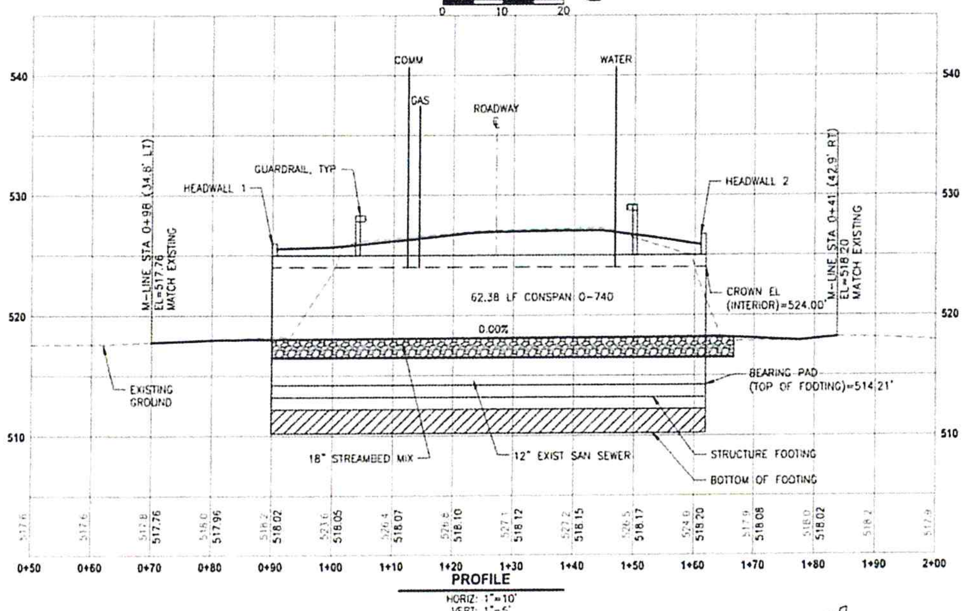
2. PRECAST FOOTINGS AND BEARING PAD ARE MINIMUM SIZES BASED ON GEOTECHNICAL ENGINEER RECOMMENDATIONS. CONTRACTOR SHALL DESIGN BOTH BEARING PAD AND STRUCTURE FOOTINGS FOR APPROVAL BY STRUCTURAL ENGINEER.

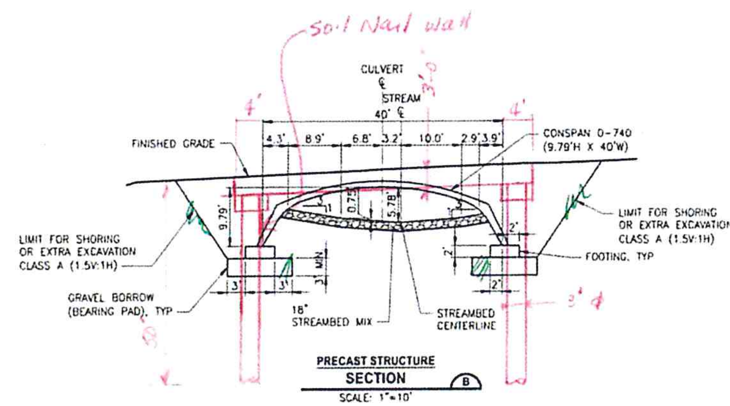
3. CONSPAN STRUCTURE DIMENSIONS ARE 40' SPAN BY 9.79' RISE. THE LENGTH IS 62.38' MEASURED ALONG THE STREAM CENTERLINE (A-LINE), WHICH IS AT A 30 DEGREE SKEW ANGLE FROM M-LINE, AS SHOWN.

   slab girders are precast prestressed 30' deep girder with 5" Concrete integrated deck on top

4. UTILITY INFORMATION AND LOCATIONS SHOWN ON THIS SHEET ARE APPROXIMATE TO THE EXTENT OF INFORMATION AVAILABLE. CONTRACTOR SHALL FIELD VERIFY UTILITY INFORMATION BEFORE CONSTRUCTION. UTILITIES THAT NEED TO PENETRATE THE CONSPAN STRUCTURE WALLS SHALL BE INSTALLED WITH METAL A SLEEVE FOR PROTECTION.

5. STREAMBED MIX GRADATIONS PROVIDED IN SPECIAL PROVISIONS.





60% REVIEW SUBMITTAL
NOT FOR CONSTRUCTION

PRELIMINARY

REVISIONS	DATE	BY

DESIGNED C. BUITRAGO
DRAWN B. PURGANAN
CHECKED P. JOHANNESSEN
APPROVED A. FISHER

ONE INCH AT FULL SCALE. IF NOT, SCALE ACCORDINGLY
FILE NAME PS3043025P01T05ST-01
JOB NO 213-3043-025 P01 T05
DATE NOVEMBER 2016

Parametrix
ENGINEERING. PLANNING. ENVIRONMENTAL SCIENCES
719 2ND AVENUE, SUITE 200 | SEATTLE, WA 98104
WWW.PARAMETRIX.COM

PROJECT NAME
COVINGTON CREEK CULVERT REPLACEMENT
CITY OF BLACK DIAMOND, WASHINGTON

CULVERT PLAN / ELEVATION

DRAWING NO. 8 OF 10
ST1

Bridge	Length	Width	Area	Unit $	Cost
	ft.	ft.	sqft.	$	$
Prestressed/Precast Slab 30" with 5" Deck	44	60	2640	$ 150	$ 396,000

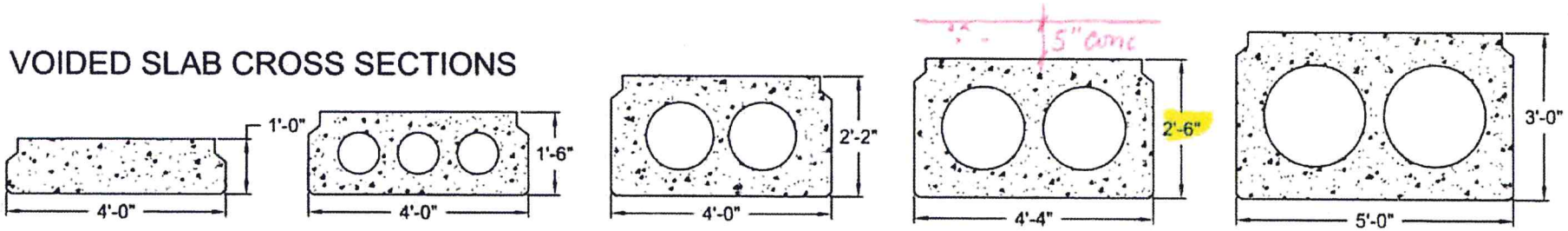
CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

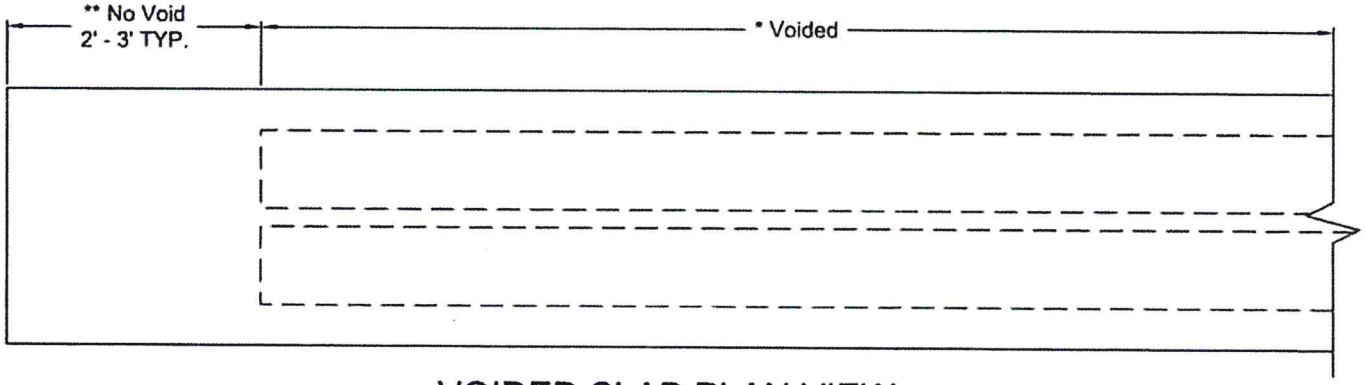
DO NOT SCALE

STANDARD WSDOT STYLE VOIDED SLABS

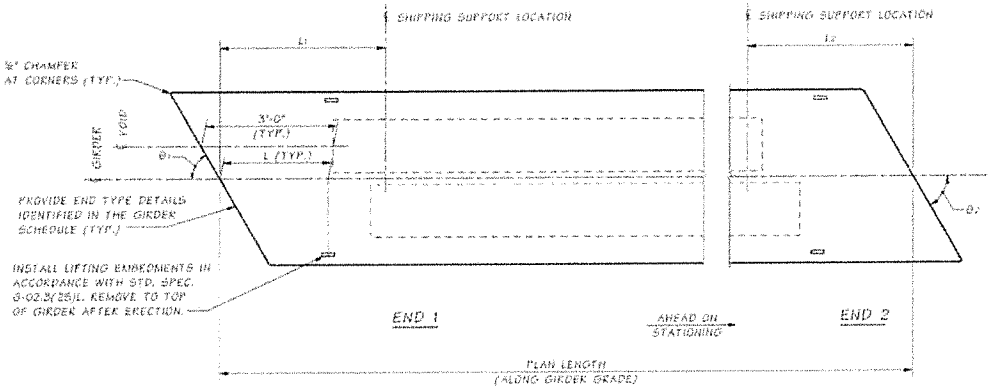
DEPTH	WIDTH	LBS./FT * (VOIDS)	LBS./FT ** (NO VOIDS)	MAX LENGTH (L/D = 30)	DIA. VOIDS
12"	4'-0"	617	617	30'-0"	--
18"	4'-0"	724	937	45'-0"	9"
26"	4'-0"	987	1,363	65'-0"	14.7"
30"	4'-4"	1,144	1,710	75'-0"	18"
36"	5'-0"	1,532	2,377	90'-0"	22"

VOIDED SLAB CROSS SECTIONS

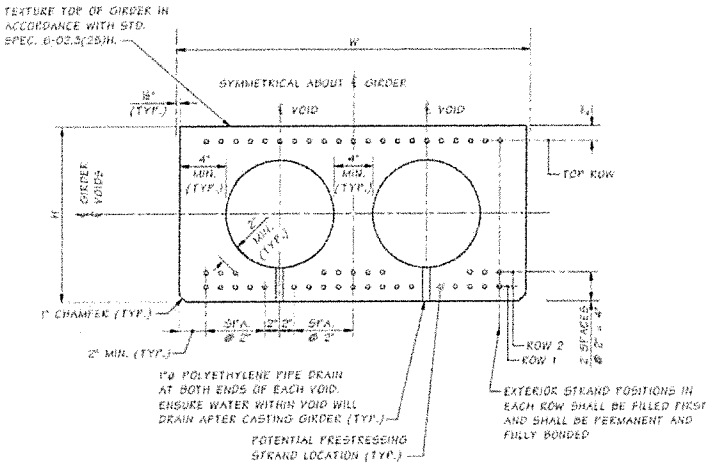




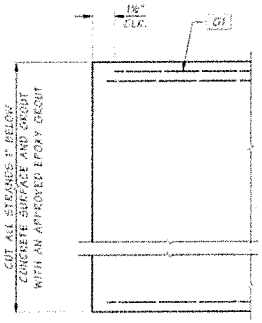
VOIDED SLAB PLAN VIEW



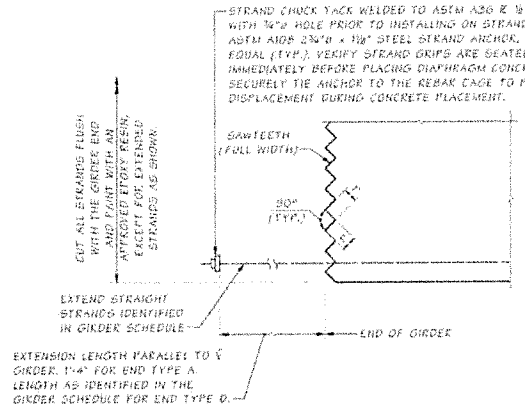
PLAN



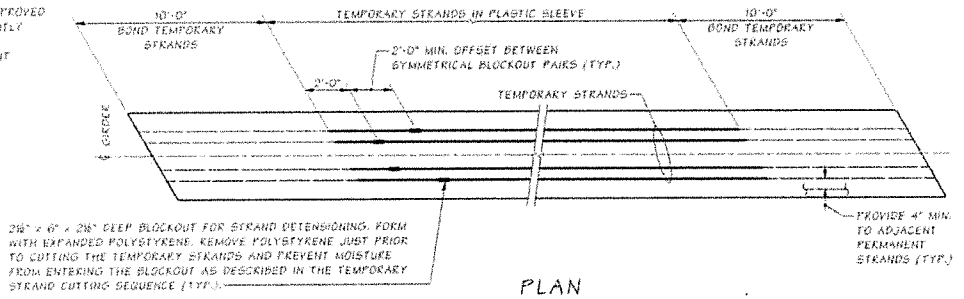
TYPICAL GIRDER SECTION



END TYPE B



END TYPES A AND D



PLAN
TEMPORARY STRANDS

TEMPORARY STRAND NOTES

1. SEE GIRDER SCHEDULE FOR REQUIRED NUMBER OF TEMPORARY STRANDS. TEMPORARY STRANDS SHALL BE PLACED IN THE TOP ROW.
2. FOR GIRDERS ERECTED ON A LONGITUDINAL GRADE, STRAND DETENSIONING BLOCKOUTS SHALL BE PLACED AT THE LOW END OF THE GIRDER.
3. SEE "TEMPORARY STRAND CUTTING SEQUENCE" ON CONSTRUCTION SEQUENCE SHEET FOR TEMPORARY STRAND DETENSIONING PROCEDURE.

Bridge Design Engr.	M:\STANDARDS\Girders\Flat Slab\SLAB 2 OF 3.MAN								
Supervisor									
Designed By									
Checked By									
Detailed By									
Bridge Projects Engr.									
Project Engr.									
Architect/Specialist	DATE	REVISION	BY	APP'D					

Fri Jun 10 14:32:56 2016

BRIDGE AND STRUCTURES OFFICE

Washington State Department of Transportation

STANDARD PRESTRESSED CONCRETE GIRDERS

SLAB GIRDER DETAILS 2 OF 3

Last revised on : 04/07/2016

5.6-A3-2