Maple Grove, MN | HEI No. 004876_0051
May 6, 2022

TROUT BROOK PHASE III

60% Design Report - DRAFT

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Engineer under the laws of the State of Minnesota.

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1 PROJECT BACKGROUND

The purpose of this report is to provide project stakeholders with the data and methodologies used to develop the Trout Brook Phase III 60% Design. This report contains description of the project background, goals, geomorphology review, hydrology and hydraulics, concept description, and opinion of probable construction costs. Project stakeholders are anticipated to provide feedback on the design which will be incorporated into the 90% design.

South Washington Watershed District is partnered with Great River Greening (GRG), the Minnesota DNR, and Vail Properties to restore Trout Brook through areas of the Afton Alps Ski Area and Afton State Park. Houston Engineering was contracted to provide engineering services to the project.

1.1 PROJECT LOCATION

The project site is located on Vail properties at the Afton Alps Ski Area and on Mn DNR property (Afton State Park), in Sections 2 and 3 of Denmark Township (T27N-R20W), approximately 3 miles south of the City of Afton in Washington County. Trout Brook outlets to the St. Croix River. The proposed project extents include project areas 1, 2, 3 and 4 and are shown in **Figure 1**.

1.2 HISTORY

Study and restoration of Trout Brook has been on-going for the last decade. The most noted issue is sedimentation within the channel which buries channel riffles and pools, limiting diversity of habitat. Previous studies include:

- Trout Brook Watershed Improvements, Concept Design Report, August 9, 2012
- Trout Brook Enhancement at Afton Alps Ski Area, 30% Design Submittal, February 2015
- Wetland Delineation Report, Afton Alps Trout Brook Restoration, September 1, 2017
- Geotechnical Evaluation Report, Trout Brook Phase II Re-Meander, September 22, 2017
- Trout Brook Phase II, Re-meander Design-Bid-Build, 100% Design Submittal, May 2018

Design plans were prepared for Phase 2 of Trout Brook restoration by Inter-fluve in May of 2018. Construction of a majority of features shown in the design plans was completed in 2019. This construction project included:

- *Relocation of a portion of the channel downstream of the chalet area, including a two-stage channel with meandering bankfull channel within a confined floodplain area.*
- *Addition of a riffle downstream of the upstream road crossing to allow fish passage.*
- *Construction of a wet crossing for vehicles at approximately Station 24+50 (proposed alignment) for off-road maintenance vehicles.*
- *Installation of several pedestrian bridge crossings and one 14-foot-wide by 10-foot-high reinforced concrete box culvert.*

1.3 PROJECT GOALS

Project goals were established during previous project phases and during the Phase III project stakeholder kick-off. The project goals and metrics of success are listed in **Table 1**.

Table 1: Project Goals and Success Criteria

Goal	Criteria
Increase longitudinal connectivity from the mouth to the crossing at St. Croix Trail South	To be achieved by replacing two semi-perched, undersized culverts within Afton Alps and incorporating strategic woody debris removal when it creates a barrier for aquatic life and impacts sediment transport (sand piling upstream of log jam)
Improve water quality and increase floodplain connectivity in Trout Brook.	To be achieved by reducing streambank erosion rates by 75% or better in work area and increasing floodplain connectivity within incised channel segments with Bank Height Ratios between 1.0 and 1.2.
Increase in-stream habitat to improve biological communities in Trout Brook, mainly in pools.	To be achieved by constructing max pool depths (measured up to bankfull) ranges from 2.3-3.1 feet and increasing the Large Woody Debris Index to greater than 450 and/or 12 LWD pieces per 100 meters. These characteristics are to be maintained for at least 10 years.
Increase recreational and long-term educational opportunities for State Park users and the public in general.	To be achieved by Heritage Brook Trout stocking and evaluation for survival. Outreach events targeted at introducing the public to trout fishing will take place.
Increase in native terrestrial habitat to improve biological communities.	To be achieved by native herbaceous cover greater than 70% (measured by sub-sampling riparian area plots randomly covering at least 2% of the total area) and woody stem basal area counts (taller than 54" and DBH < 3") are >13 stems sqm/hectare.
Improvement both stream and ski functions.	To be achieved by increasing the non-game fish community in both abundance and diversity in all four survey locations. Afton Alps maintains the same or greater number of parking spots and is not limited during potential future expansion.

2 EXISTING CONDITIONS

2.1 SURVEY

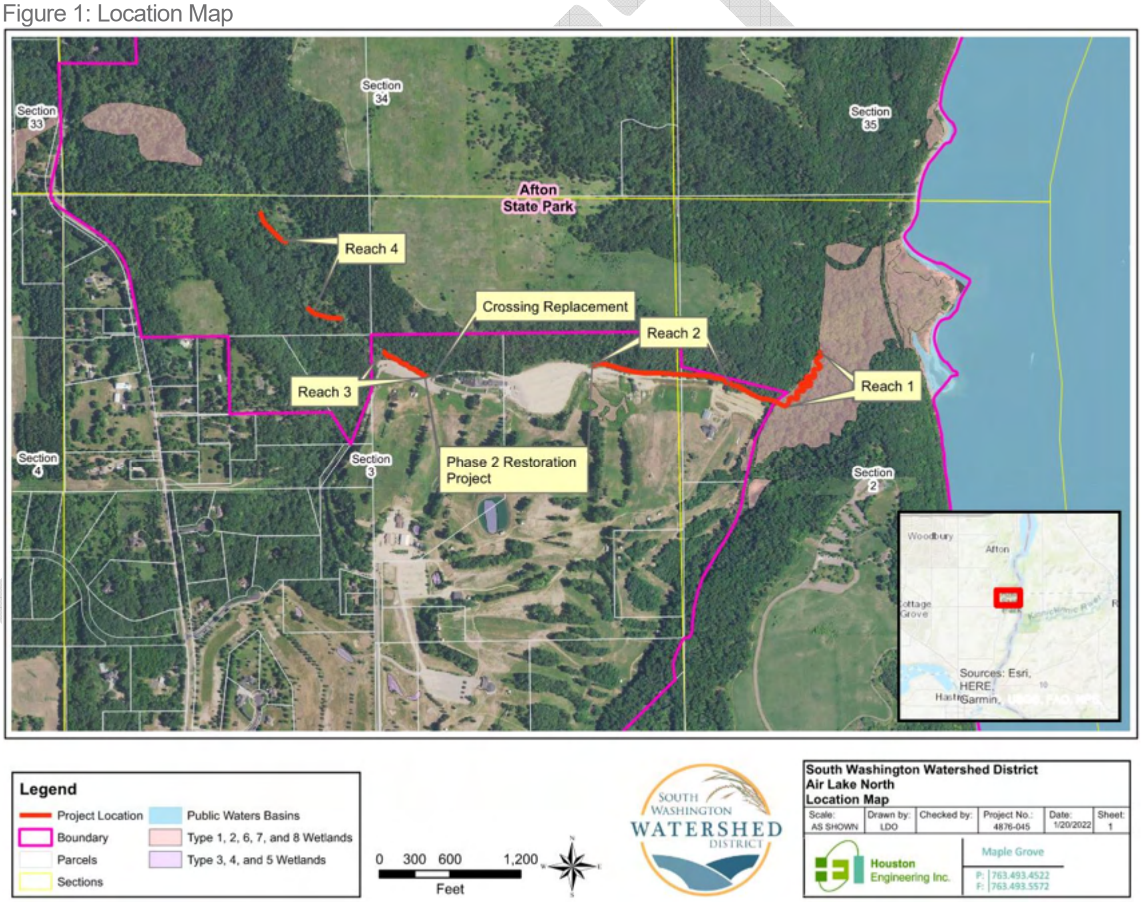
Survey data was collected in October and November of 2021 and February of 2022 to identify the existing condition of the site. Additional survey information was provided by the MnDNR and from previous project phases. All survey data collected by HEI utilizes the Washington County Coordinate System and North American Vertical Datum 1988 (NAVD88). (Note: Unless otherwise noted, all elevations provided herein are based on NAVD88 vertical datum).

2.2 WETLANDS

A wetland survey was conducted in October 2021. Results of the field delineations indicate there is one wetland area (1.84 acres) and one linear watercourse (approximately 3,362 linear feet) within the 11.24-acre survey area. The aquatic resource classifications include Type 1 seasonally flooded floodplain wetland (PFO1A) which is a forested floodplain to the St. Croix River, and the intermittent trout stream and Minnesota Public Water (PWI ID 82028a), Trout Brook, respectively. The wetland appears to have a surface connection to the St. Croix River, the nearest traditional navigable water or water body, as well as

Trout Brook, which flows into the St. Croix. The wetland delineation is shown in **Appendix A – Wetland Delineation**.

Figure 1: Location Map



2.3 HYDROLOGY

Flow frequency statistics are necessary to size project features. Results from several methodologies were compared to determine design discharges for Trout Brook. The recommended discharges are based on USGS Regression Equations (StreamStats). The bankfull discharge was calculated by the MnDNR using reference reach data and regional curves developed by the MnDNR. **Appendix B - Hydrology** describes the methods used to define the design discharges. Table 2 shows the recommended discharge frequency curves throughout the site.

Table 2: Recommended Discharges (cfs)

Recurrence Interval (year)	At Site Culvert and upstream	Adjacent to Maintenance Road	Through Afton State Park
Bankfull	48	48	48
1.5	68.3	69.9	78.6
2	98.7	101	113
5	196	200	223
10	281	287	319
25	406	415	460
50	510	521	576
100	631	643	710

2.4 HYDRAULICS

A HEC-RAS model (version 6.0.0) was developed to determine the water surface profiles for the site. The HEC-RAS model was originally created by Inter-fluve with version 5.0.5 in 2018 for design of the Phase II project features. The model was updated to extend and realign the main Trout Brook channel, extend existing cross sections, add additional cross sections, and to update various other hydraulic parameters.

Topography for the HEC-RAS model came from a combination of field surveyed cross sections, surface data provided by Inter-fluve and LiDAR (LiDAR obtained from MnDNR). The additional cross sections added to the model were based on this combined survey and LiDAR topography. **Figure 2** shows a schematic of the HEC-RAS model.

Field survey elevations were collected referencing vertical datum NAVD88. The Washington County LiDAR references vertical datum NAVD88. Thus, no datum conversions were needed.

The roughness coefficients used for this study were estimated based on consistency with modeling completed during previous phases, field reconnaissance, photos taken by surveyors, consistency through similar reaches, calibration, and tables within the HEC-RAS manual [6]. **Table 3** shows the Manning's "n" values used for the channel and overbank for each reach.

The starting water surfaces elevations for the Trout Brook model were calculated using normal depth with a slope of 0.008. Backwater elevations from the downstream St. Croix River were not utilized, since normal depth will result in more conservative velocity calculations.

Figure 2: HEC-RAS Existing Conditions Model Schematic

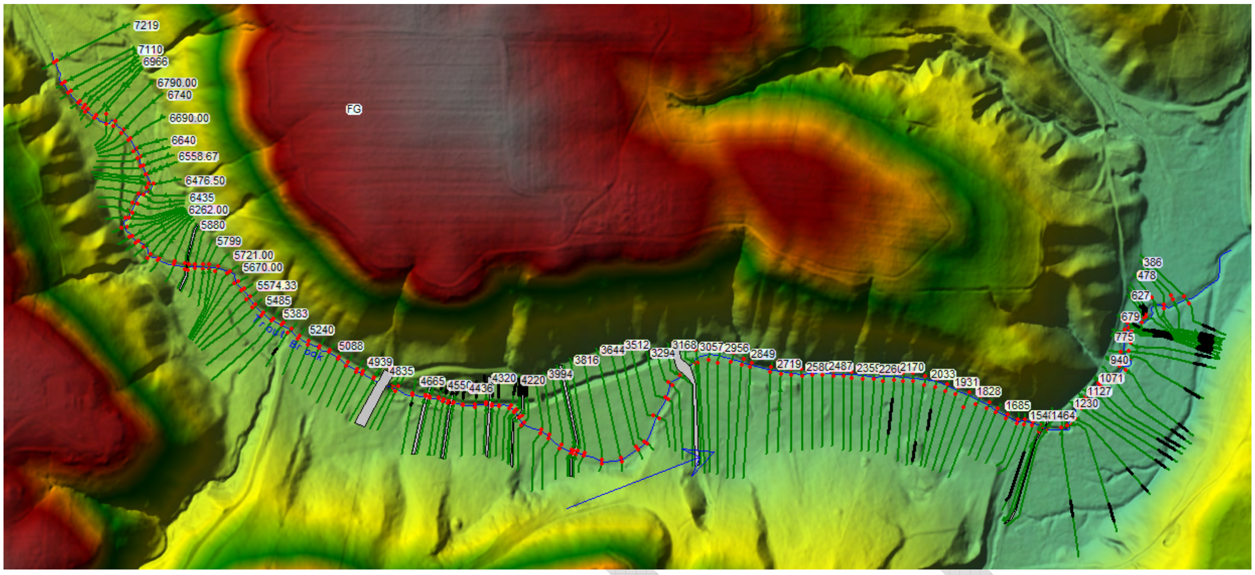


Table 3: Roughness Factors ("Manning's "n")

Location	Channel	Overbanks	
		Left	Right
Stations 7219 – 5291	0.045	0.1	0.1
Stations 5240 - 4665	0.035	0.1	0.035
Stations 4608 - 3387	0.03	0.05	0.04
Stations 3294 - 1548	0.035	0.1	0.04
Stations 1509 - 327	0.05	0.1	0.1

3 PROJECT DESIGN

3.1 CHANNEL AND FLOODPLAIN GEOMETRY

Previous design documents provide detailed narrative on the history of the site geomorphology.

The MnDNR surveyed several reference reach sites and provided an initial geomorphic assessment. Reference reach data was collected by the MnDNR during design of Phase II of the project and following construction. The DNR also collected data to record the response of the newly constructed Phase II site. The existing site is generally a G stream type, while the proposed stream type is B4c. Riffles and pools are often filled with sediment and not functioning to provide habitat.

Stream components were largely designed using Rosgen methodology in alignment with the concept design from the MnDNR. Stream dimensions were roughly modeled in HEC-RAS to calculate velocities and shear stress throughout the reaches. The design will be further refined with additional modeling moving into the 90% design.

The MnDNR calculated concept design parameters such as cross section and profile data, as well as minimum, average, and maximum values for cross section, profile, and pattern variables. This data was reviewed by HEI for concurrence. The MnDNR also provided an initial alignment and profile through Afton State Park (Reach 1). **Table 4** below shows how the resultant stream dimensions compared with the concept design and the Phase II constructed design.

The alignment provided by the MnDNR through reach 1 was refined to facilitate off-line construction. This will allow vegetation to be established prior to discharges being introduced to the reach. This reach will transition from the confined channel adjacent to the maintenance road to a type $B4_c$ with floodplain connectivity. The channel will be re-meandered with an excavated floodplain bench to increase floodplain connectivity and storage.

Reaches 2 and 3 are generally very confined. They will be constructed under wet conditions, though it is anticipated the contractor will utilize pumps and coffer dams to create dry conditions where construction is imminently occurring. Due to the construction conditions, it is desired to limit disturbance of vegetation. Since the low flow channel is similar to the calculated stable dimensions, grading was limited to intermittent floodplain excavation. In-channel structures such as rootwads, pools, and riffles are proposed to create a more diverse habitat. The downstream end of reach 3 will include a culvert replacement, which will be discussed more in Section 0 below.

Reach 4 consists of excavation of a floodplain bench.

The resultant alignment, profile, and cross sections are shown in more detail in **Appendix C – 60% Design Plans**.

3.2 HYDRAULICS

The proposed condition was modeled in HEC-RAS version 6.0. Due to the excavation of a downstream floodplain bench, and the increase in culvert size at the chalet crossing, there are no increases in water surface elevation for 100-year profiles. Smaller events have isolated locations of water surface elevation increase on the Afton State Park property. Due to the remeander, the Afton State Park area has different reach lengths in proposed vs existing condition. The table compares similar locations, which have much greater stream length and therefore greater water surface elevations. **Table 5** shows the results of the HEC-RAS modeling.

It is anticipated that more detailed modeling will occur during development of the 90% design to facilitate placement of channel structures and vegetation practices in locations with high velocities or shear stress.

Reach 4 consists of excavation of a floodplain bench. The benefits of this channel improvement are primarily in reduced velocities in the channel. The locations where floodplain benches are proposed are based on recommendations by the MN DNR resultant from their BEHI analysis. The changes in velocity are described in **Figure 3** and **Figure 4.**

Table 4: Stream Dimensions

		MnDNR Concept Design	Reach 1 (Afton State Park)	Reach 2 (Afton Alps Adjacent to Maintenance Road)	Phase II	Reach 3 (Upstream Chalet Crossing)
Riffle Width, ft (Wbkf)	Mean:	13.5	13.5	13.5	15	13.5
	Min:	12.6	13.5	13.5		13.5
	Max:	14.3	13.5	13.5		13.5
Riffle Mean Depth, ft (dbkf)	Mean:	1.06	1.11	1.11	1.3	1.11
	Min:	1.00	1.11	1.11		1.11
	Max:	1.13	1.11	1.11		1.11
Riffle Width/Depth Ratio (Wbkf/dbkf)	Mean:	12.8	12.2	12.2	11.5	12.2
	Min:	11.1	12.2	12.2		12.2
	Max:	14.4	12.2	12.2		12.2
Riffle Cross-Sectional Area, ft^2 (Abkf)	Mean:	14.3	15.0	15.0	19.5	15.0
	Min:		15.0	15.0		15.0
	Max:		15.0	15.0		15.0
Pool Mean Depth, ft (dbkfp)	Mean:	1.43	1.25	1.25		1.25
	Min:	1.13	1.25	1.25		1.25
	Max:	1.69	1.25	1.25		1.25
Stream Meander Length, ft (Lm)	Mean:	262.1	160	75	129	58
	Min:	187.6	130	75	86	50
	Max:	392.2	180	75	192	65
Stream Meander Length Ratio (Lm/Wbkf)	Mean:	19.4	11.9	5.6	8.6	4.3
	Min:	13.9	9.6	5.6	5.7	3.7
	Max:	29.0	13.3	5.6	12.8	4.8
Belt Width, ft (Wblt)	Mean:	129.2	69	31	40	31
	Min:	53.7	54	25		26
	Max:	188.5	82	35		32
Meander Width Ratio (Wblt/Wbkf)	Mean:	9.55	5.11	2.30	2.67	2.30
	Min:	3.98	4.00	1.85		1.93
	Max:	13.95	6.07	2.59		2.37
Radius of Curvature, ft (Rc)	Mean:	29.2	31.7	40.0	54	30.0
	Min:	18.9	20.0	30.0	35	25.0
	Max:	45.3	45.0	45.0	76	45.0
Radius of Curvature to Riffle Width (Rc/Wbkf)	Mean:	2.16	2.35	2.96	3.6	2.22
	Min:	1.40	1.48	2.22	2.3	1.85
	Max:	3.35	3.33	3.33	5.1	3.33
Riffle Length (Lr), ft	Mean:	26.3	24.0	25.0	23	27.1
	Min:	18.3	20.0	20.0	14	20.0
	Max:	35.5	30.0	30.0	39	30.0
Individual Pool Length, ft (Lp)	Mean:	32.4	40.9	49.1	15	29.3
	Min:	18.3	28.0	35.0	9	28.6
	Max:	45.1	61.0	65.5	39	32.5
Pool-to-Pool Spacing, ft (Ps)	Mean:	54.7	75.6	87.0	56	60.3
	Min:	35.8	55.0	78.5	40	52.5
	Max:	68.8	93.5	95.5	81	66.5
Sinuosity (k)		1.20	1.26	1.02	1.10	1.01

Table 5: HEC-RAS Results

Location Description	Stream Length (measured from Afton State Park Trail)	2-year (Existing Water Surface Elevation)	10-year (Existing Water Surface Elevation)	100-year (Existing Water Surface Elevation)	2-year (Proposed Water Surface Elevation)	10-year (Proposed Water Surface Elevation)	100-year (Proposed Water Surface Elevation)	2-year (Proposed-Existing Water Surface Elevation)	10-year (Proposed-Existing Water Surface Elevation)	100-year (Proposed-Existing Water Surface Elevation)
	7483	747.52	748.79	749.51	747.48	748.34	749.08	-0.04	-0.45	-0.43
Floodplain Excavation (Reach 4)	7375	746.12	747.62	748.21	745.58	746.26	747.07	-0.54	-1.36	-1.14
	7327	745.72	747.07	747.89	745.19	745.86	746.66	-0.53	-1.21	-1.23
	7263	745.18	746.36	747.2	744.72	745.41	746.19	-0.46	-0.95	-1.01
	7230	744.83	745.74	746.78	744.49	745.19	746.03	-0.34	-0.55	-0.75
	7210	744.63	745.58	746.33	744.33	745	745.7	-0.3	-0.58	-0.63
	7165	744.06	744.69	745.6	743.88	744.53	745.47	-0.18	-0.16	-0.13
	7104	743.02	743.96	744.74	743.02	743.96	744.74	0	0	0
	7054	742.56	743.43	744.14	742.56	743.43	744.14	0	0	0
	7004	742.04	743.13	743.86	742.04	743.13	743.86	0	0	0
	6954	741.29	742.37	742.98	741.29	742.37	742.98	0	0	0
	6904	740.57	741.51	742.3	740.57	741.51	742.3	0	0	0
	6863	740.08	740.99	741.71	740.08	740.99	741.71	0	0	0
	6823	739.66	740.75	741.46	739.66	740.75	741.46	0	0	0
	6782	738.59	740.16	740.7	738.59	740.16	740.7	0	0	0
	6741	738.21	739.22	740.05	738.21	739.22	740.05	0	0	0
	6699	737.62	738.64	739.37	737.62	738.64	739.37	0	0	0
	6656	737.27	738.17	738.88	737.27	738.17	738.88	0	0	0
	6613	736.89	737.82	738.35	736.89	737.82	738.35	0	0	0
	6569	736.16	737.18	737.91	736.16	737.18	737.91	0	0	0

Location Description	Stream Length (measured from Afton State Park Trail)	2-year (Existing Water Surface Elevation)	10-year (Existing Water Surface Elevation)	100-year (Existing Water Surface Elevation)	2-year (Proposed Water Surface Elevation)	10-year (Proposed Water Surface Elevation)	100-year (Proposed Water Surface Elevation)	2-year (Proposed-Existing Water Surface Elevation)	10-year (Proposed-Existing Water Surface Elevation)	100-year (Proposed-Existing Water Surface Elevation)
	6526	735.4	736.75	737.63	735.4	736.75	737.63	0	0	0
	6483	734.97	736.33	737.35	734.97	736.33	737.35	0	0	0
	6440	734.31	735.72	736.7	734.32	735.72	736.7	0.01	0	0
	6401	734.07	735.59	736.38	734.08	735.59	736.38	0.01	0	0
	6362	733.2	734.98	735.68	733.01	734.98	735.68	-0.19	0	0
Floodplain Excavation (Reach 4)	6315	732.94	734.43	735.4	732.66	733.49	734.5	-0.28	-0.94	-0.9
	6268	732.55	733.83	734.71	732.3	733.24	734.3	-0.25	-0.59	-0.41
	6195	731.56	733.63	734.33	731.47	733.09	734.15	-0.09	-0.54	-0.18
	6144	731.15	733.58	734.2	730.93	733.03	734.09	-0.22	-0.55	-0.11
Trail Bridge								0	0	0
Floodplain Excavation (Reach 4)	6129	730.95	732.27	733.14	730.71	731.86	732.72	-0.24	-0.41	-0.42
	6098	730.69	732.09	732.99	730.49	731.74	732.6	-0.2	-0.35	-0.39
	6063	730.4	731.57	732.31	730.29	731.51	732.24	-0.11	-0.06	-0.07
	6036	730.19	731.29	731.94	730.11	731.23	731.91	-0.08	-0.06	-0.03
	5985	728.95	730.34	731.04	728.95	730.34	731.04	0	0	0
	5934	727.79	729.06	730.14	727.79	729.06	730.14	0	0	0
	5883	727.41	728.77	729.9	727.41	728.77	729.9	0	0	0
	5839	726.85	728.07	729.37	726.85	728.07	729.37	0	0	0
	5794	726.61	727.85	729.04	726.61	727.85	729.03	0	0	-0.01
	5749	726.28	727.46	728.48	726.29	727.46	728.43	0.01	0	-0.05
	5698	725.55	726.68	728.06	725.54	726.63	727.93	-0.01	-0.05	-0.13
	5647	725.1	726.38	727.87	724.98	726.25	727.72	-0.12	-0.13	-0.15
	5601	724.82	725.9	727.45	724.56	725.46	726.68	-0.26	-0.44	-0.77
	5555	724.67	725.93	727.54	723.92	725.31	726.98	-0.75	-0.62	-0.56
Afton Alps (Reach 3)	5506	724.22	725.3	726.68	723.24	724.39	725.52	-0.98	-0.91	-1.16
	5459	723.64	724.74	725.65	722.79	723.9	725.26	-0.85	-0.84	-0.39
	5405	723.17	724.24	725.26	722.25	723.37	724.53	-0.92	-0.87	-0.73
	5357	722.87	723.98	724.99	721.47	722.54	723.98	-1.4	-1.44	-1.01
	5307	722.37	723.69	724.77	720.84	722.09	723.78	-1.53	-1.6	-0.99
	5260	721.93	723.54	724.66	720.5	721.86	723.69	-1.43	-1.68	-0.97
	5207	721.3	723.47	724.62	720.34	721.74	723.68	-0.96	-1.73	-0.94
	5179	721.1	723.45	724.59	720.27	721.67	723.65	-0.83	-1.78	-0.94
	5124	720.7	723.22	724.43	720.1	721.3	722.93	-0.6	-1.92	-1.5
Chalet Crossing								0	0	0
	5035	719.98	720.86	721.52	719.98	720.86	721.52	0	0	0
	5013	719.82	720.83	721.72	719.82	720.83	721.72	0	0	0
	4935	718.83	720.04	721.58	718.83	720.04	721.58	0	0	0
	4878	718.6	719.7	721.53	718.6	719.7	721.53	0	0	0
Pedestrian Bridge								0	0	0
	4858	718.1	719.5	721.5	718.1	719.5	721.5	0	0	0
	4820	718.07	719.34	721.47	718.06	719.34	721.47	-0.01	0	0
	4797	717.84	719.18	721.46	717.84	719.18	721.46	0	0	0
	4770	717.71	719.1	721.37	717.71	719.1	721.37	0	0	0
Pedestrian Bridge								0	0	0
	4748	717.1	717.94	719.33	717.1	717.94	719.33	0	0	0
	4706	716.29	717.26	718.86	716.29	717.26	718.86	0	0	0
	4648	715.58	716.84	718.38	715.58	716.84	718.37	0	0	-0.01
	4602	715.3	716.55	718.1	715.3	716.55	718.1	0	0	0
Pedestrian Bridge								0	0	0
	4574	714.35	715.34	716.58	714.35	715.34	716.58	0	0	0
	4545	713.52	714.53	715.85	713.52	714.53	715.85	0	0	0
	4490	712.77	713.77	715.22	712.77	713.77	715.22	0	0	0
	4464	712.61	713.66	715.2	712.61	713.66	715.2	0	0	0
	4458	712.59	713.65	715.14	712.58	713.65	715.14	-0.01	0	0
Pedestrian Bridge								0	0	0
	4426	712.12	712.96	713.93	712.05	712.85	713.77	-0.07	-0.11	-0.16
	4393	711.76	712.54	713.45	711.76	712.54	713.45	0	0	0
	4307	710.93	711.72	712.72	710.93	711.72	712.71	0	0	-0.01
	4264	710.57	711.42	712.46	710.57	711.42	712.45	0	0	-0.01
	4197	709.96	710.77	711.98	709.95	710.77	711.97	-0.01	0	-0.01
	4143	709.45	710.39	711.76	709.45	710.39	711.76	0	0	0
	4136	709.39	710.35	711.73	709.39	710.35	711.73	0	0	0
Pedestrian Bridge								0	0	0

Location Description	Stream Length (measured from Afton State Park Trail)	2-year (Existing Water Surface Elevation)	10-year (Existing Water Surface Elevation)	100-year (Existing Water Surface Elevation)	2-year (Proposed Water Surface Elevation)	10-year (Proposed Water Surface Elevation)	100-year (Proposed Water Surface Elevation)	2-year (Proposed-Existing Water Surface Elevation)	10-year (Proposed-Existing Water Surface Elevation)	100-year (Proposed-Existing Water Surface Elevation)
	4119	709.24	709.96	710.94	709.24	709.96	710.94	0	0	0
	4086	708.8	709.63	710.64	708.8	709.63	710.64	0	0	0
	4001	708.06	708.89	709.84	708.06	708.89	709.84	0	0	0
	3914	707.1	707.94	708.97	707.1	707.94	708.97	0	0	0
	3827	706.48	707.37	708.42	706.48	707.37	708.42	0	0	0
	3782	705.6	706.63	708.01	705.6	706.63	708.01	0	0	0
	3657	704.76	705.82	707.93	704.76	705.82	707.93	0	0	0
	3564	704.14	705.23	707.72	704.14	705.23	707.72	0	0	0
	3494	703.6	704.78	707.63	703.6	704.78	707.63	0	0	0
	3438	702.35	704.52	707.4	702.35	704.52	707.4	0	0	0
Phase II Box Culvert								0	0	0
Afton Alps (Reach 2)	3354	702.46	703.83	705.42	702.46	703.83	705.42	0	0	0
	3327	702.33	703.8	705.47	702.33	703.8	705.47	0	0	0
	3270	701.99	703.64	705.33	701.99	703.64	705.33	0	0	0
	3225	701.93	703.58	705.28	701.93	703.58	705.28	0	0	0
	3169	701.63	703.29	704.94	701.63	703.29	704.94	0	0	0
	3119	701.3	702.82	704.25	701.3	702.82	704.25	0	0	0
	3079	700.76	702.1	703.82	700.76	702.1	703.82	0	0	0
	2989	700.01	701.5	703.2	700.01	701.5	703.2	0	0	0
	2943	699.73	701.22	702.79	699.73	701.22	702.79	0	0	0
	2898	699.42	700.95	702.47	699.42	700.95	702.47	0	0	0
	2850	699.21	700.8	702.33	699.21	700.8	702.33	0	0	0
	2806	698.99	700.63	702.13	698.99	700.62	702.13	0	-0.01	0
	2757	698.76	700.47	702.13	698.76	700.47	702.13	0	0	0
	2711	698.28	699.67	701.46	698.28	699.67	701.46	0	0	0
	2664	697.92	699.47	701.24	697.92	699.46	701.24	0	-0.01	0
	2629	697.56	698.87	700.06	697.56	698.86	700.05	0	-0.01	-0.01
	2578	697.35	698.71	700.13	697.35	698.68	700.13	0	-0.03	0
	2530	696.86	698.36	699.66	696.84	698.31	699.64	-0.02	-0.05	-0.02
	2487	696.64	698.16	699.47	696.61	698.09	699.42	-0.03	-0.07	-0.05
	2440	696.37	697.9	699.11	696.32	697.8	699.02	-0.05	-0.1	-0.09
	2400	696.11	697.68	698.99	696.02	697.53	698.84	-0.09	-0.15	-0.15
	2356	695.73	697.39	698.84	695.46	697.05	698.57	-0.27	-0.34	-0.27
	2303	695.46	697.11	698.59	695.02	696.65	697.93	-0.44	-0.46	-0.66
	2251	695.15	696.76	698.06	694.73	696.39	697.6	-0.42	-0.37	-0.46
	2201	694.63	696.23	697.41	694.08	695.36	697.08	-0.55	-0.87	-0.33
	2151	694.38	695.87	696.95	693.76	695.28	696.45	-0.62	-0.59	-0.5
	2097	693.77	695.5	696.84	693.56	695.07	696.34	-0.21	-0.43	-0.5
	2046	693.58	695.18	696.44	693.47	694.99	696.39	-0.11	-0.19	-0.05
	1997	692.73	694.49	696.32	692.72	694.41	696.23	-0.01	-0.08	-0.09
	1954	692.34	694.16	695.51	692.3	694.12	695.45	-0.04	-0.04	-0.06
	1901	691.99	693.67	695.71	691.93	693.58	695.62	-0.06	-0.09	-0.09
	1851	691.72	693.39	695.73	691.61	693.24	695.65	-0.11	-0.15	-0.08
	1817	691.62	693.32	695.73	691.49	693.15	695.65	-0.13	-0.17	-0.08
	1778	691.42	692.98	695.72	691.23	692.72	695.64	-0.19	-0.26	-0.08
	1741	691.31	692.8	695.71	691.07	692.48	695.62	-0.24	-0.32	-0.09
	1732	691.23	692.73	695.57	690.9	692.35	695.43	-0.33	-0.38	-0.14
Pedestrian Bridge								0	0	0
Afton State Park Remeander Area (Reach 1)	1708	690.41	691.43	692.89	690.24	691.05	691.95	-0.17	-0.38	-0.94
	1647	689	690.41	692.26	689.62	690.36	691.24	0.62	-0.05	-1.02
	1543	688.23	689.53	690.77	688.74	689.33	689.84	0.51	-0.2	-0.93
	1516	687.92	689.35	691.27	688.39	688.95	689.46	0.47	-0.4	-1.81
	1470	687.11	688.48	689.89	688.1	688.53	689.01	0.99	0.05	-0.88
	1427	686.61	687.94	689.35	687.71	688.06	688.45	1.1	0.12	-0.9
	1328	686.52	687.87	689.19	686.8	687.28	687.7	0.28	-0.59	-1.49
	1299	686.23	687.62	688.9	686.54	686.88	687.26	0.31	-0.74	-1.64
	1189	685.61	686.98	688.09	685.45	685.93	686.44	-0.16	-1.05	-1.65
	1061	685.23	686.44	687.54	684.19	685.23	686.16	-1.04	-1.21	-1.38
	997	684.41	685.62	686.26	683.95	684.76	685.81	-0.46	-0.86	-0.45
	960	684.14	685.11	686.07	683.98	684.71	685.4	-0.16	-0.4	-0.67
	902	683.91	684.55	685.03	683.91	684.54	685.03	0	-0.01	0
	859	683.56	684.1	684.57	683.56	684.1	684.57	0	0	0
	835	683.39	683.84	684.31	683.39	683.84	684.29	0	0	-0.02
	806	683.21	683.64	684.14	683.21	683.63	684.13	0	-0.01	-0.01
	754	681.98	683.3	683.94	681.98	683.31	683.94	0	0.01	0

Location Description	Stream Length (measured from Afton State Park Trail)	2-year (Existing Water Surface Elevation)	10-year (Existing Water Surface Elevation)	100-year (Existing Water Surface Elevation)	2-year (Proposed Water Surface Elevation)	10-year (Proposed Water Surface Elevation)	100-year (Proposed Water Surface Elevation)	2-year (Proposed-Existing Water Surface Elevation)	10-year (Proposed-Existing Water Surface Elevation)	100-year (Proposed-Existing Water Surface Elevation)
	724	681.81	683.1	683.76	681.81	683.1	683.76	0	0	0
	680	681.55	682.79	683.57	681.55	682.79	683.57	0	0	0
	605	681.19	682.56	683.32	681.19	682.56	683.32	0	0	0
	564	681.01	682.2	683.09	681	682.2	683.09	-0.01	0	0
	513	680.71	681.76	682.87	680.71	681.76	682.87	0	0	0
	454	680.3	681.36	682.3	680.3	681.36	682.3	0	0	0

Figure 3: Channel Velocities Adjacent to Proposed Floodplain Excavation (Location 1)

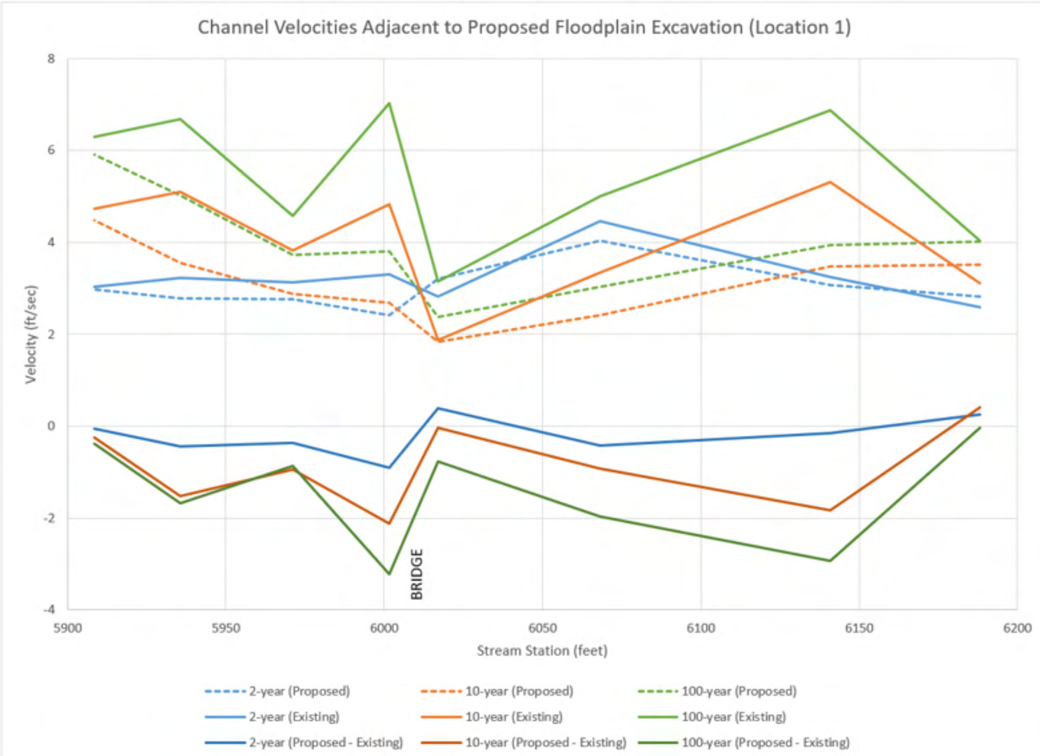
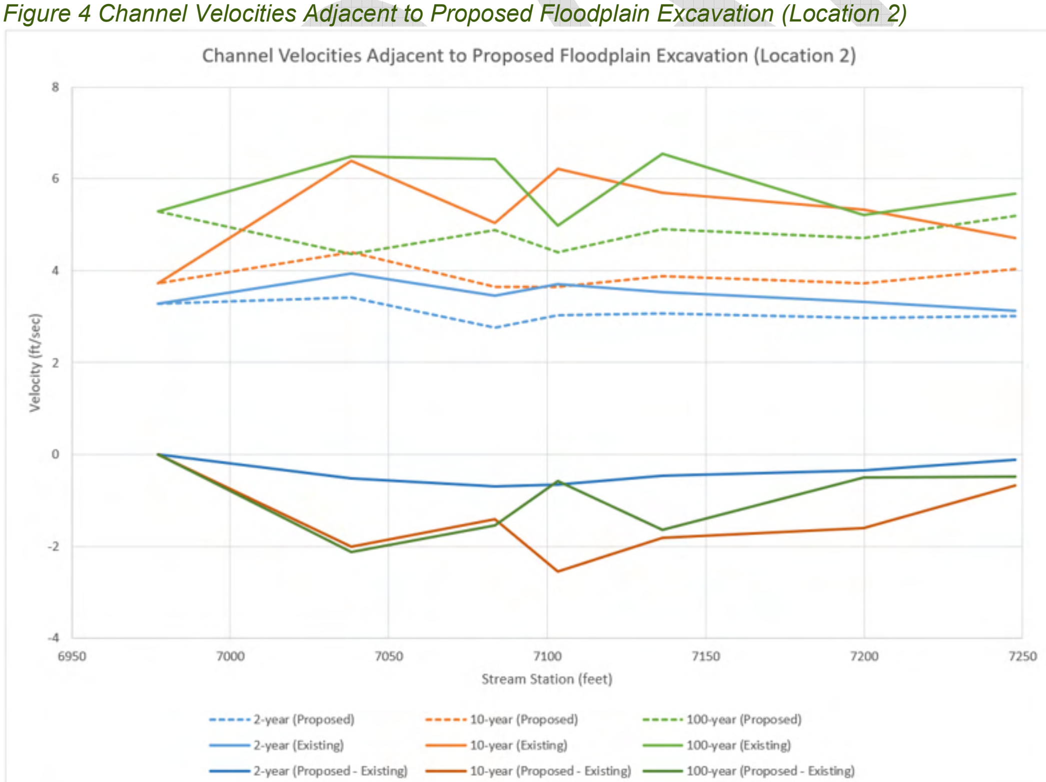


Figure 4 Channel Velocities Adjacent to Proposed Floodplain Excavation (Location 2)



3.3 SEDIMENT TRANSPORT AND RIPRAP SIZING

The MnDNR provided calculations indicating the largest moveable particle during bankfull shear stress is 3.33 inches in diameter, however at key grade control locations it is necessary to consider larger rock sizes, both for stability and diversity.

Rock sizing at riffles was alternatively sized using two methods, 1) Lanes equation, which utilizes mean depth and water surface slope, and 2) the USACE unit discharge method, which utilizes channel slope, design discharge, and bottom width. Depth and width information was pulled from each cross section using HEC-RAS. For a conservative calculation, a slope of 1.8% (max riffle grade) was used for the channel slope and water surface slope at all cross sections. The cross sections were split by design segment to distinguish between locations with floodplain connectivity and sections that remain constricted. The results of this analysis are shown in **Table 6.**

The results indicate that generally riffles can be designed with a D50 of 3.5 inches based on the bankfull D50 calculation, this will allow riffles and pools to migrate over time, similar to natural streams. However riffles that perform a grade control function should be designed with larger D50 sizes, in line with Class III MnDOT sizing. Of note is that these calculations are based on angular rock, if rounded rock is preferred, sizes may be upsized 25-50%. It is anticipated that further detail will be added to the riffle design during 60% and 90% design.

Table 6: Rock Sizing Calculations (inches)

Segment	Event	Lanes Method D50 (Average)	Lanes Method D50 (Max)	USACE Unit Discharge Method D50 (Average)	USACE Unit Discharge Method D50 (Max)
Reach 1 (Afton State Park >100 feet downstream of bridge)	Bankfull	1.2	3.0	1.3	2.6
	2-year	0.9	3.1	1.0	4.0
	10-year	1.1	2.8	1.0	1.5
	50-year	1.6	3.6	1.4	1.5
	100-year	1.8	4.0	1.5	1.7
Reach 1 (Afton State Park just downstream of bridge)	Bankfull	1.6	2.1	1.9	2.6
	2-year	1.1	1.5	1.1	1.6
	10-year	1.9	2.7	1.3	2.6
	50-year	2.8	4.4	1.3	2.1
	100-year	3.4	5.1	1.4	1.9
Reach 2 (Afton Alps Adjacent to Maintenance Road)	Bankfull	2.6	3.9	2.4	3.0
	2-year	3.5	4.4	3.3	4.2
	10-year	4.8	6.5	4.8	6.8
	50-year	4.5	7.9	4.7	9.0
	100-year	4.0	8.3	4.1	9.0
Reach 3 (Upstream Chalet Crossing)	Bankfull	2.1	3.2	1.9	2.5
	2-year	2.8	3.9	2.7	3.6
	10-year	3.8	5.3	3.9	5.1
	50-year	4.0	6.5	4.2	6.5
	100-year	3.9	5.2	4.0	6.5

3.4 ECOLOGY

Stream habitat features included in the project include root wads, log-step-pools, riffle-pool sequences, and wood riffles.

Tree clearing will occur to construct the floodplain bench. Where the drip line of trees outside the excavation area is disturbed due to excavation, trees outside but adjacent to the excavation area will be cleared. Woody debris from cleared trees is anticipated to be utilized for rootwads and woody debris riffles. The quantity of rootwads will be reduced as needed by field staff based on the salvaged wood from the site. The channel is relatively shallow, thus making it difficult to include toe-wood benches, as such they were not incorporated into the plans.

All areas will be seeded with native seed mixes, specified based on inundation likelihood. Shrubs and tree plantings will be utilized in areas with increased shear stress or velocities. The DNR has requested that bare root specimens be utilized. Additionally, Great River Greening has provided notes on planting specs from Phase II, to be revised during phase III. These notes will be incorporated during specification development (90% plans)

3.5 STREAM CROSSING AT CHALET

One portion of the Trout Brook Phase III project consists of removing and replacing two existing 54" corrugated metal pipe (CMP) culverts located to the west of the Alps Village. The crossing provides connectivity to the Afton Alps facility for the public and staff. The objective of the replacement is to improve channel conditions at the stream crossing and create a more efficient waterway opening. The improved waterway opening of the proposed structure will match the channel bankfull width, reduce stream velocity to enhance conditions for fish passage, and reduce the likelihood of overtopping.

During concept design, HEI prepared a structure type memo which compared 4 crossing alternatives. Structure alternatives were selected to maintain a similar channel profile, meet minimum cover requirements (2' min.) and minimize impacts to the existing roadway profile and alignment as well as the adjacent parking lot. This memo is provided in **Appendix D – Structure Type Design Memo**. The memo was presented to stakeholders during the concept design stakeholder meeting. The precast concrete box culvert option was selected based on cost, maintenance, and ability to install fill and boulders inside without damaging the structure.

The crossing is shown in more detail in **Appendix C – 60% Design Plans**.

3.5.1 HYDRAULICS

Below is a description of the hydraulic analysis regarding the proposed crossing. **Table 7** shows existing crossings upstream and downstream of the site.

Table 7: Existing Crossings

Location	Description	Waterway Area (sq.ft.)
CSAH 21 (0.99 miles upstream)		275
Trail Bridge (0.04 miles downstream)	Truss Bridge Connecting to Main Chalet	90
Trail Bridge (0.06 miles downstream)	Truss Bridge Connecting to Main Chalet	90
Maintenance Road (0.10 miles downstream)	Truss Bridge Connecting to Main Chalet	140
Pedestrian Bridge (0.13 miles downstream)	Truss Bridge Connecting to East Parking	110
Pedestrian Bridge (0.18 miles downstream)	Truss Bridge Connecting to East Parking	140
Gravel Maintenance Crossing (0.32 miles downstream)	Box Culvert under Maintenance Road	140
Trail Crossing (0.64 miles downstream)	Concrete Beam Bridge (area estimated)	80

Because the goals of the project include fish passage and habitat, the proposed structure was designed with the MESBOAC approach:

- Match Culvert width to bankfull stream width: The proposed culvert width is 16-feet which is based on the bankful width provided by the MnDNR of 12.6-14.3 feet (average 13.5).
- Extend Culvert Length through the side slope toe of the road: The culvert is extended through the side slope of the road and will utilize end sections to transition from the culvert into the channel.
- Set culvert slope the same as the stream slope: The channel slope through this reach is generally 1%, however slopes on riffles range from 1.5 to 1.8%. The slope of the culvert is set nearly flat. The proposed box culvert will be filled in with material to match the adjacent channel bottom thus matching slope.
- Bury the Culvert: The culvert is anticipated to be buried 1 foot on the bottom, with sporadic larger boulders placed, and thus modeled assuming a fill depth of 1.5 feet.
- Offset multiple culverts: Due to the low overtopping elevation in the adjacent parking lot, floodplain culverts are not necessary to relieve shear stress and velocities for larger events.
- Align the culvert with the stream channel: The stream channel has been generally altered to straighten the reach. The proposed restoration project will add meanders where feasible and the culvert alignment will fit the proposed stream alignment.
- Consider head cuts and cutoffs: Both the upstream and downstream channel segments are stabilized with designed riffles.

The proposed crossing was analyzed in the previously described HEC-RAS model. Table 8 below describes the site hydraulic data.

The existing crossing overtops during a 10-year. Following the MESBOAC approach resulted in a significantly larger waterway area which significantly reduced the frequency of flooding in the parking lot. The proposed crossing overtops during an event greater than the 100-year..

In addition to the MESBOAC approach, the DNR was consulted on appropriate culvert velocities given the species of fish in the channel and likely burst speeds. Assuming an approximate culvert length of 70 feet and DNR guidance materials resulted in a maximum 2-year velocity of 2.3 ft/sec. The proposed crossing has a 2-year velocity of 1.95 ft/sec, which is within the constraints.

Table 8: Chalet Crossing Hydraulic Data

		No Crossing	Existing	Proposed
General Data	Crossing Description	NA	2 – 54x70" CMP Culverts	1 - 16'x7' Box culvert
	Waterway Area (sq.ft.)	NA	41	112
	Flowline Elevation	717.5	717.7	715.6
	Overtopping Elevation	NA	722.6	722.6
Bankfull Event	Culvert Discharge (cfs)	68.3	68.3	68.3
	Overflow Discharge (cfs)	NA	0	0
	Headwater Elevation (ft)	720.7	720.9	720.0
	Mean Velocity through culvert (ft/sec)	NA	3.3	1.5
	Mean Velocity in Downstream Channel (ft/sec)	3.0	3.0	3.0
2-year Event	Culvert Discharge (cfs)	98.7	98.7	98.7
	Overflow Discharge (cfs)	NA	0	0
	Headwater Elevation (ft)	721.1	721.2	720.3
	Mean Velocity through culvert (ft/sec)	NA	4.1	2.0
	Mean Velocity in Downstream Channel (ft/sec)	3.3	3.3	3.3
10-year Event	Culvert Discharge (cfs)	281	281	281
	Overflow Discharge (cfs)	NA	0	0
	Headwater Elevation (ft)	722.5	723.3	721. 7
	Mean Velocity through culvert (ft/sec)	NA	7.8	4.4
	Mean Velocity in Downstream Channel (ft/sec)	3.9	3.9	3.9
25-year Event	Culvert Discharge (cfs)	406	379.7	406
	Overflow Discharge (cfs)	NA	26.3	0
	Headwater Elevation (ft)	723.2	725.2	722.4
	Mean Velocity through culvert (ft/sec)	NA	9.8	5.8
	Mean Velocity in Downstream Channel (ft/sec)	4.5	4.5	4.5
50-year Event	Culvert Discharge (cfs)	510	390.8	510
	Overflow Discharge (cfs)	NA	119.2	0
	Headwater Elevation (ft)	723.7	725.5	723.1
	Mean Velocity through culvert (ft/sec)	NA	9.9	6.9
	Mean Velocity in Downstream Channel (ft/sec)	4.8	4.8	4.8
100-year Event	Culvert Discharge (cfs)	631	398.2	631
	Overflow Discharge (cfs)	NA	232.8	0
	Headwater Elevation (ft)	724.2	725.7	723.8
	Mean Velocity through culvert (ft/sec)	NA	9.9	8.0
	Mean Velocity in Downstream Channel (ft/sec)	5.2	5.2	5.2

4 OPINION OF PROBABLE COSTS

The estimated construction project costs for the project described in this report are as follows:

Table 9 – Opinion of Probable Construction Costs

	Afton Park (Reach 1)	Afton Alps (Reach 2 and 3)	Culvert Crossing	Upstream Floodplain (Reach 4)	Total
Construction Costs	$347,500	$147,900	$316,600	$103,000	$914,900
Construction Contingency (15%)	$52,100	$22,200	$47,500	$15,500	$137,300
Other Costs	$175,900	$77,400	$80,800	$49,200	$383,300
Total Project Costs	$575,500	$247,500	$444,900	$167,700	$1,435,500

*Other costs include: engineering, legal, and other administrative costs.

A detailed breakdown of the project costs is included as **Exhibit E** to this report, Project Itemized Cost Estimate.

5 RECOMMENDATION AND NEXT STEPS

Following stakeholder review of the 60% Plans and Design Report, comments and revisions will be incorporated to create the 90% plan set. The 60% plan set will be used for permitting submittals. Specifications and bidding documents will be prepared in conjunction with the 90% plans. Any necessary revisions that arise during regulatory review will be incorporated prior to construction.

APPENDIX A – WETLAND DELINEATION

Trout Brook Restoration
Wetland / Watercourse Delineation

Created By: ebaskerville Date Created: 10/27/21 Date Exported: 11/3/2021 Image: MnGEO 2020 7-County Elevation Data: NA
Horizontal Datum: NAD 1983 UTM Zone 15N Vertical Datum: North American 1983
H:\Maple Grove\JBN\4800\4876\4876_0051 Trout Brook Ph3\GIS\Maps\trout_brook_emmy_WEST.mxd

N E S W

0 190 380
Feet
1 inch = 187 feet

HOUSTON engineering, inc.

Trout Brook Restoration
Wetland / Watercourse Delineation

Created By: ebaskerville   Date Created: 10/27/21   Date Exported: 1/28/2022   Image: MnGEO 2020 7-County   Elevation Data: NA
Horizontal Datum: NAD 1983 UTM Zone 15N   Vertical Datum: North American 1983
H:\JBN\4800\4876\4876_0051 Trout Brook Ph3\GIS\Maps\trout_brook_emmy_EAST.mxd

Project Area Delineation
Stormwater Feature
Wetland
Watercourse Boundary
Sample Points

N E S W

0 140 280
Feet
1 inch = 141 feet

HOUSTON engineering, inc.

APPENDIX B - HYDROLOGY

Flow frequency statistics are necessary to size project features. Results from several methodologies were compared to determine design discharges for Trout Brook. Unless otherwise referenced all discharges are calculated at the footbridge near the Afton Alps – MnDNR property line.

USGS REGRESSION EQUATIONS

The project site is located miles from the Wisconsin border; thus discharges were calculated using both SIR 2009-5250 (Minnesota Regression Equations), and WRIR 03-4250 (Wisconsin Regression Equations). The site is in Minnesota Region B, however geographically close to regions D and F. For comparison, discharges were calculating using all three regional equations. The watershed characteristics were calculated using StreamStats v4.6.2. The resultant discharges are shown in **Table 10** below.

Table 10: USGS Regression Equations Resultant Discharges (cfs)

Event	Stream Stats (USGS Regression Equations) MN Region B	Stream Stats (USGS Regression Equations) MN Region D	Stream Stats (USGS Regression Equations) MN Region F	Stream Stats (USGS Regression Equations) WI Region 2
1.5 yr	70	86	267	
2 yr	101	123	364	318
5 yr	200	245	648	584
10 yr	286	349	873	781
25 yr	414	505	1192	1069
50 yr	520	640	1449	1291
100 yr	643	796	1727	1522

EXISTING DATA STUDIES

CSAH 21 (St. Croix Trail South) has a waterway study and risk assessment on record that was completed by a contractor for Washington County. This study was completed in 1999 and used a Hydrocad model. A drainage area transfer equation was used to transfer the calculated discharges to the project site. An exponent of 0.65 was used.

Table 11: CSAH 21 MnDOT Risk Assessment Discharges

Location/ Drainage Area/ Event	Discharge at CR 21	Discharge at Parcel Boundary Foot Bridge (gage)
	5.92 Square Miles	6.85 Square Miles
2yr	310	341
5yr	663	729
10yr	973	1070
25yr	1460	1605
50yr	1880	2067
100yr	2370	2606

HYDROCAD MODELING (SCS)

To compare results, a HydroCAD model (v10.10-4b) was developed. The SCS curve number method was utilized along with Atlas 14 rainfall depths. The model included 9 subcatchments, 3 storage areas, and 8 reaches. The main catchment was originally gathered from Streamstats and refined via county LiDAR data. Subcatchments range in area between 60 – 2,000 acres with the time of concentration for each subcatchment estimated using the velocity method. Reaches were split into sections ranging from 500 - 5,000 feet using the Muskingum-Cunge method with representative cross sections for each reach cut from LiDAR data. Storage curves were developed based on county LiDAR.

Table 12: HydroCAD Model Results (cfs)

Event	HydroCAD (Developed November 2021)
1.5 yr	148
2 yr	176
5 yr	310
10 yr	473
25 yr	768
50 yr	1062
100 yr	1426

DRAINAGE AREA RATIO FROM USGS GAGING STATIONS ON SIMILAR STREAMS

Due to the variation in calculated discharges via varied methodologies, an analysis was done using drainage area transfer from nearby USGS gages for comparison. Gages near the site, but on different streams with similar watershed characteristics were used. The flow frequency curves in SIR 2009-5250 were used at each gage. The results of the drainage area transfer and comparison is shown in **Table 13** and **Table 14.**

Table 13: Nearby Gage Watershed Characteristics

	Site	USGS Gage 053450000	USGS Gage 053455150
Location	Parcel Boundary Foot Bridge	Vermillion River near Empire, MN	Pine River Near Cannon Falls, MN
Years of Data in Discharge-Frequency Analysis	NA	33 years of data; 1943, 1974-2005	21 years of data; 1960-1980
Drainage area (DAREA) (mi2)	6.85	129	20.6
Main-channel slope (SLOPE) (ft/mi)	50.2	8.37	11.8
Lake area (LAKE) (percent)	0	0.88	0
Storage area (STOR) (percent)	1.87	10.8	0.81
Soil hydrologic group A (SOILA) (percent)	0	8.95	12.9
Soil hydrologic group D (SOILD) (percent)	0	0.63	4.72
Generalized mean annual runoff (ROFF) (in/yr)	6.68	6.04	6.37

Table 14: Nearby Gage Drainage Area Transfer Resultant Discharges (cfs)

Event	At USGS Gage 053450000	USGS Gage 053450000 to Site	USGS Gage 053455150	USGS Gage 053455150 to Site
1.5 yr	488	50	99	50
2 yr	703	70	155	78
5 yr	1450	141	347	172
10 yr	2140	205	515	255
25 yr	3260	310	767	378
50 yr	4280	405	981	483
100 yr	5490	518	1210	595

GAGE DATA

Gage data was provided by South Washington Watershed District for Trout Brook. Gage data has been collected during the summer from 2004-2007, and 2011-2020. The largest events on record were 2015, 2005, and 2019.

Unfortunately, in 2015, the gage malfunctioned and the peak was not collected, however the nearby gage at Afton showed 6.5 inches of rain in a 24-hr period, which is just greater than a 50-year event (using Atlas 14 precipitation depths). Site photos of the event show that water was just breaking out into the nearby parking lot and below the top of culvert at the crossing. The hydraulic modeling indicates that this was likely an approximately 150-200 cfs event. This event was ranked 1st.

The event in 2005 was recorded by the gage with no issues noted. Nearby gages indicate 4.0 to 5.5 inches fell within 24 hours. This would correspond to an approximately 7 to 30-year event. This event was ranked 2nd.

The event in 2019 was a spring snowmelt and rainfall event. The gage was not yet recording discharge data when the event occurred. This event was ranked 3rd.

HEC-SSP statistical software was used to perform a Bulletin 17C analysis. Station skew was used and the events in 2015 and 2019 were incorporated as historical events. Missing years were not considered since local knowledge indicates they did not have large events. **Table 15** and **Table 16** show the results of this analysis.

Table 15: Gage Data

Year	Rank	Discharge at Gage (cfs)	% Chance Annual Exceedance	Recurrence Interval (year)
2015	1	150-200 (estimated)	6.7%	14.9
2005	2	150	13.3%	7.5
2019	3	NA	20.0%	5.0
2020	4	142	26.7%	3.7
2007	5	103	33.3%	3.0
2013	6	100	40.0%	2.5
2014	7	81	46.7%	2.1
2017	8	56	53.3%	1.9

Year	Rank	Discharge at Gage (cfs)	% Chance Annual Exceedance	Recurrence Interval (year)
2012	9	35	60.0%	1.7
2006	10	34	66.7%	1.5
2018	11	33	73.3%	1.4
2004	12	29	80.0%	1.3
2016	13	16	86.7%	1.2
2011	14	16	93.3%	1.1

Table 16: Bulletin 17C Flow Frequency Analysis

Characteristic	Bulletin 17C Discharge Frequency Analysis at Gage	Bulletin 17C Discharge Frequency Analysis (95% Confidence Limit) at Gage
1.5 yr	43	66
2 yr	63	95
5 yr	122	191
10 yr	168	313
25 yr	232	553
50 yr	282	790
100 yr	335	1102
500 yr	389	1520

RECOMMENDED DESIGN DISCHARGES

Table 17, **Figure 5**, and **Figure 6** show the results of all the various hydrologic calculation methods.

Gage data is typically the best available data for calculating flow frequency relationships; however, with only 14 years of data, there is high potential variability in plotting positions. There appears to be a jump in the graphical plot near the 1.5 to 3-year event. This may be due to upstream storage or other factors. As a result of the limited period of record and jump, the 90% confidence limits for the 1.5-year and 2-year events are 26-66 cfs and 41-95 cfs respectively.

The design discharges to be utilized are those based on USGS Regression equations in Region B. This methodology is recommended for the following reasons:

1. The discharges for all events calculated using USGS regression equations fit between the Bulletin 17C discharge and the 95% confidence limit.
2. There is a steep jump on the plotted gaged discharges near the 1.5-2-year discharge. This indicates that a log-Pearson Type III curve may not be a good fit near the reoccurrence interval of concern.
3. This is consistent with the methodology used during previous phases.
4. Generally, Minnesota has seen increases in intense rainfall events in the last several decades, therefore a conservative discharge will increase the resiliency of the project.
5. While local knowledge indicates that 2019 was the only snowmelt event, its possible the gage is missing spring runoff peaks which is skewing the Bulletin 17C analysis to lower discharges during smaller events. It is feasible that spring snowmelt events in the 1.5 to 2-year frequency range are overlooked by local observers.
6. The USGS regression equations are based flow frequency of numerous gages with longer periods of record.

Table 17: Summary of Discharge Calculations

Recurrence Interval (year)	USGS Regression Equations MN Region B	USGS Regression Equations MN Region D	USGS Regression Equations MN Region F	USGS Regression Equations WI Region 2	MnDOT Upstream Bridge Hydraulic Report	Drainage Area Transfer USGS Gage 05345000	Drainage Area Transfer USGS Gage 05355150	HydroCAD (Developed November 2021)	Bulletin 17C	Bulletin 17C 95 % Confidence
1.5	**78**	70	86	267			50		43	95
2	**112**	101	123	364	318	341	70	176	63	191
5	**222**	200	245	648	584	729	141	310	122	313
10	**317**	286	349	873	781	1070	205	473	168	553
25	**457**	414	505	1192	1069	1605	310	767	232	790
50	**572**	520	640	1449	1291	2067	405	1062	282	1102
100	**705**	643	796	1727	1522	2606	518	1426	335	1520

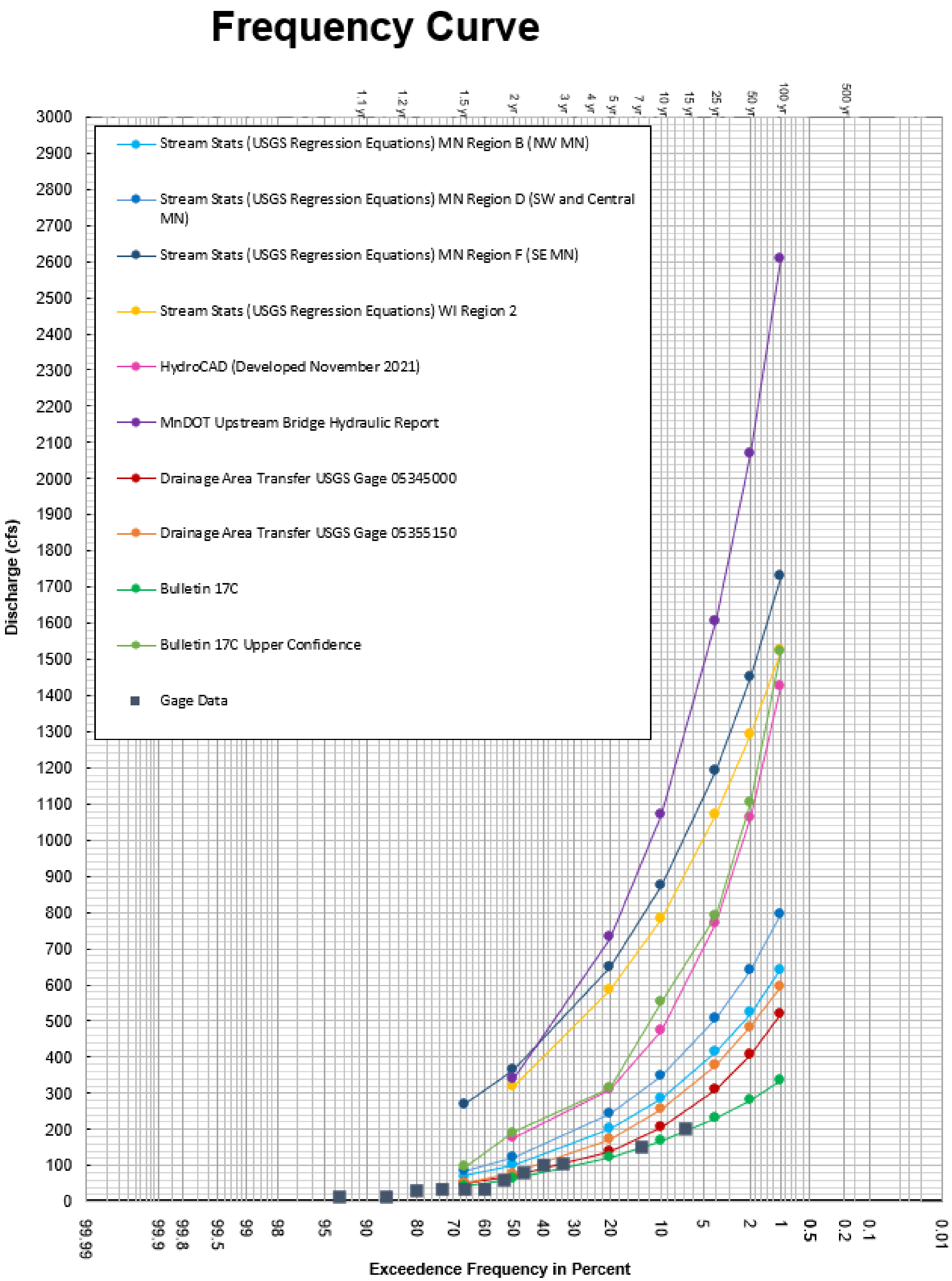


Figure 5: Discharge Frequency Plots of all Calculated Methods

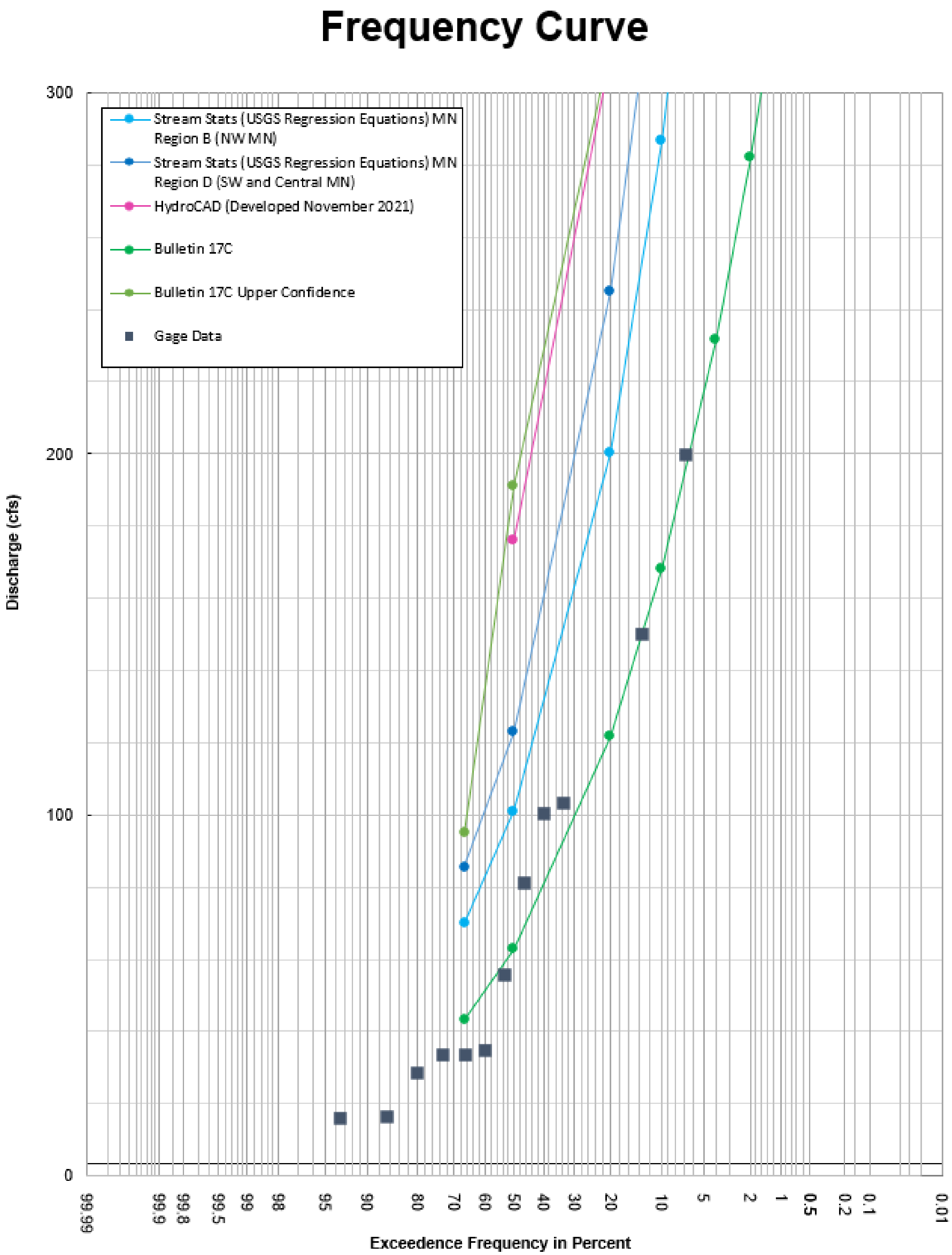


Figure 6: Discharge Frequency Plots of all Calculated Methods (low flow scale)

APPENDIX C – 60% DESIGN PLANS

CONSTRUCTION PLANS FOR

SOUTH WASHINGTON WATERSHED DISTRICT
TROUT BROOK RESTORATION PHASE 3

AFTON ALPS, MN
MAY 2022

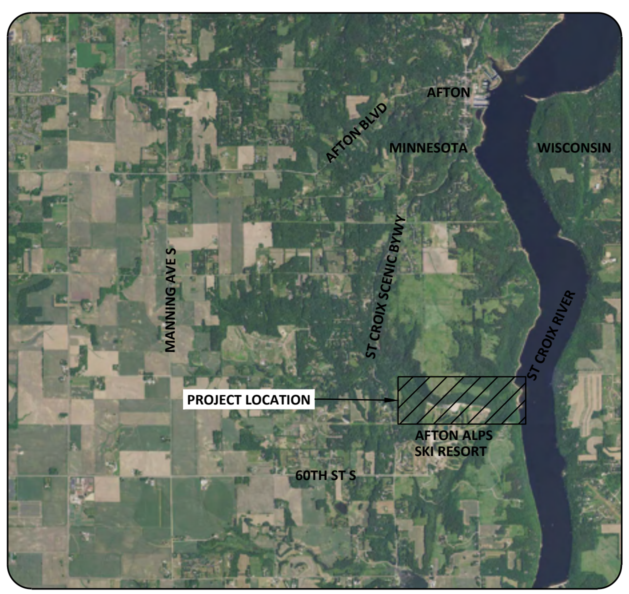
HOUSTON engineering, inc.
7550 MERIDIAN CIR N
SUITE 120
MAPLE GROVE, MN 55369
P: 763.493.4522
T: 1.866.319.2040
www.houstoneng.com

SHEET INDEX

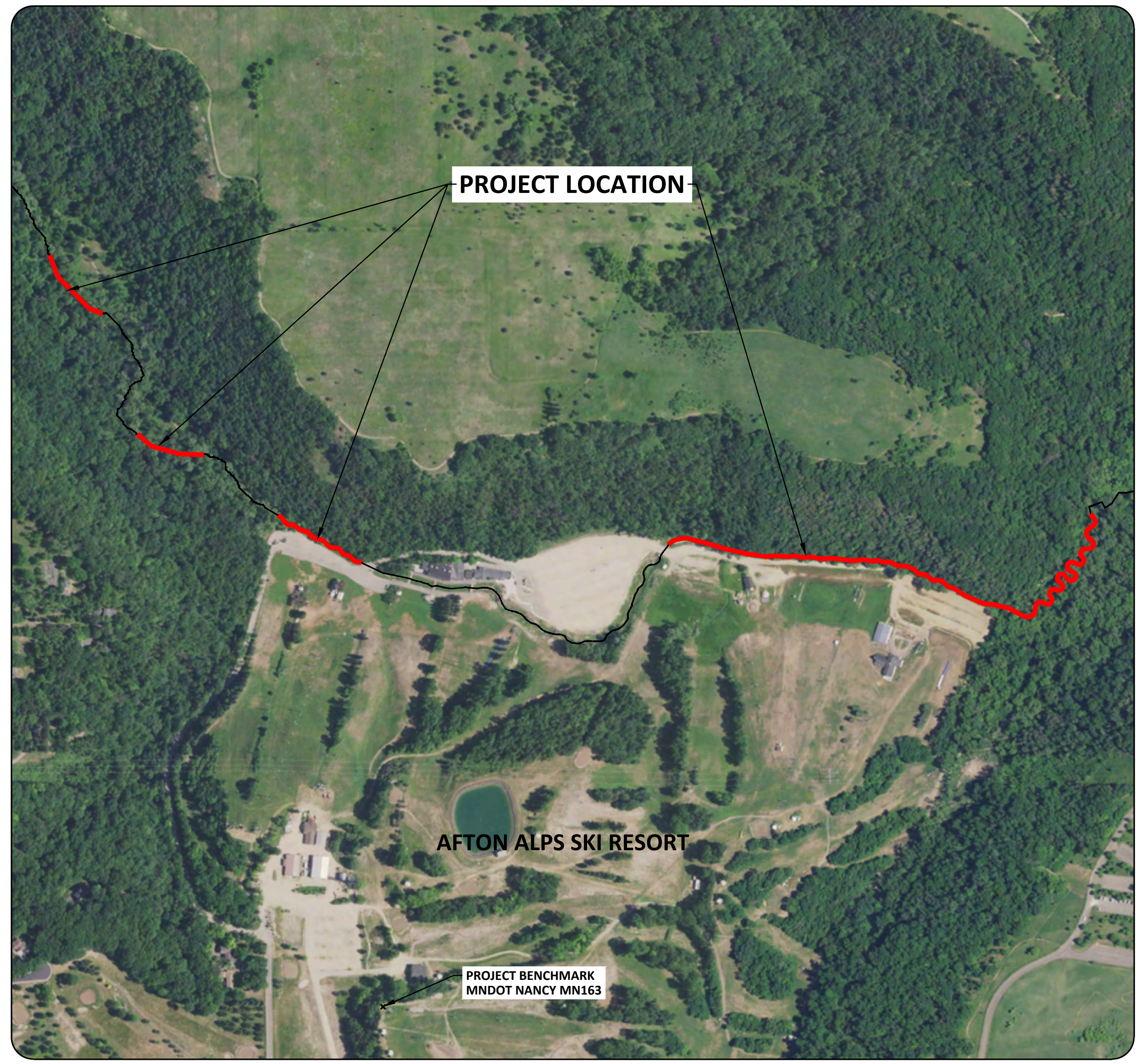
1	COVER
2	SITE ACCESS AND STAGING
3-9	CHANNEL PLAN AND PROFILE
10-15	CROSS SECTIONS
16	TYPICAL CHANNEL PLAN VIEW
17-18	RIFFLE DETAILS
19	LOG STEP POOL DETAIL
21	BOX CULVERT GENERAL PLAN
22	BOX CULVERT TYPICAL SECTION
23	BRIDGE SURVEY
24	BOX CULVERT PLAN AND PROFILE
25-27	VEGETATION MANAGEMENT & EROSION CONTROL PLAN
28	SOIL AREA STABILIZATION
29	EROSION CONTROL DETAILS
30	SWPPP NOTES

PROJECT BENCHMARK:
MNDOT DISK (STAMPED NANCY 88) 4.5 MILES SOUTH OF AFTON, IN THE AFTON ALPS SKI AREA, IN MOST SOUTHERN SKI LIFTS, ON THE HIGHEST POINT IN SKI AREA, AT THE MOST NORTH OF 3 CHAIR LIFTS, 104.7 FEET NORTH-NORTHEAST OF COUNTY STATION ALPS, 39.3 FEET NORTHWEST OF A RADIO POLE, 33.8 FEET EAST-NORTHEAST OF A 4.0 INCH DIAMETER RED CEDAR TREE, 28.2 FEET SOUTH OF A LIGHT POLE, 21.8 FEET WEST-NORTHWEST OF A WOOD POST, 13.6 FEET SOUTHEAST OF A WITNESS POST. = 919.654 (NAD83)

VERTICAL DATUM: NAVD 1988
HORIZONTAL DATUM: NAD 1983



VICINITY MAP



LOCATION MAP

PRELIMINARY
NOT FOR CONSTRUCTION

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Project No. 4876-0051

SITE ACCESS NOTES:

1. WORK AND ACCESS ONLY PERMITTED ON AFTON ALPS PROPERTY FROM APRIL 15TH TO OCTOBER 15TH.
2. TREE CLEARING ONLY ALLOWED AUGUST 1ST TO MAY 31ST.
3. IN-STREAM WORK ONLY ALLOWED APRIL 2ND TO AUGUST 31ST.
4. ACCESS MUST BE MAINTAINED TO THE PUBLIC ON AFTON STATE PARK TRAILS JUNE 24 TO JULY 10.
5. IT IS ANTICIPATED THAT THE CHANNEL WORK FROM STA 110+00 TO 116+00 WILL BE COMPLETED OFFLINE AND ALLOWED ONE GROWING CYCLE PRIOR TO REMOVING PLUGS AND BRINGING ON LINE.

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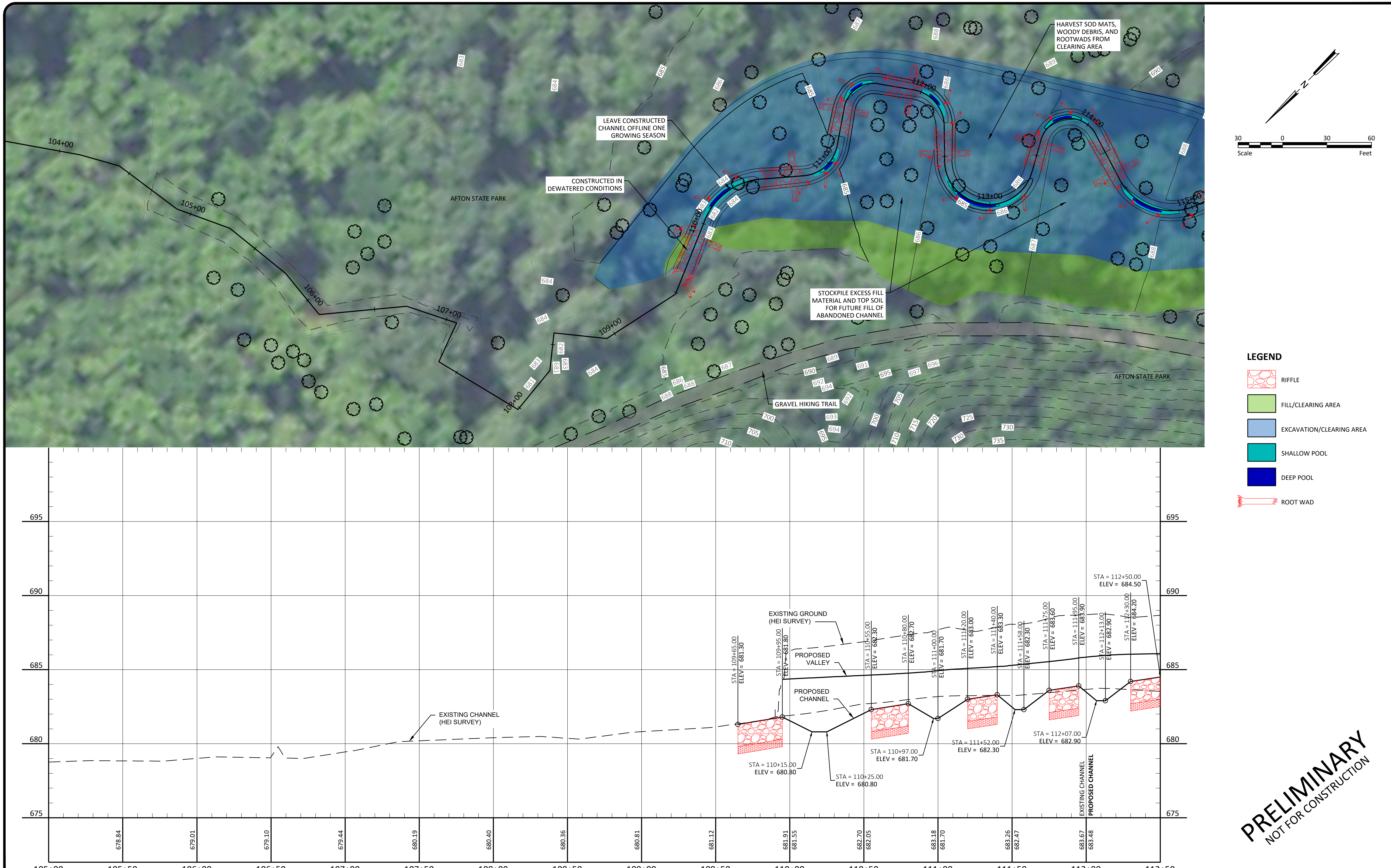
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

SITE ACCESS AND STAGING
PROJECT NO. 4876-0051

SHEET 2



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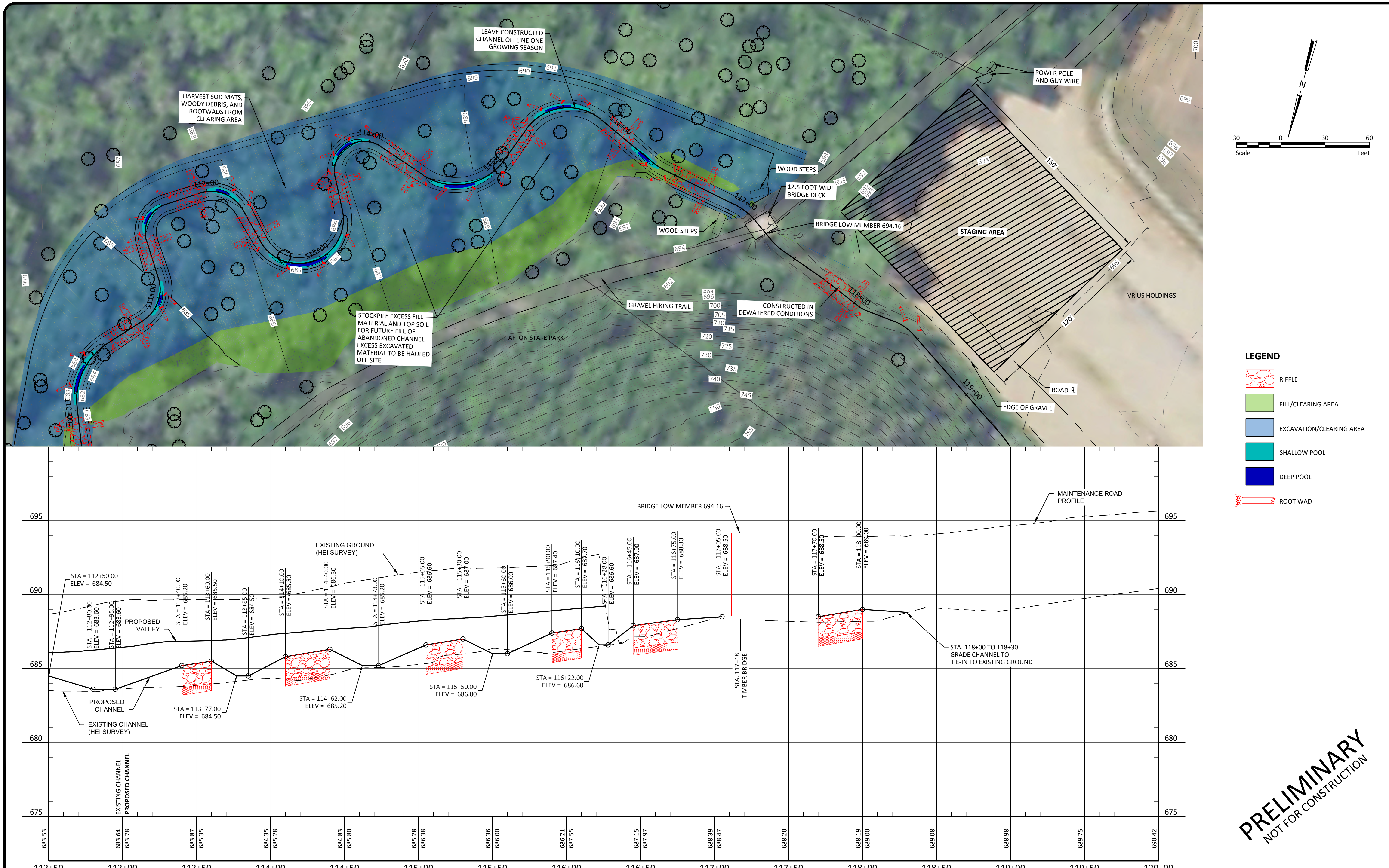
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

PLAN AND PROFILE

PROJECT NO. 4876-0051

SHEET 3



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SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

PLAN AND PROFILE

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SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

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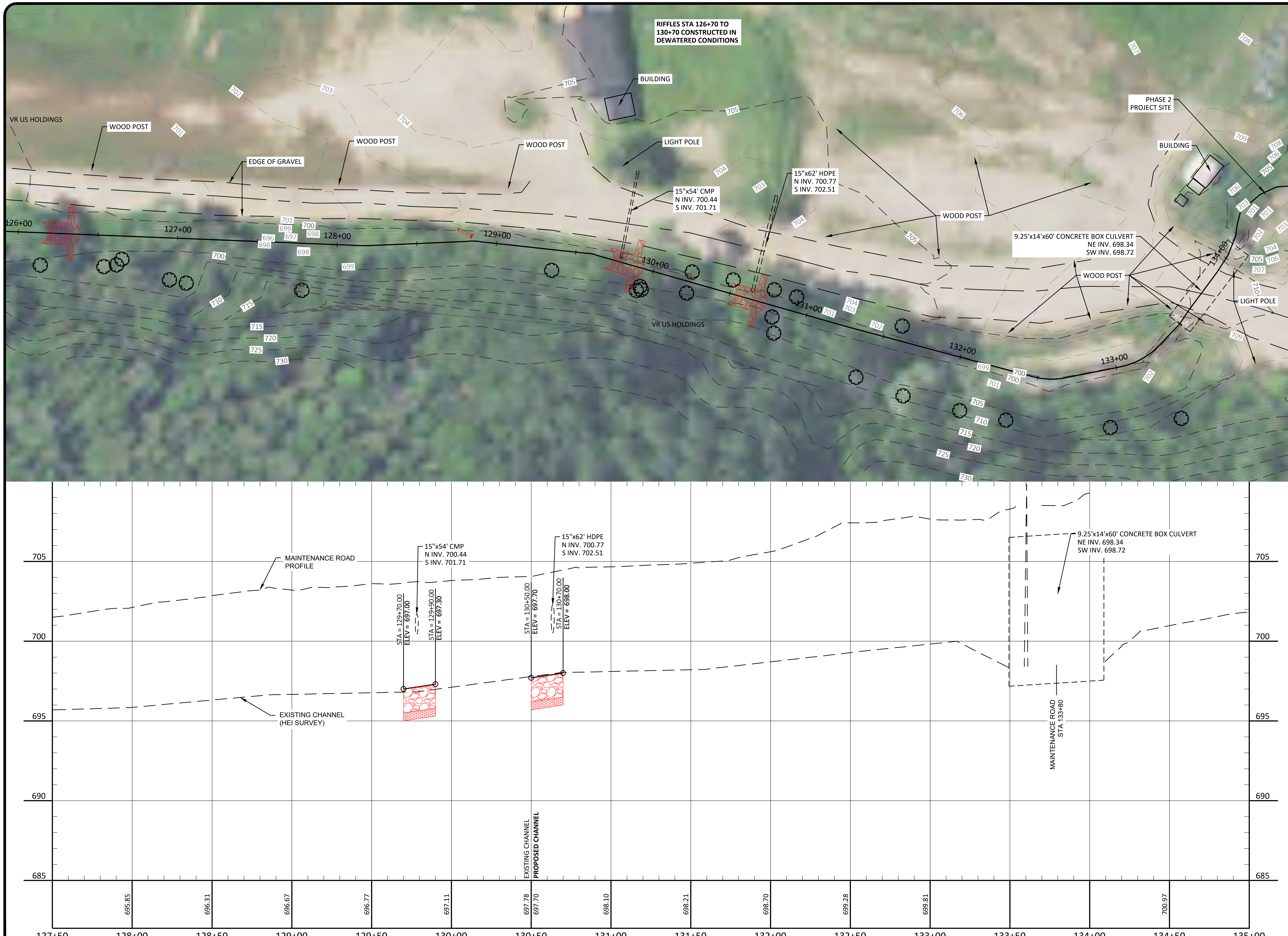

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- EXCAVATION/CLEARING AREA
- SHALLOW POOL
- DEEP POOL
- ROOT WAD

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AFTON, MN

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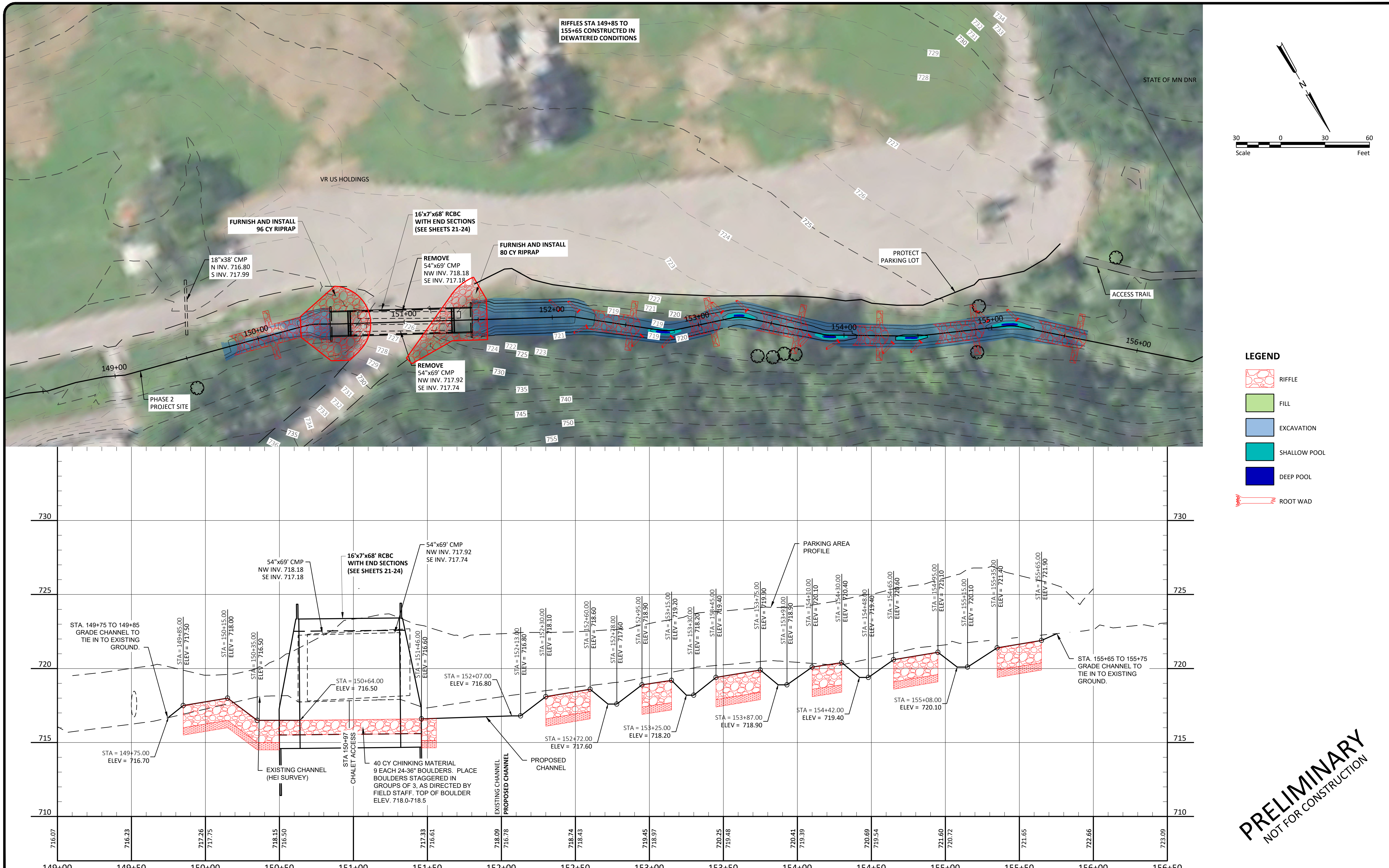

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SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

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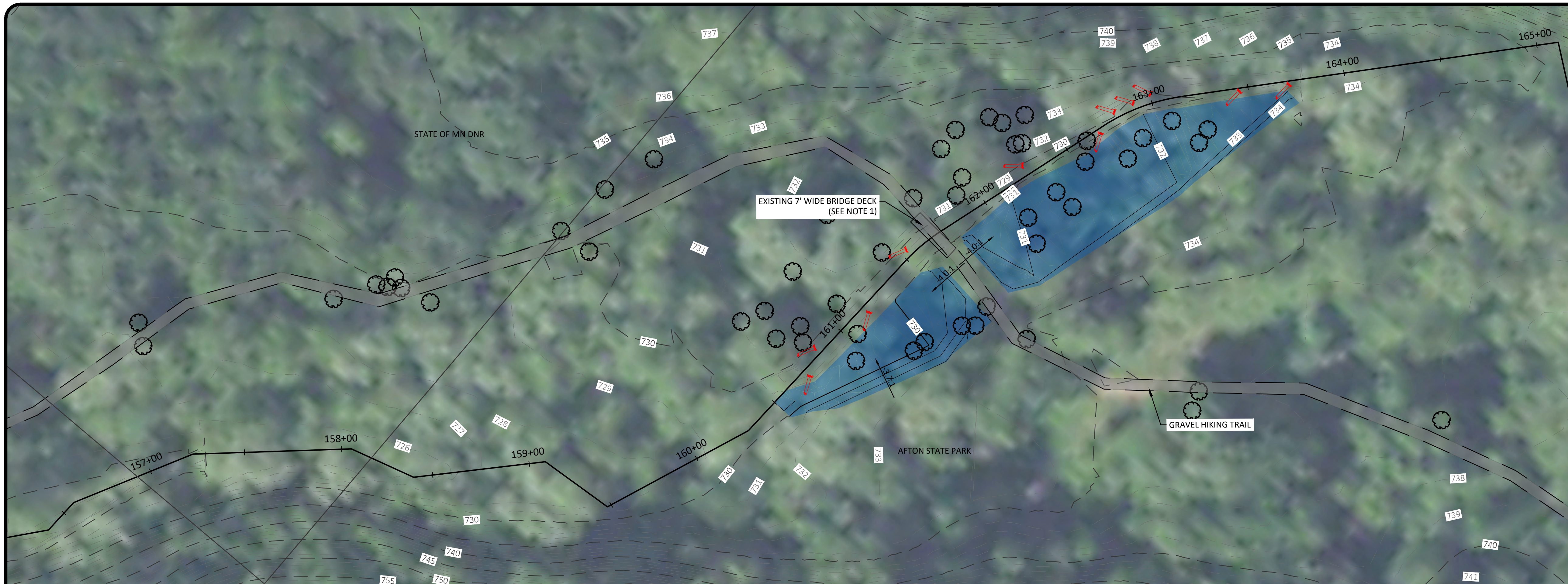

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NOTES:

1. EXISTING BRIDGE IS RATED FOR PEDESTRIAN TRAFFIC ONLY. NO EQUIPMENT WILL BE PERMITTED OVER BRIDGE AND SHALL NOT BE USED FOR CONSTRUCTION ACTIVITIES

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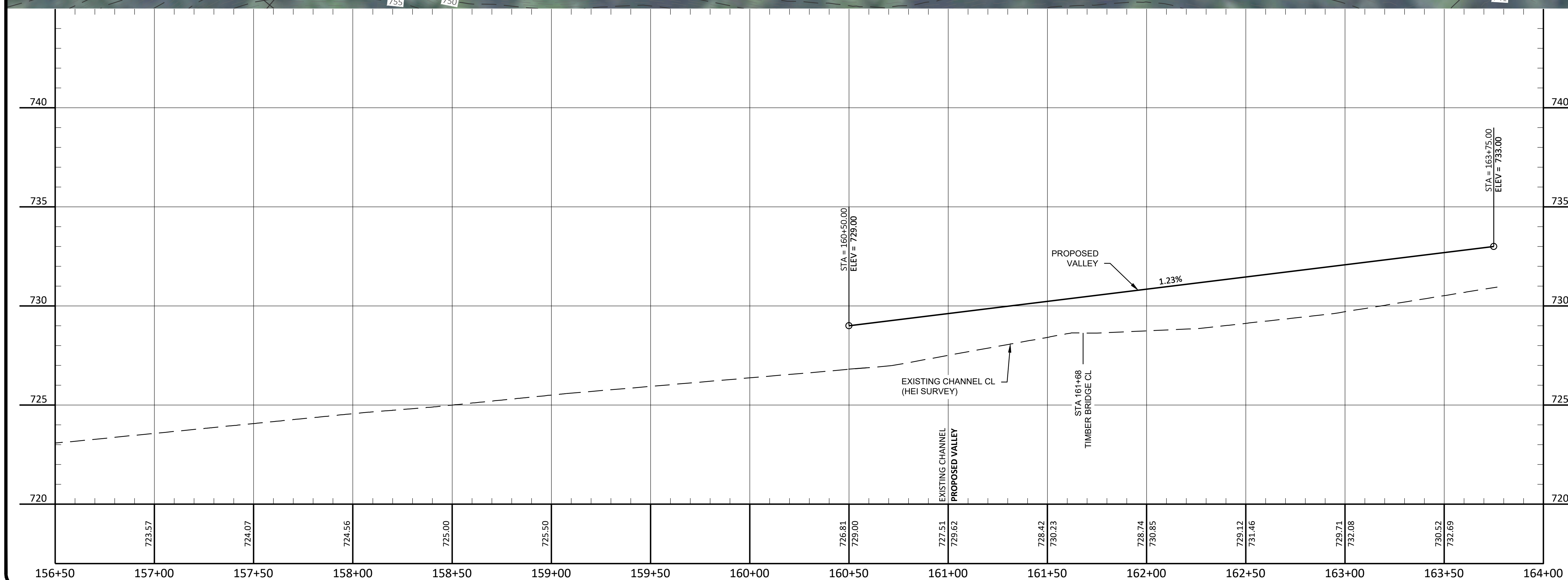
- SHALLOW POOL
- DEEP POOL
- ROOT WAD



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SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

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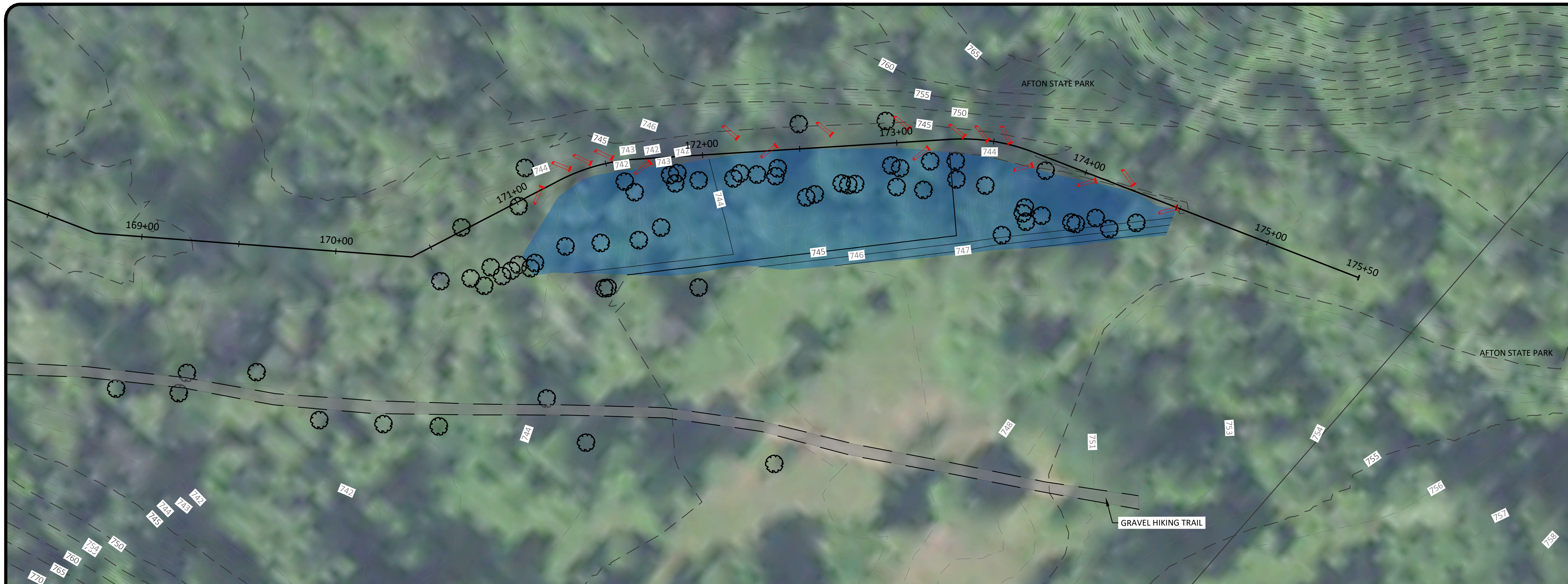

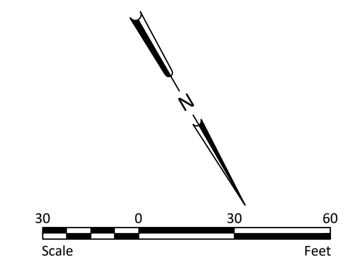

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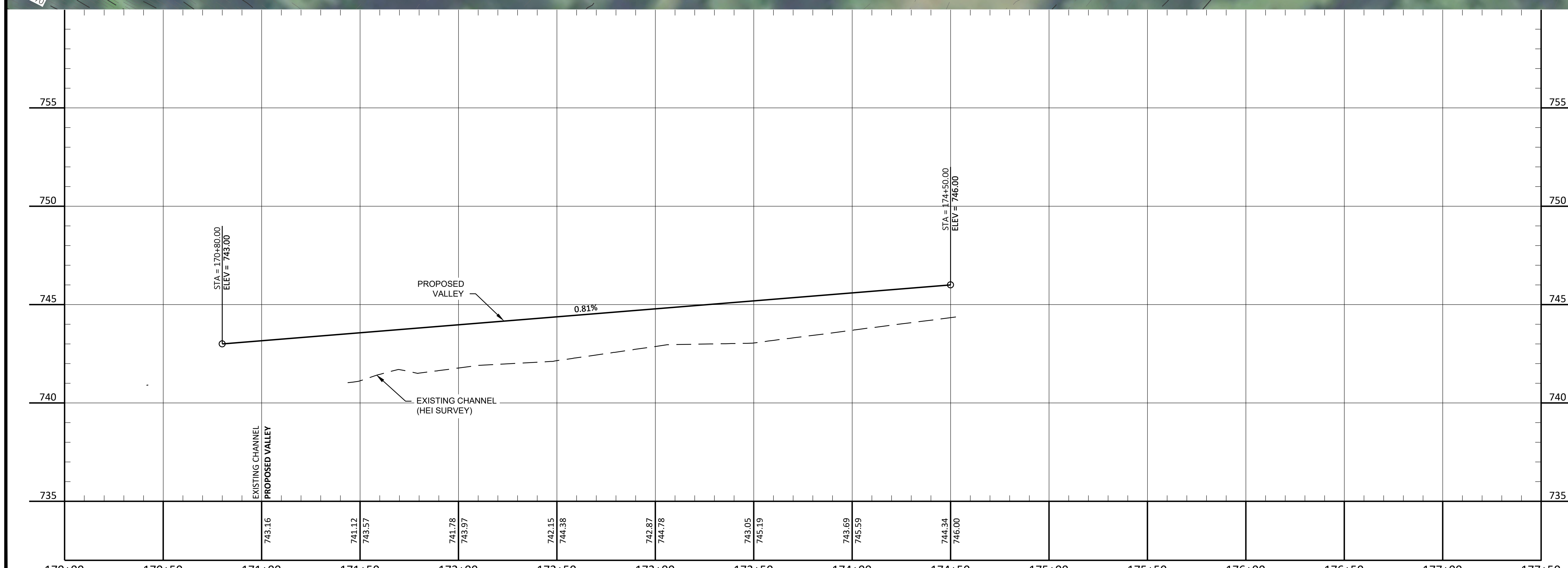

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SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

PLAN AND PROFILE

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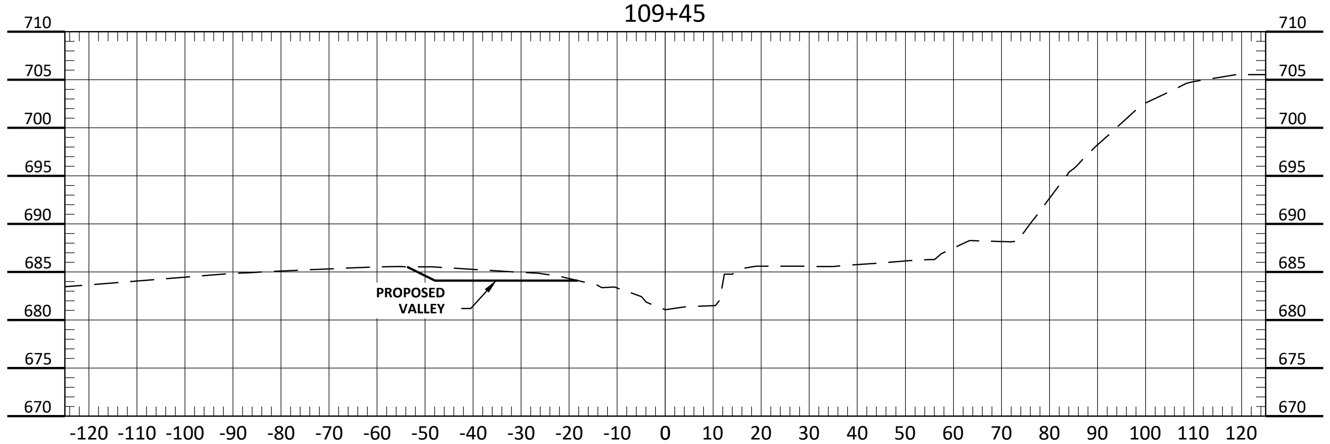

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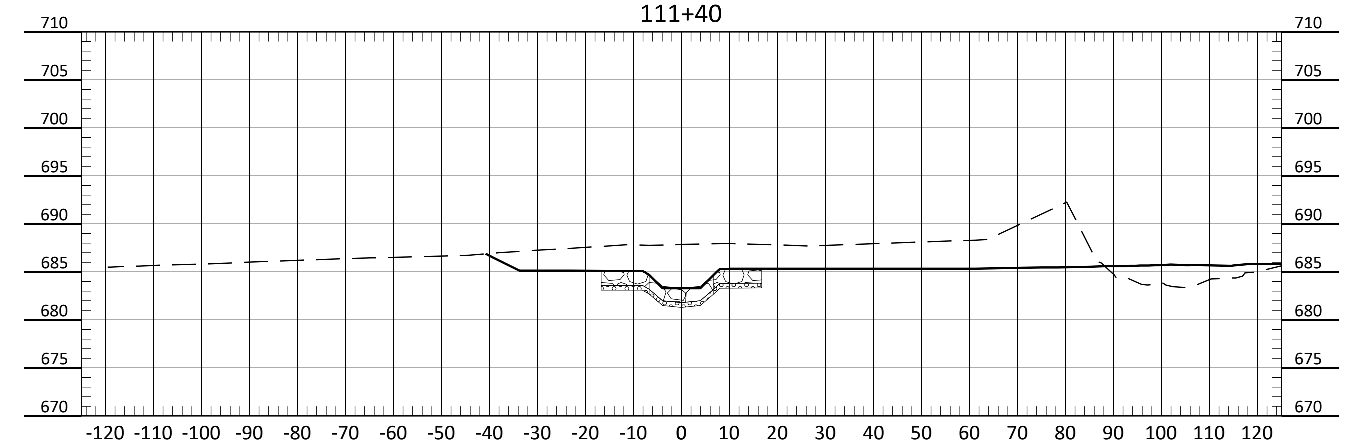

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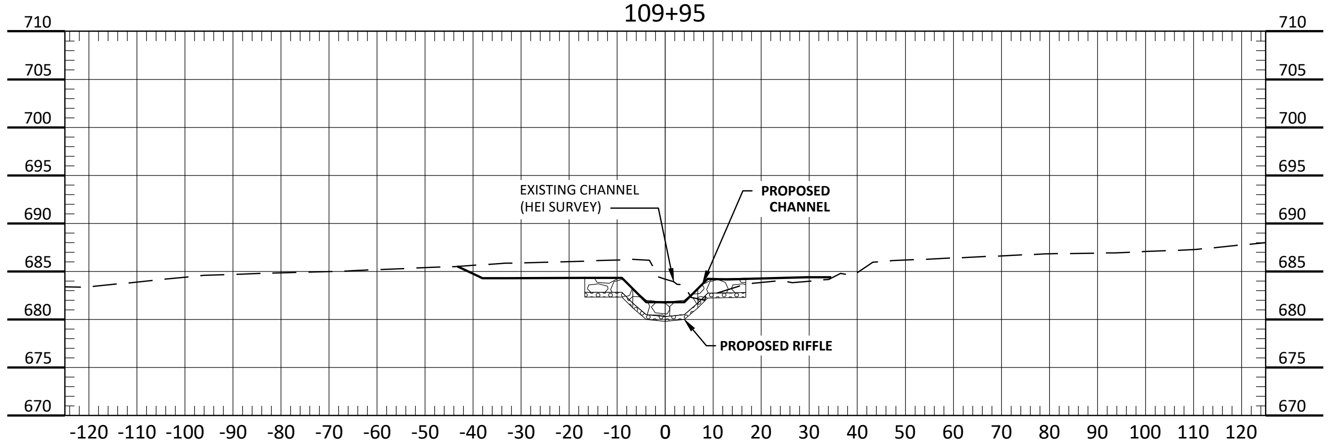

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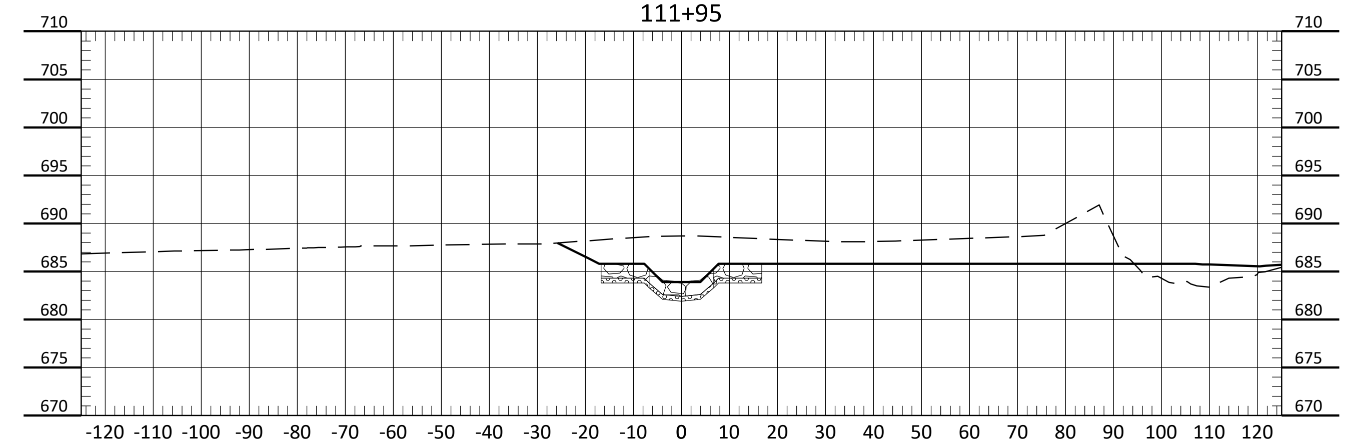

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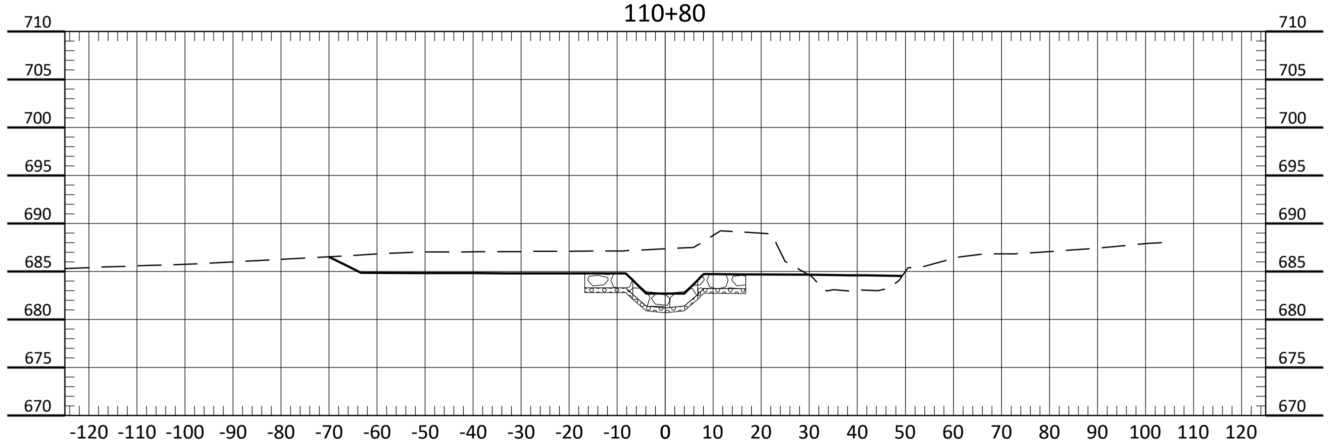

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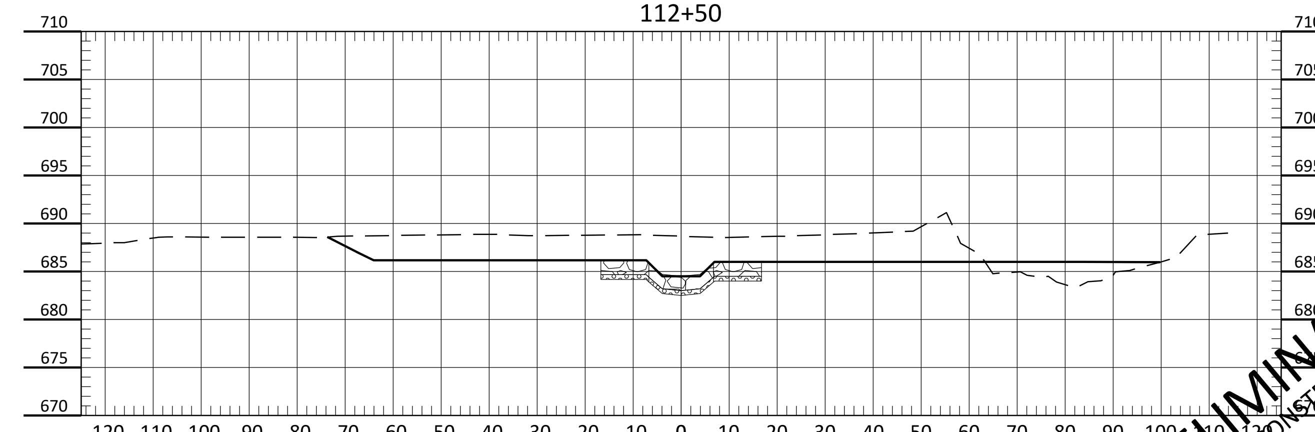

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TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

CROSS SECTIONS

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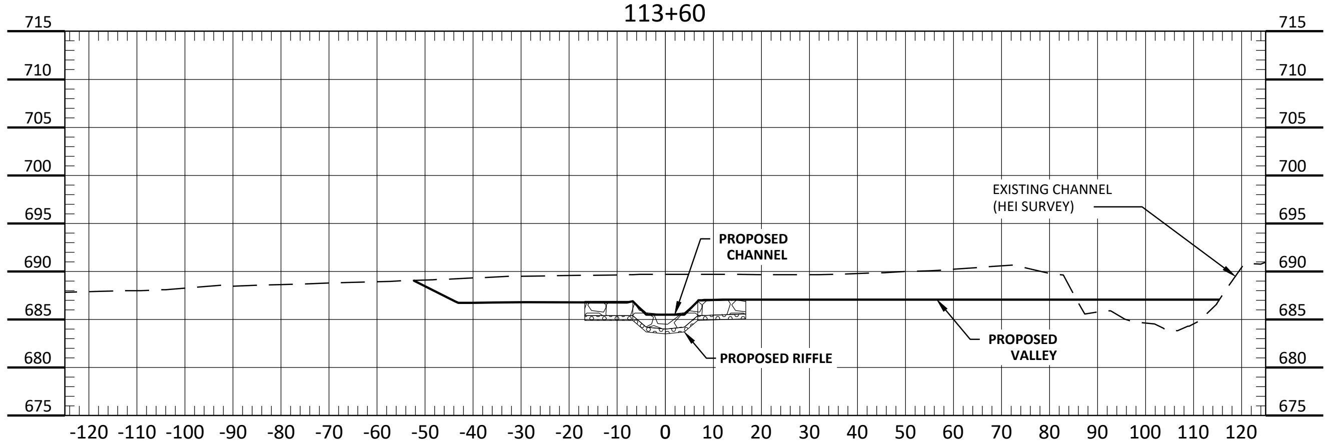

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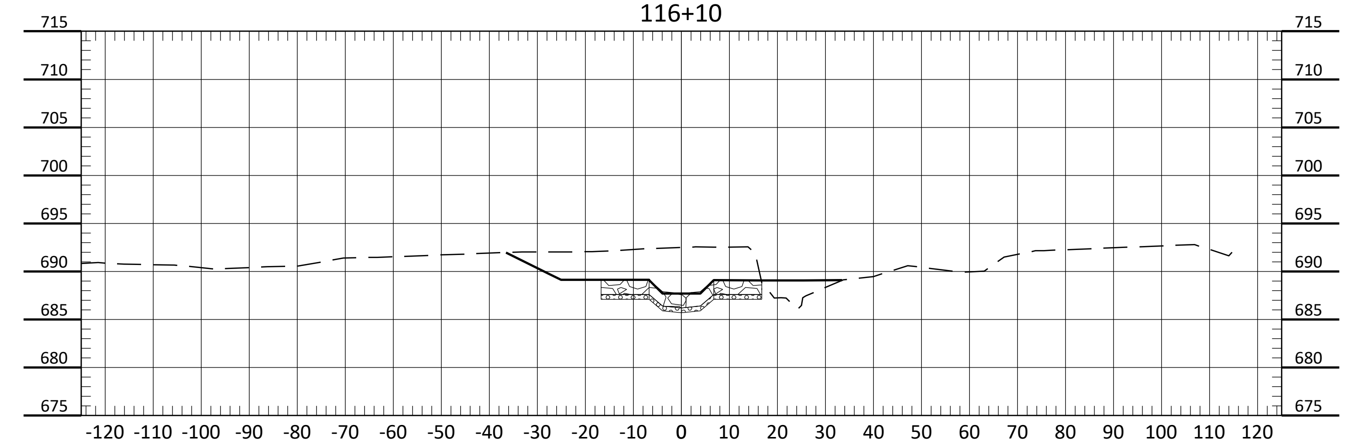

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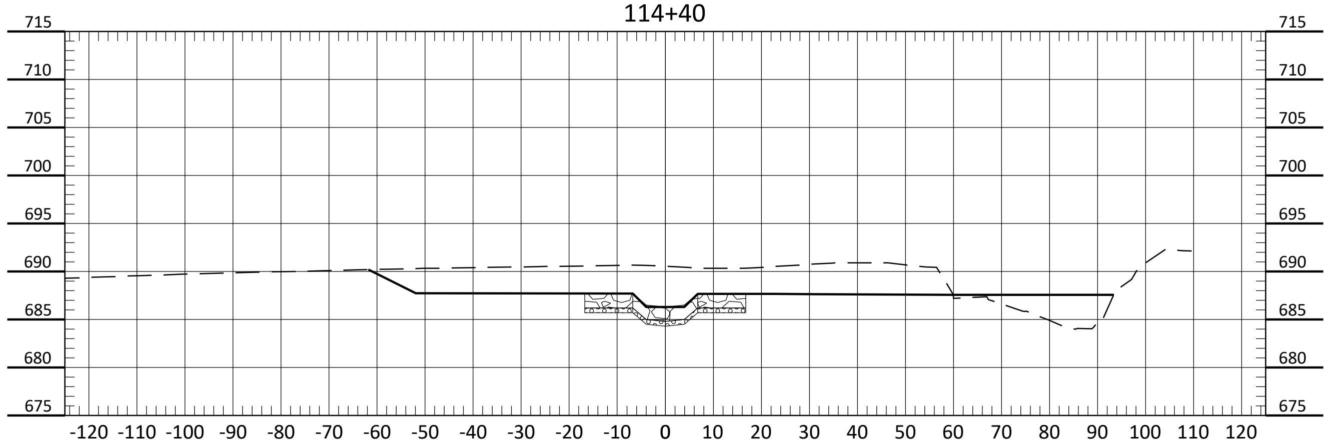

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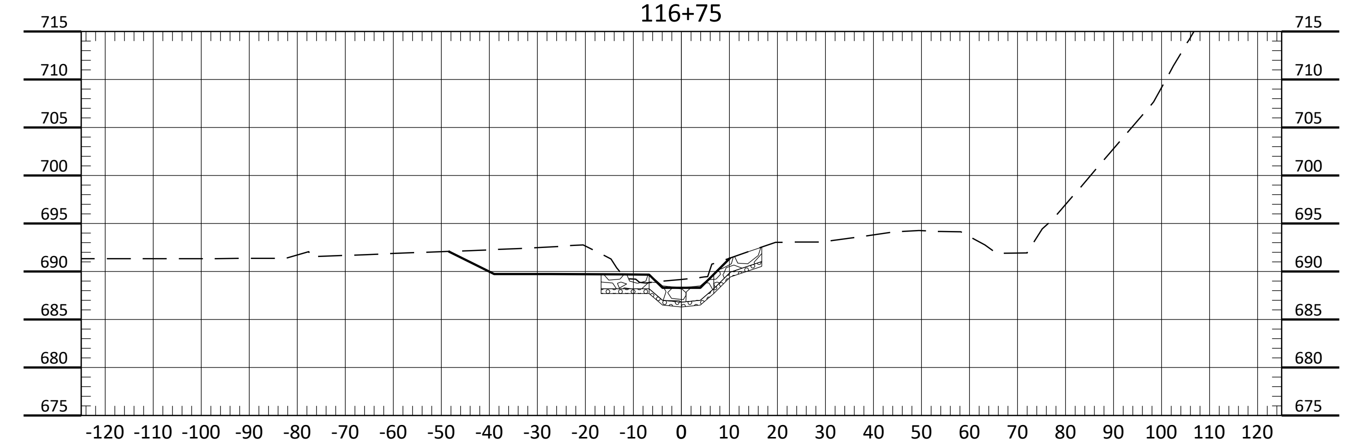

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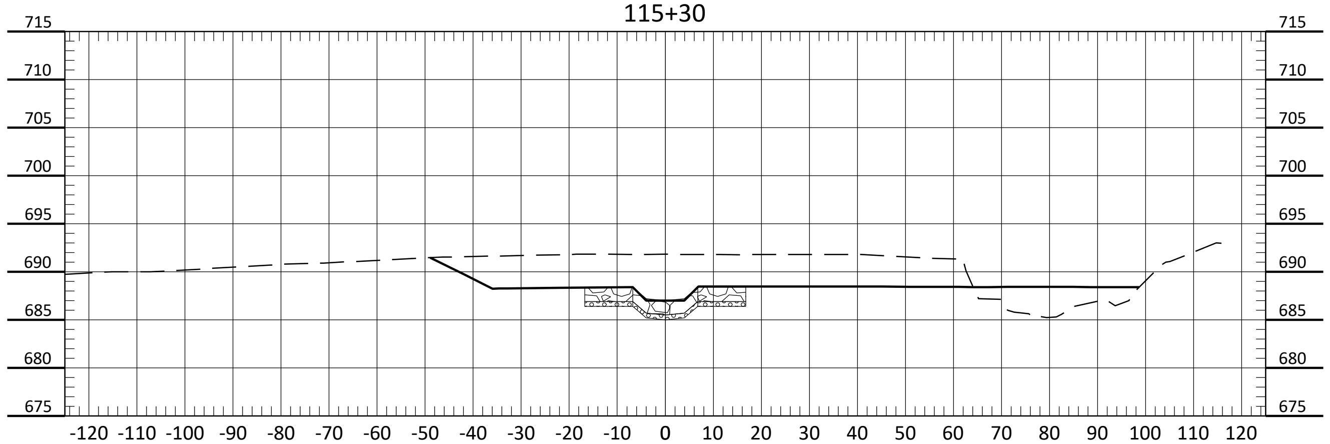

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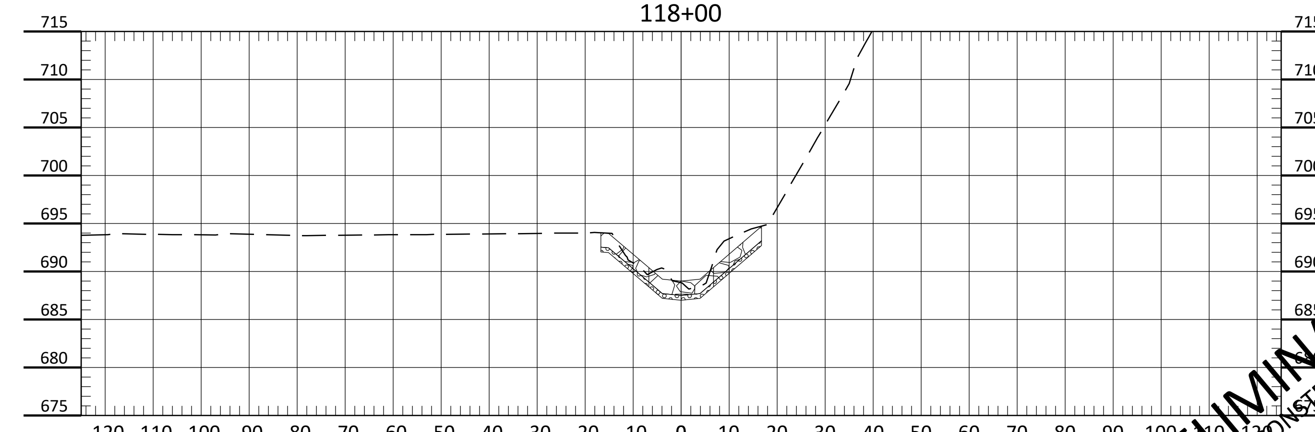

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TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

CROSS SECTIONS

PROJECT NO. 4876-0051

SHEET 11

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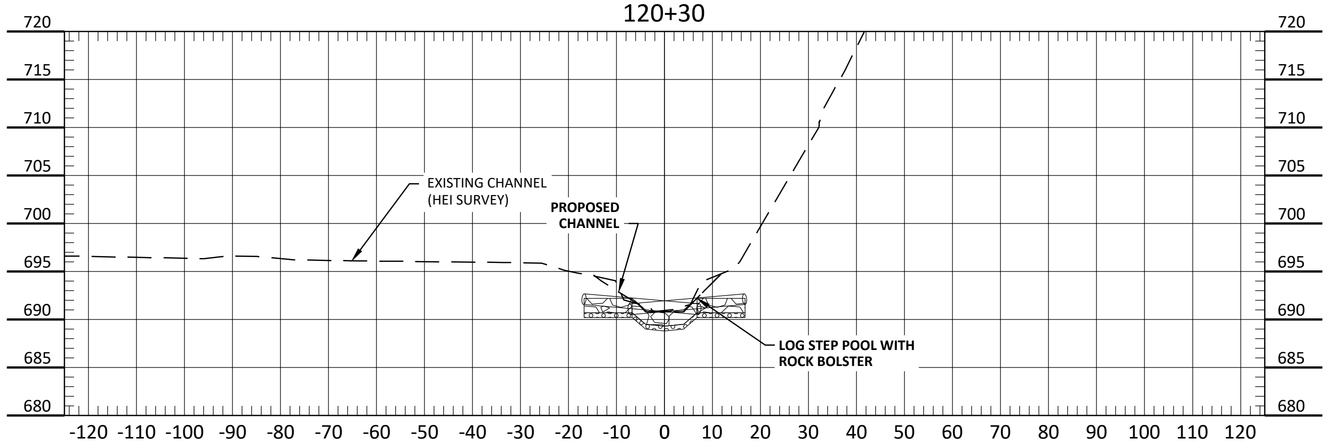

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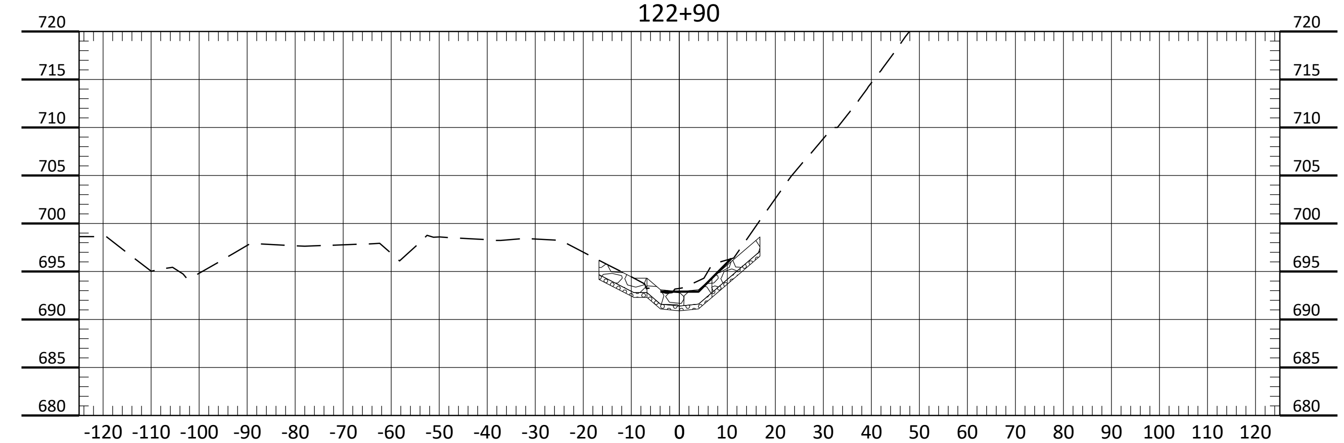

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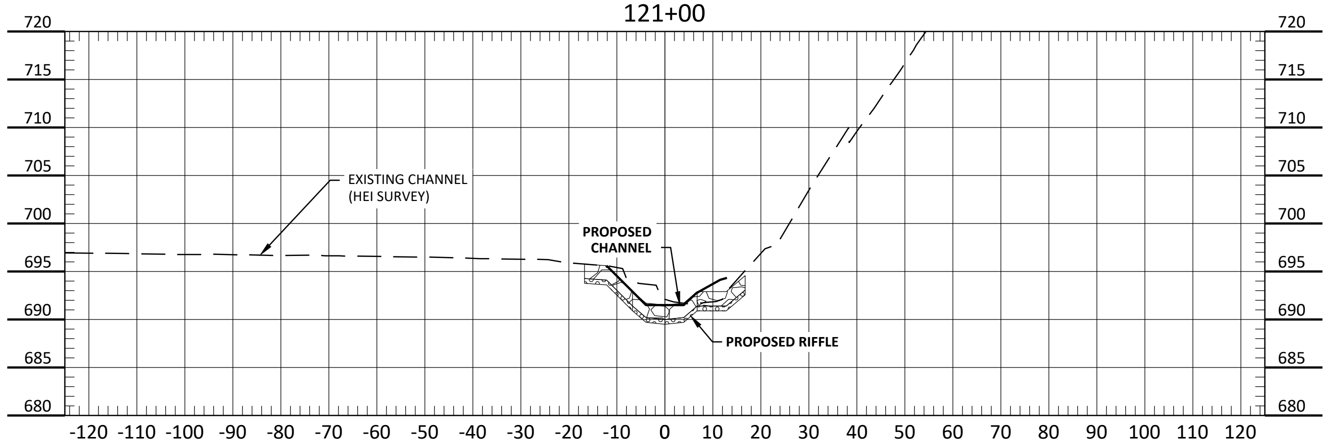

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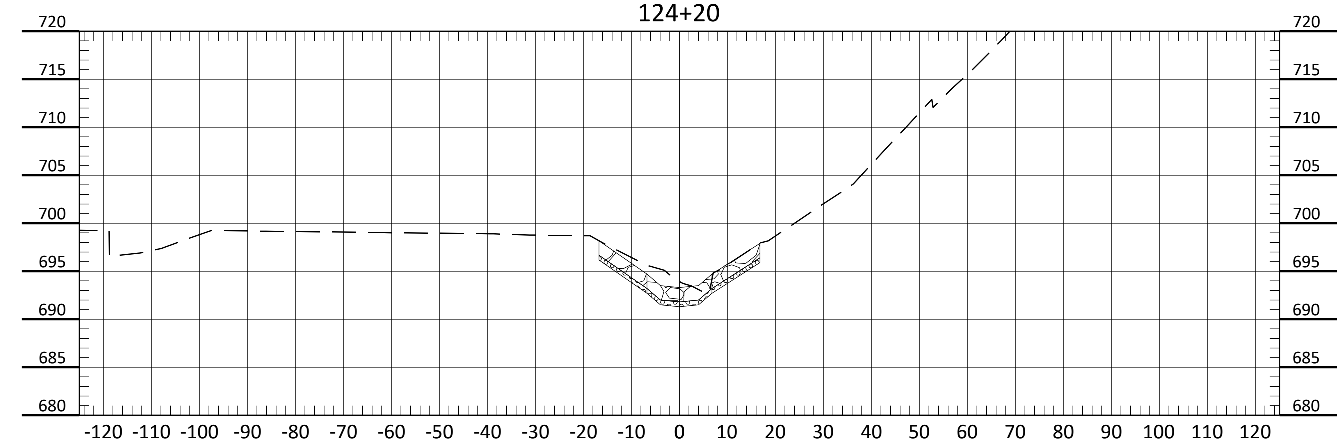

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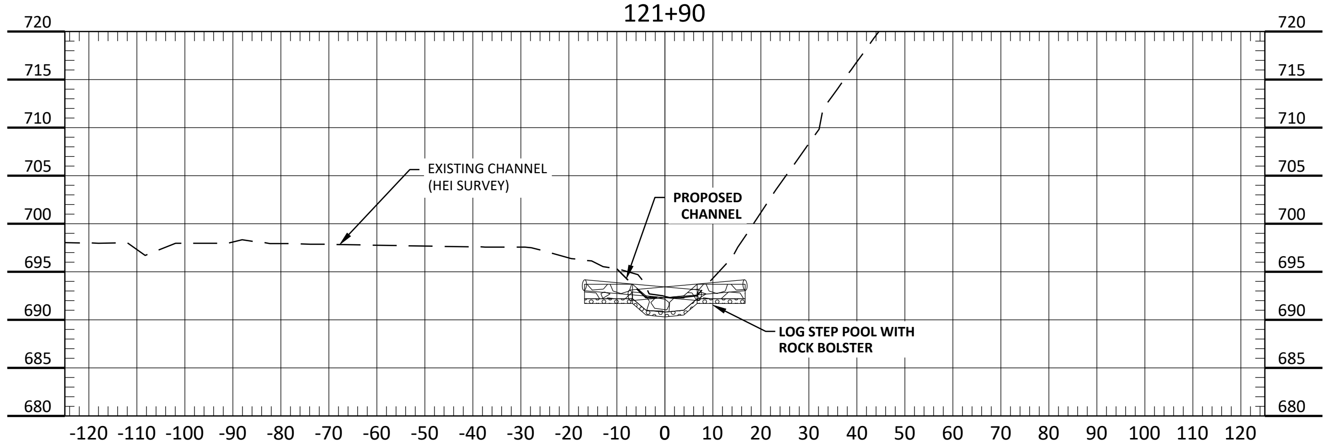

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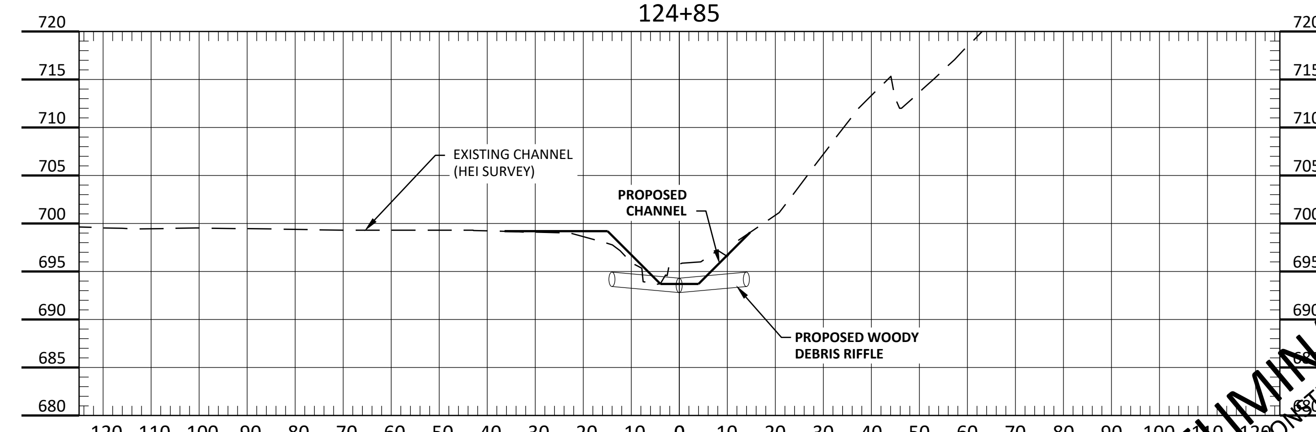


No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

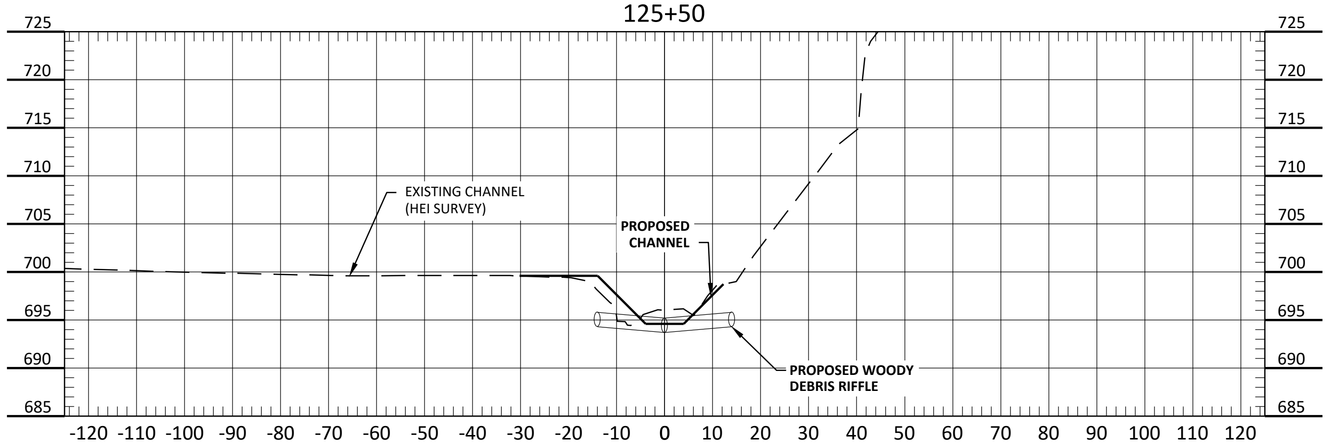
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

CROSS SECTIONS

PROJECT NO. 4876-0051

SHEET 12

125+50



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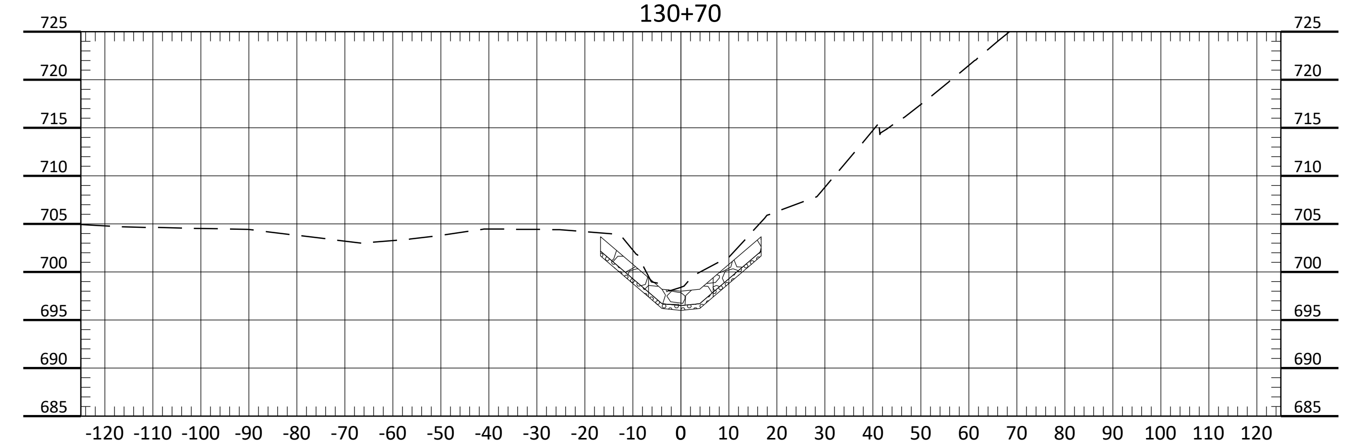

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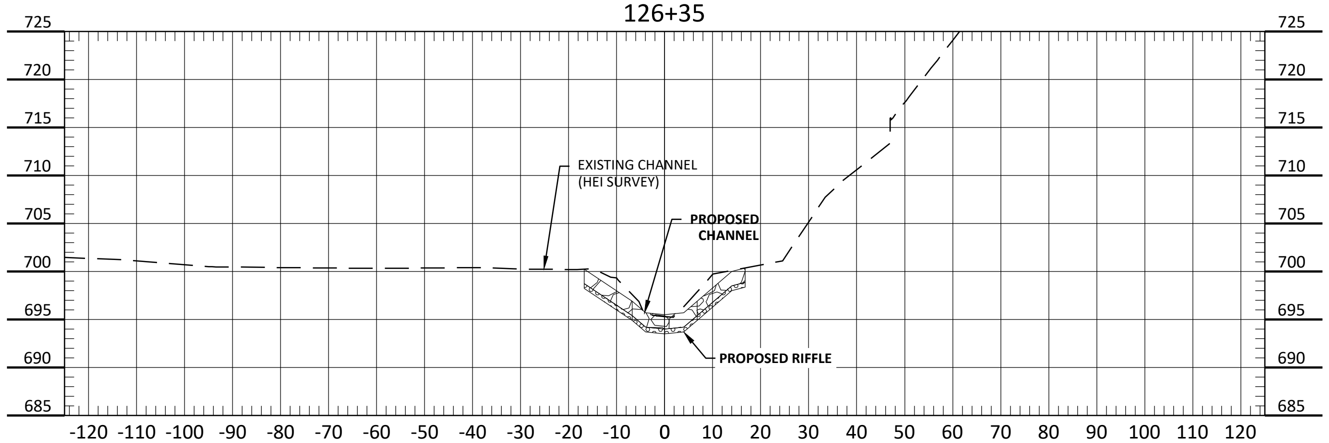

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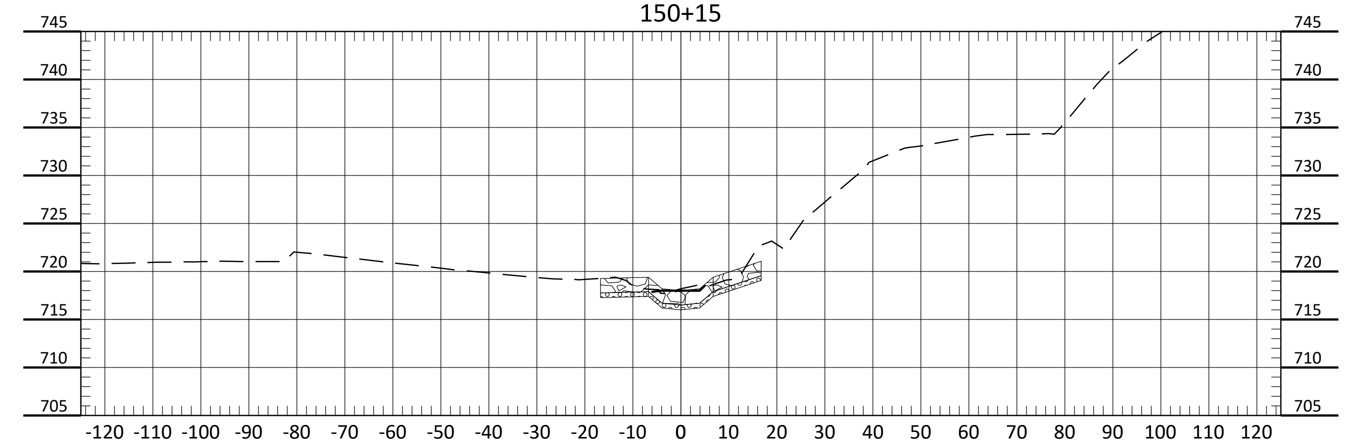

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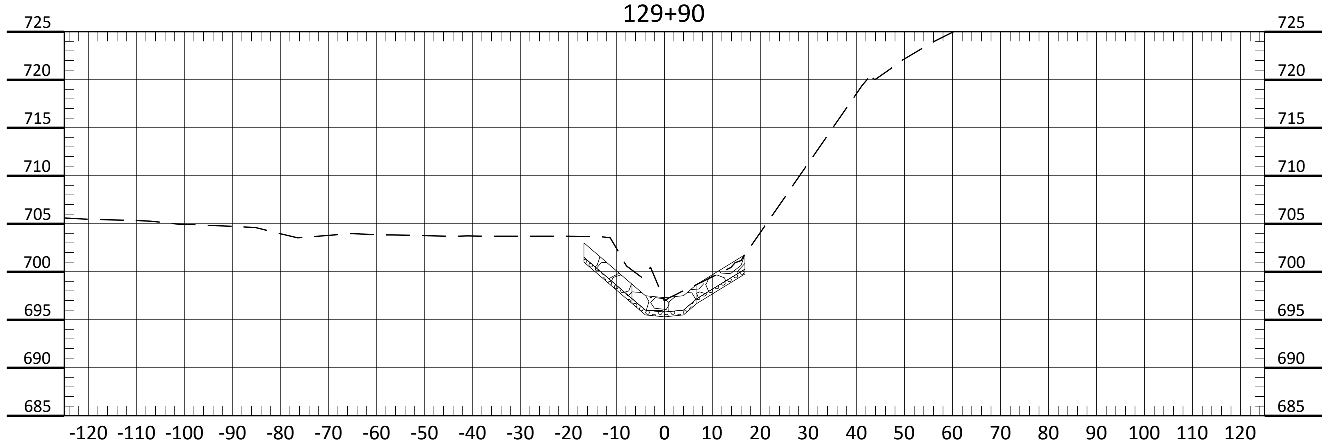

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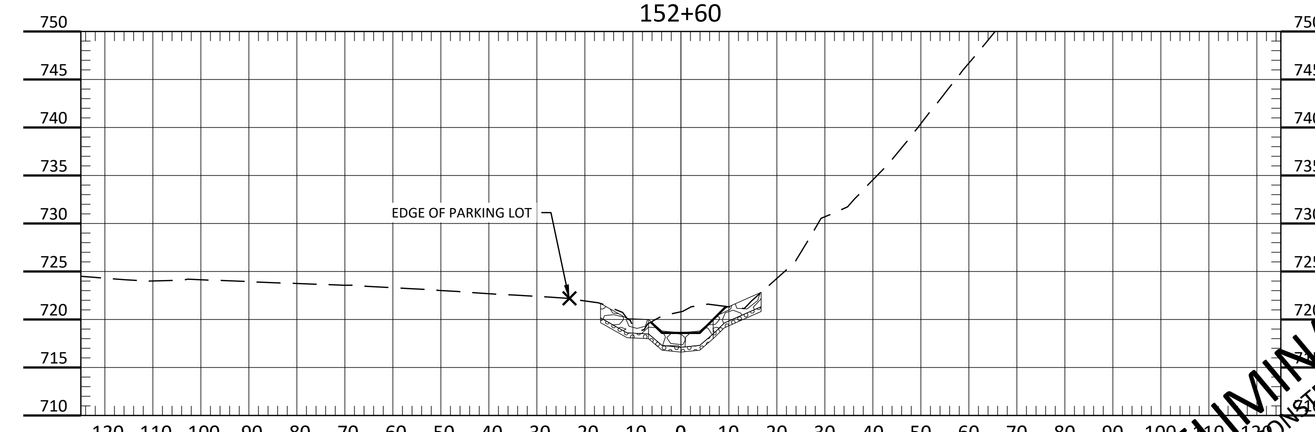

PRELIMINARY
NOT FOR CONSTRUCTION

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No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
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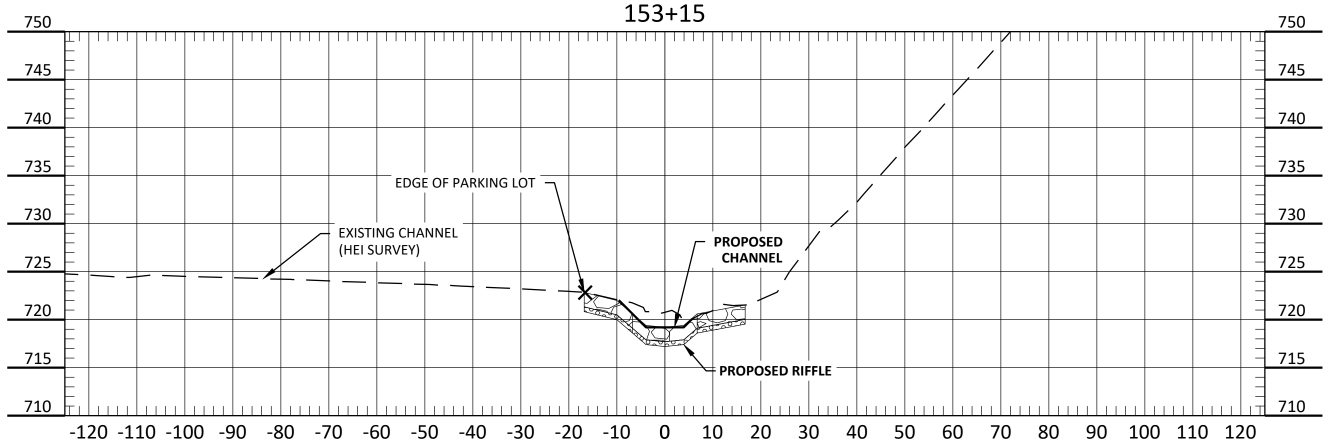
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

CROSS SECTIONS

PROJECT NO. 4876-0051

SHEET
13

153+15



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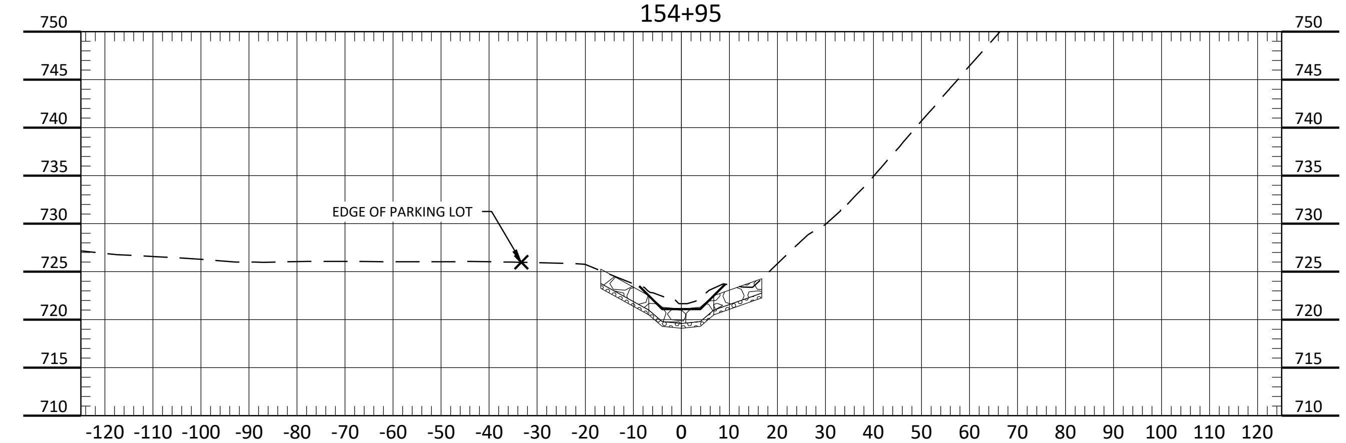

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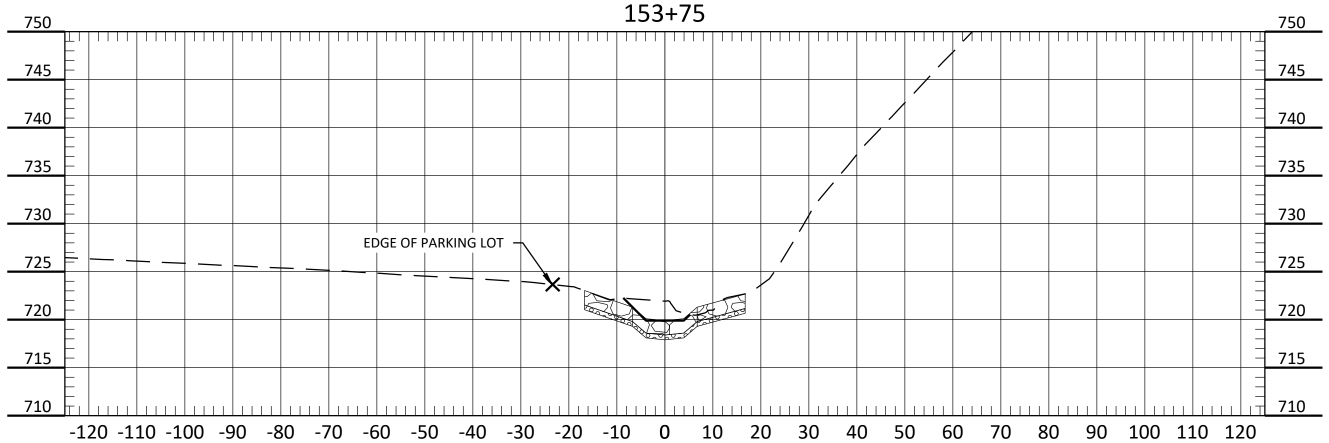

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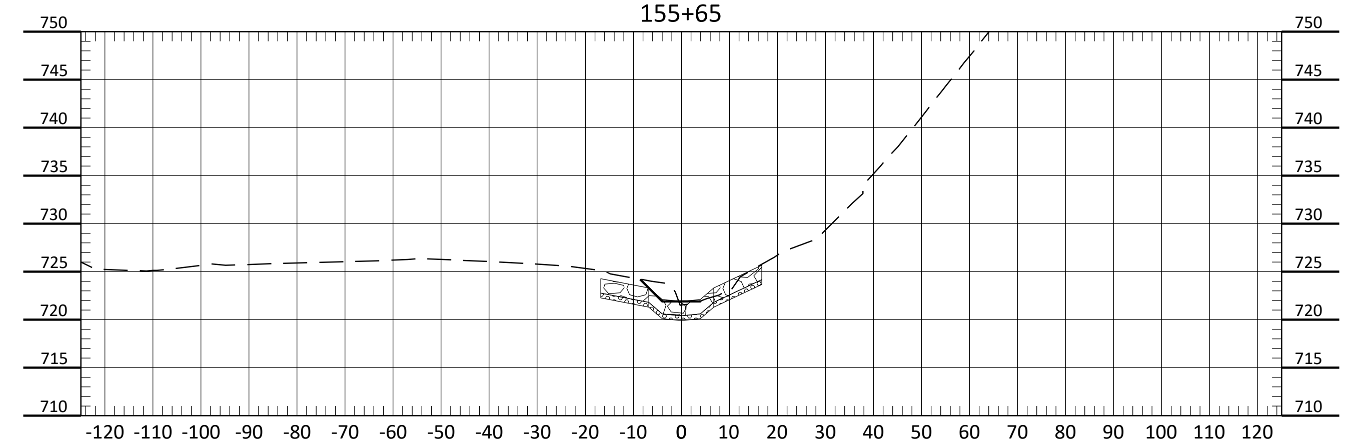

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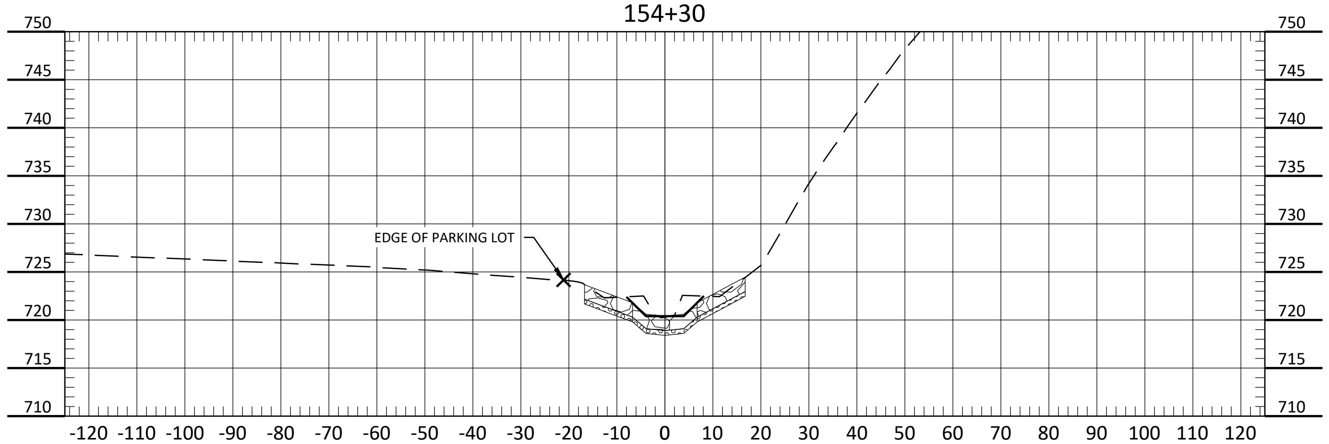

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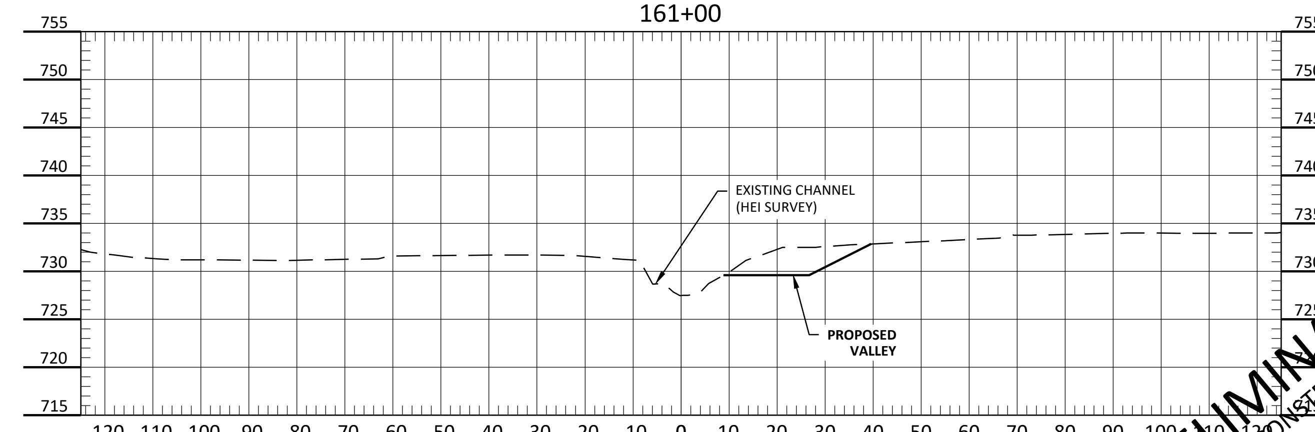

No.	Revision	Date	By

HOUSTON engineering, inc.

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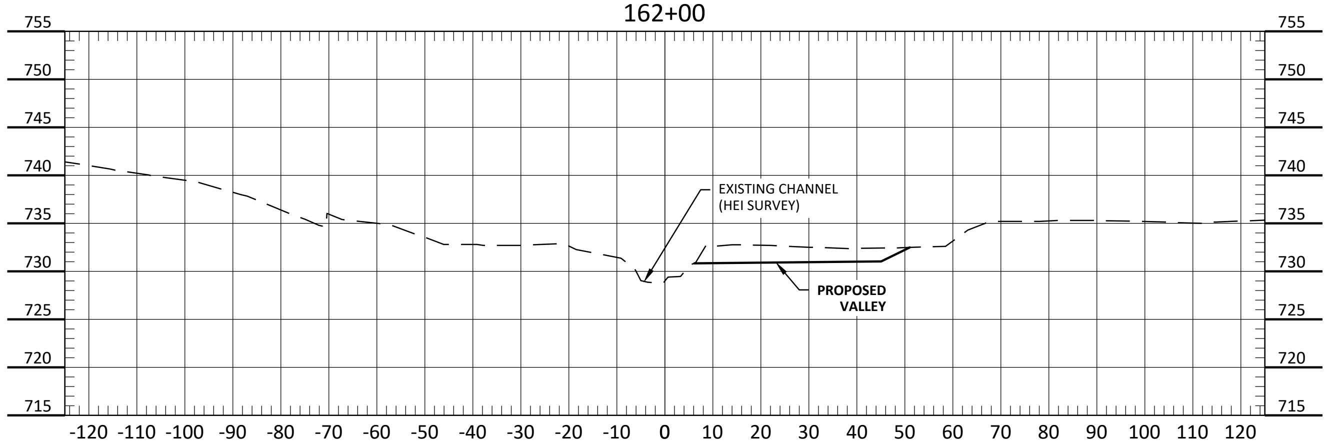
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

CROSS SECTIONS

PROJECT NO. 4876-0051

SHEET 14

162+00



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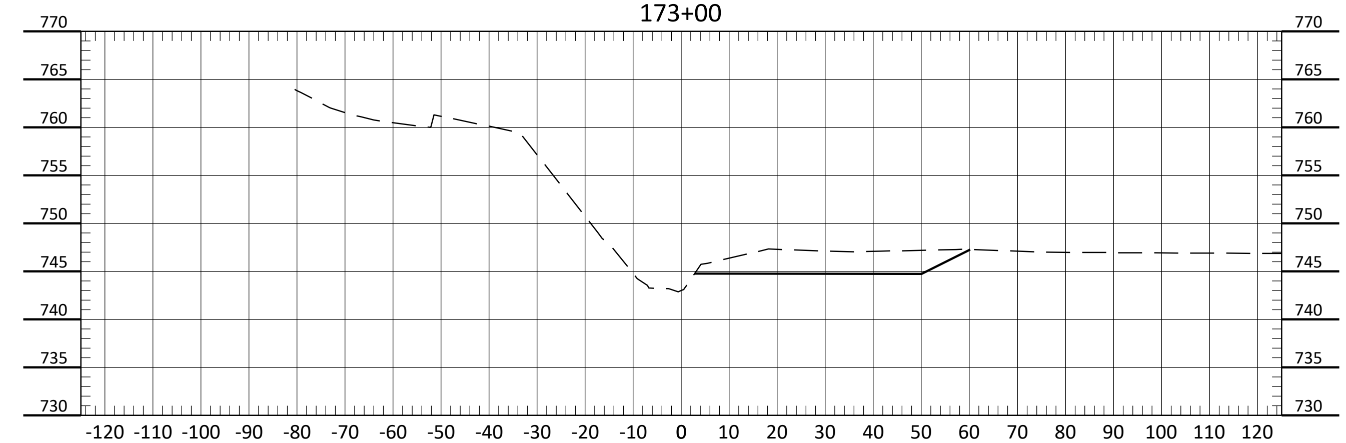

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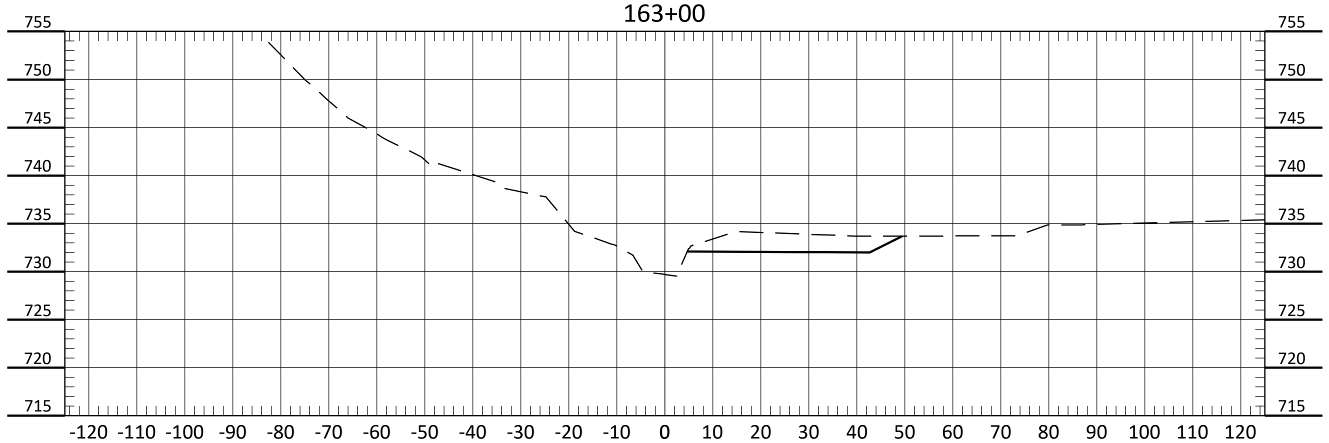

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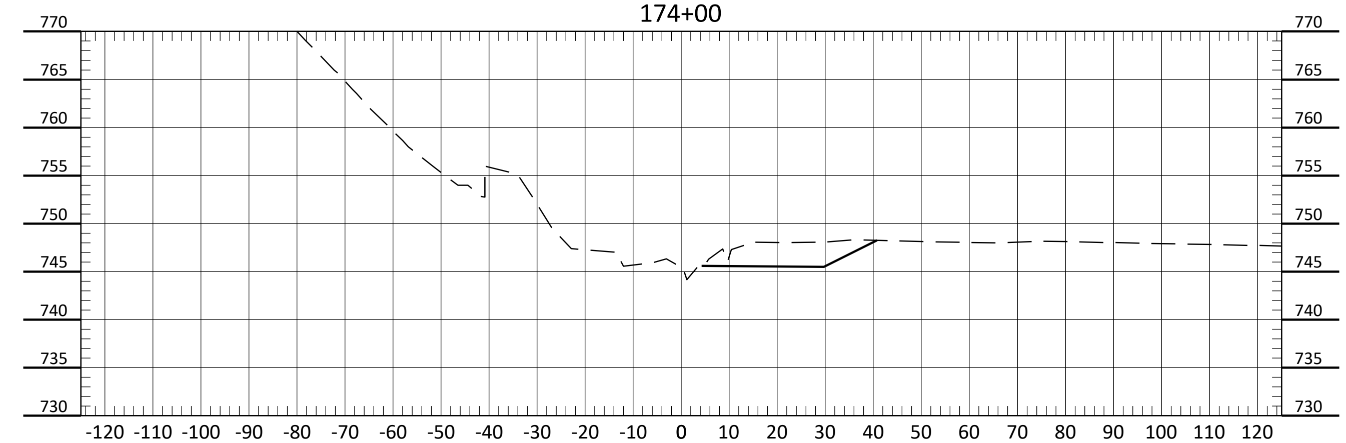

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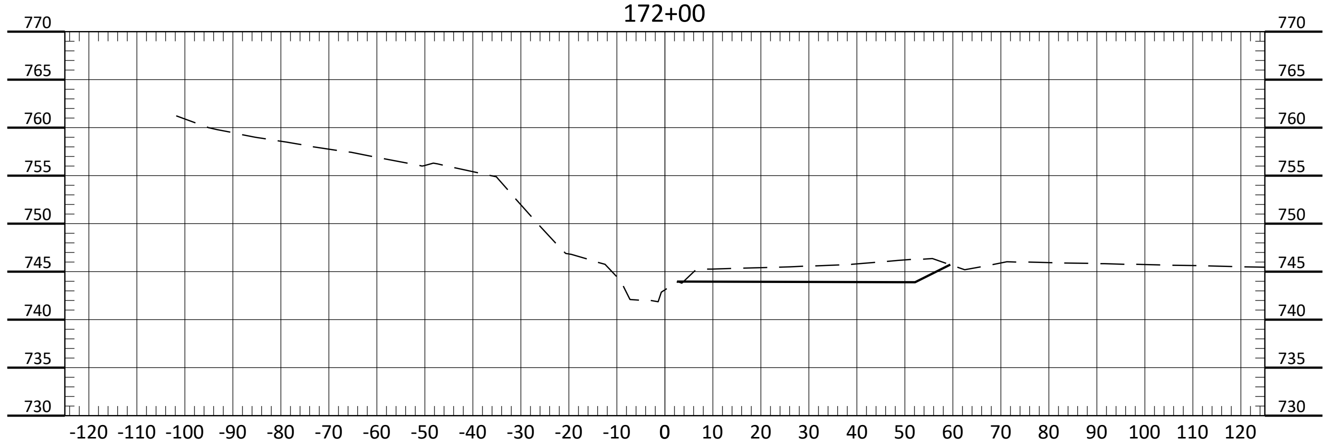

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No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

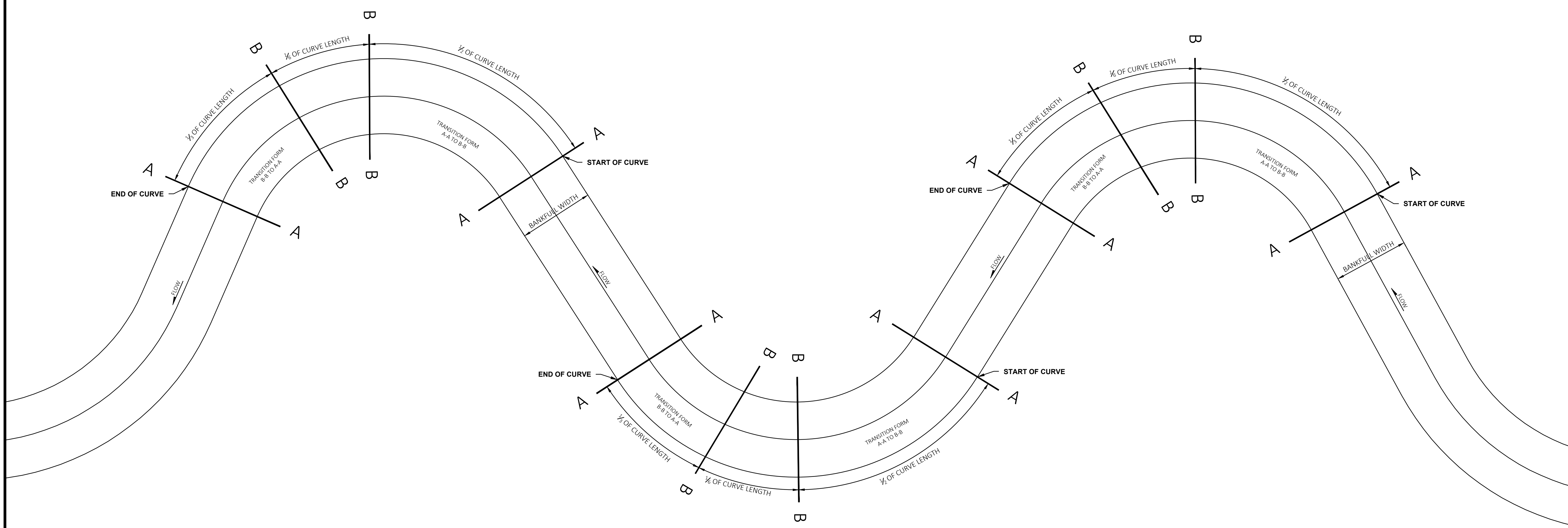
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

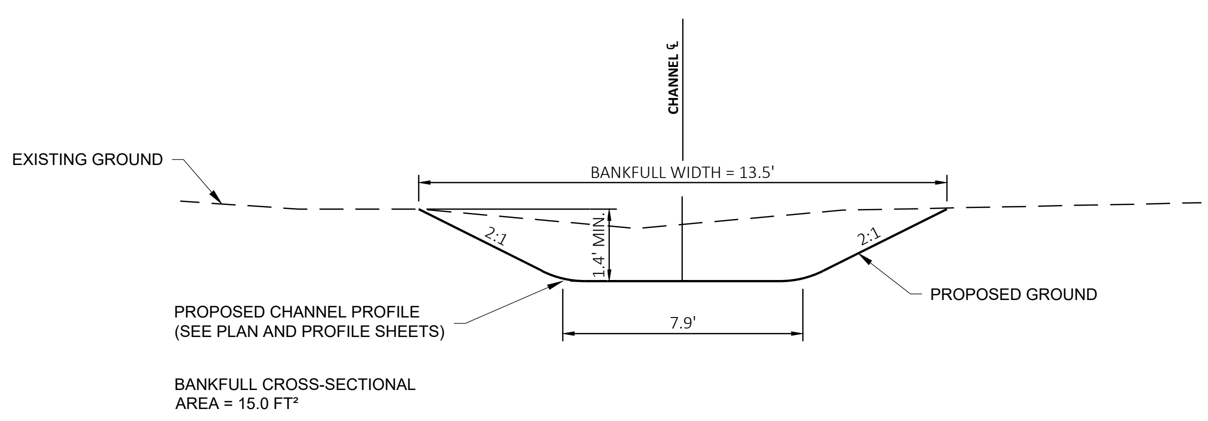
CROSS SECTIONS

PROJECT NO. 4876-0051

SHEET 15

HEI NO. 4876-0051

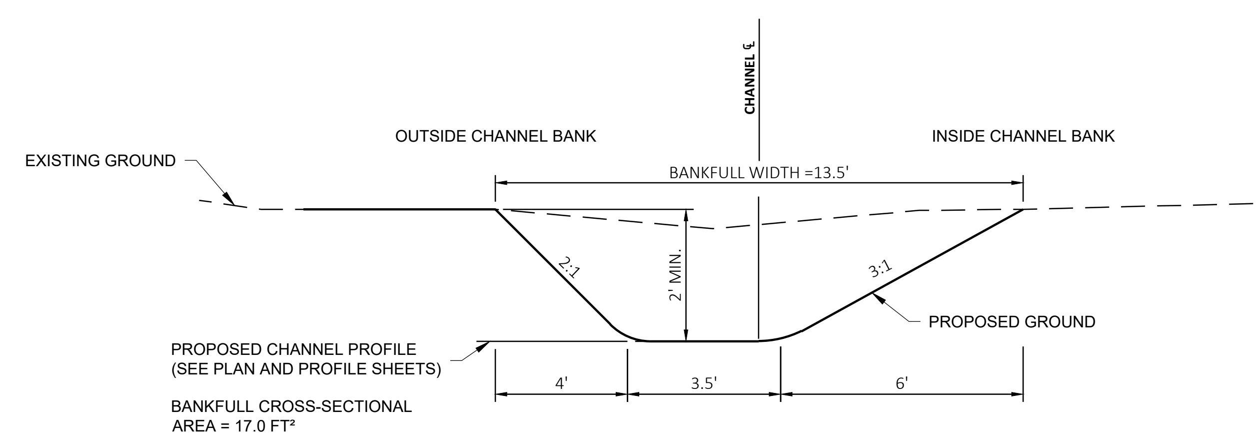




STA. 109+65 TO 117+05
STA. 120+00 TO 122+90
STA. 149+85 TO 155+65

A-A TYPICAL CHANNEL SECTION

NOT TO SCALE



STA. 109+65 TO 117+05
STA. 120+00 TO 122+90
STA. 149+85 TO 155+65

B-B TYPICAL CHANNEL SECTION

NOT TO SCALE

No.	Revision	Date	By

HOUSTON engineering, inc.

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TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

TYPICAL CHANNEL PLAN VIEW

PROJECT NO. 4876-0051

SHEET 16

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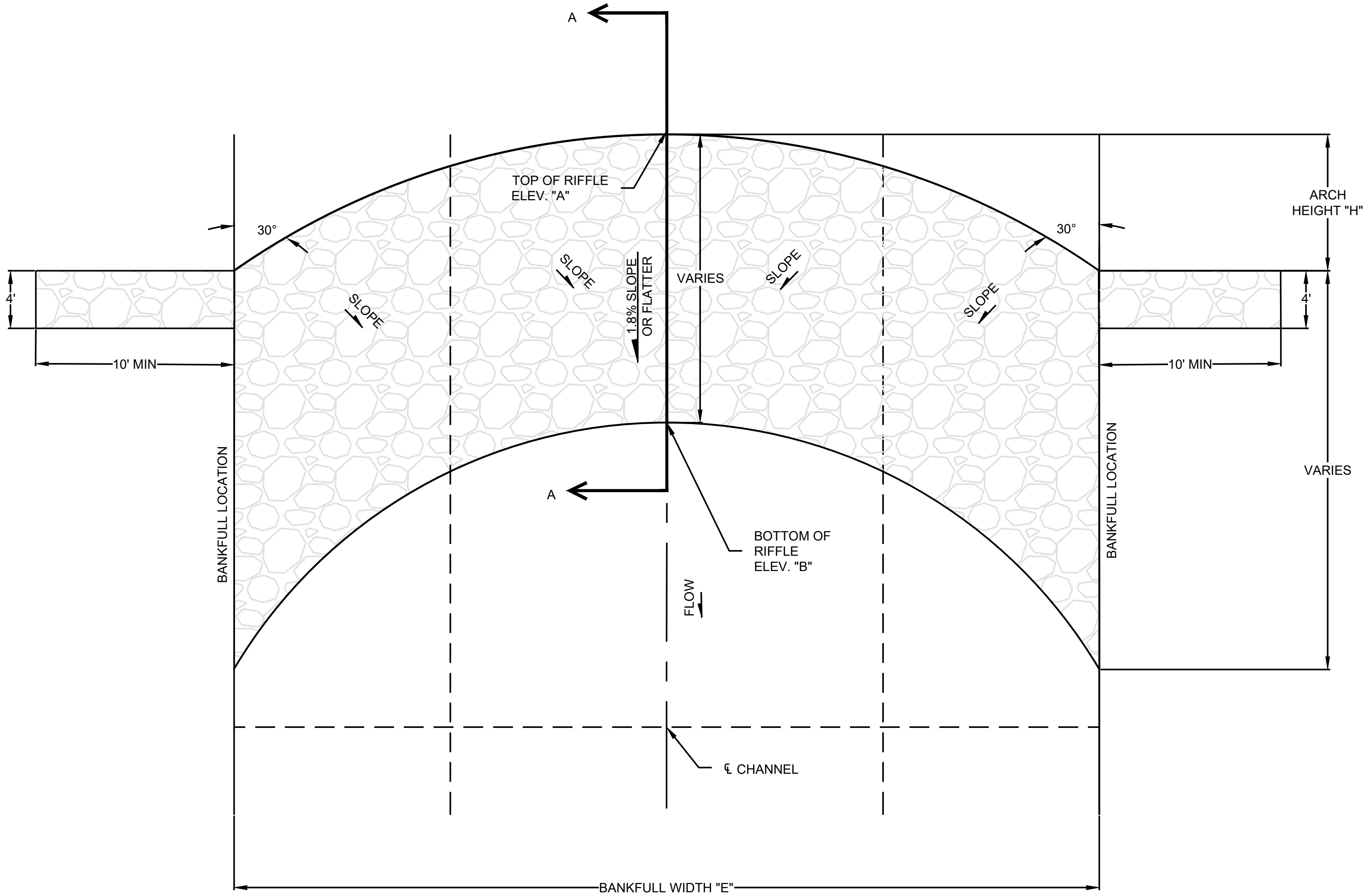
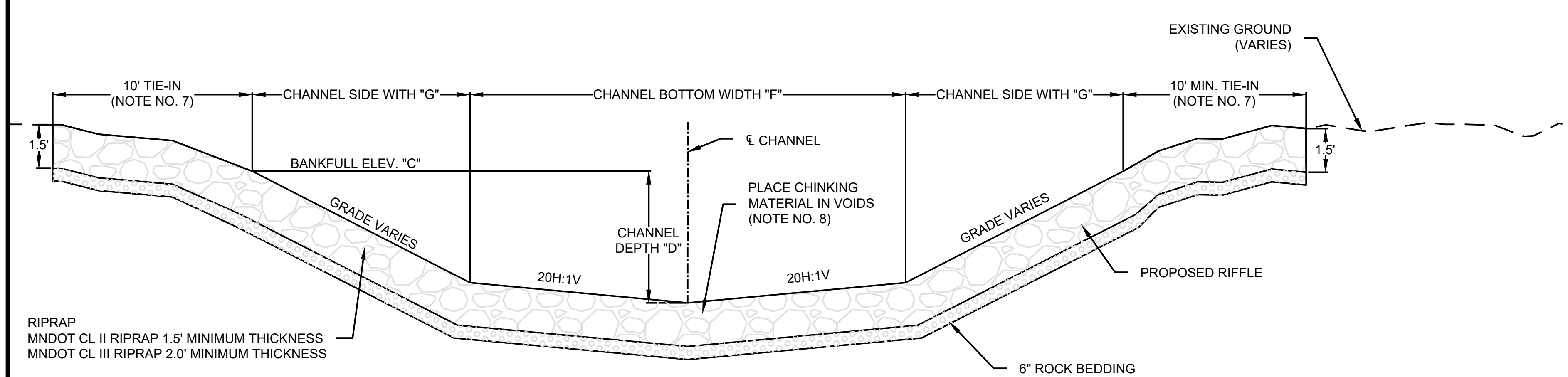




TROUT BROOK RIFFLE DETAIL

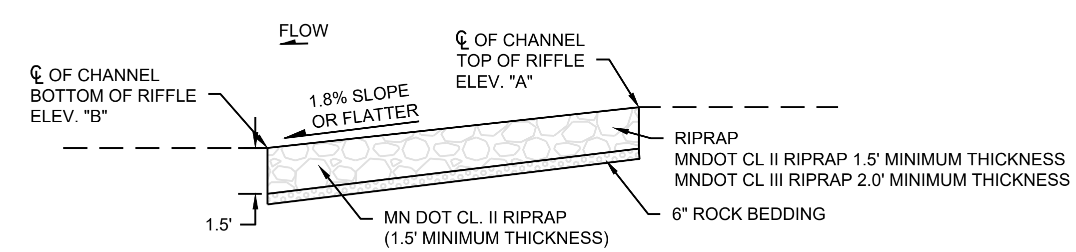
NOT TO SCALE

DETAIL TABLE

RIFFLE NO.	TOP OF RIFFLE STATION	BOTTOM OF RIFFLE STATION	TOP OF RIFFLE ELEV. "A"	BOTTOM OF RIFFLE ELEV."B"	BANKFULL ELEV. "C"	CHANNEL DEPTH "D"	BANKFULL WIDTH "E"	CHANNEL BOTTOM WIDTH "F"	CHANNEL SIDE WIDTH "G"	ARC HEIGHT "H"	CLASS II RIPRAP (CY)	CLASS III RIPRAP (CY)	ROCK BEDDING (CY)	CHINKING MATERIAL (CY)
1	109+95	109+65	681.8	681.3	683.2						27		9	18
2	110+80	110+55	682.7	682.3	684.1						23		8	15
3	111+40	111+20	683.3	683.0	684.7						19		6	13
4	111+95	111+75	683.9	683.6	685.3						19		6	13
5	112+50	112+30	684.5	684.2	685.9						19		6	13
6	113+60	113+40	685.5	685.2	686.9						19		6	13
7	114+40	114+10	686.3	685.8	687.7						27		9	18
8	115+30	115+05	687.0	686.6	688.4						23		8	15
9	116+10	115+90	687.7	687.4	689.1						19		6	13
10	116+75	116+45	688.3	687.9	689.7						27		9	18
11	118+00	117+70	689.0	688.5	690.4							36	9	18
12	121+00	120+70	691.5	691.0	692.9	1.4 FT	13.5 FT	7.9 FT	2.8 FT	4.0 FT		36	9	18
13	122+90	122+65	692.9	692.5	694.3							31	8	15
14	124+20	124+00	693.3	693.0	694.7							25	6	13
15	126+35	126+15	695.5	695.2	696.9							25	6	13
16	129+90	129+70	697.3	697.0	698.7							25	6	13
17	130+70	130+50	698.0	697.7	699.4							25	6	13
18	150+15	149+85	718.0	716.5	719.4							36	9	18
19	152+60	152+30	718.6	718.1	720.0							36	9	18
20	153+15	152+95	719.2	718.9	720.6							25	6	13
21	153+75	153+45	719.9	719.4	721.3							36	9	18
22	154+30	154+10	720.4	720.1	721.8							25	6	13
23	154+95	154+65	721.1	720.6	722.5							36	9	18
24	155+65	155+35	721.9	721.4	723.3							36	9	18
										TOTAL	222	433	180	368

NOTE:

1. CHANNEL EXCAVATION REQUIRED TO PLACE RIPRAP AND ROCK BEDDING SHALL NOT BE MEASURED FOR SEPARATE PAYMENT BUT SHALL BE CONSIDERED INCIDENTAL TO OTHER BID ITEMS.
2. A 6" THICK LAYER OF ROCK BEDDING WILL BE USED AS A FOUNDATION FOR RIPRAP. 90% OF ROCK BEDDING SHALL CONSIST OF 1" TO 3" STONES. ROCK BEDDING WILL BE PAID ON A PER CUBIC YARD BASIS UNDER THE ROCK BEDDING BID ITEM.
3. MN DOT CL. II RIPRAP AT THE DOWNSTREAM END OF RIFFLE MUST BE SUBCUT INTO THE CHANNEL TO A DEPTH OF 1.5 FT. (CLASS III RIPRAP TO A DEPTH OF 2.0 FEET) WILL BE PAID ON A PER CUBIC YARD BASIS UNDER THE MN DOT CL. II AND CL. III RIPRAP BID ITEM.
4. WHERE FEASIBLE, RIFFLES SHALL BE CONSTRUCTED PRIOR TO DIVERTING RIVER FLOWS INTO THE NEW CHANNEL.
5. ANY DISTURBED VEGETATED AREAS ARE REQUIRED TO BE SEEDED.
6. CLEARING AND GRUBBING WILL ONLY BE CONDUCTED AS NECESSARY TO CONSTRUCT THE RIFFLES. CLEARING AND GRUBBING IS INCIDENTAL TO THE TREE AND BRUSH REMOVAL BID ITEM.
7. TIE-IN TO BE CONSTRUCTED 10 FEET HORIZONTALLY INTO THE EXISTING BANK AND SHOULD NOT PROTRUDE ABOVE ADJACENT GROUND. DISTURBED AREAS ALONG THE EXISTING BANK ARE TO BE RESTORED TO THE EXISTING CONDITION. ALL WORK ASSOCIATED WITH RESTORING THE EXISTING BANK WILL NOT BE MEASURED FOR SEPARATE PAYMENT BUT SHALL BE CONSIDERED SUBSIDIARY TO OTHER BID ITEMS.
8. VOIDS IN THE PLACED RIPRAP SHALL BE FILLED WITH A WELL GRADED MIX OF AGGREGATE VARYING FROM THE NO. 40 SIEVE UP TO 3 INCH STONES. THE MIX OF AGGREGATE SHOULD BE SUCH THAT IT IS NOT BLOWN OUT OF THE RIPRAP BY THE RIVERS CURRENT BUT INSTEAD FORCES FLOW OVER THE RIPRAP.



SECTION A - A

NOT TO SCALE

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

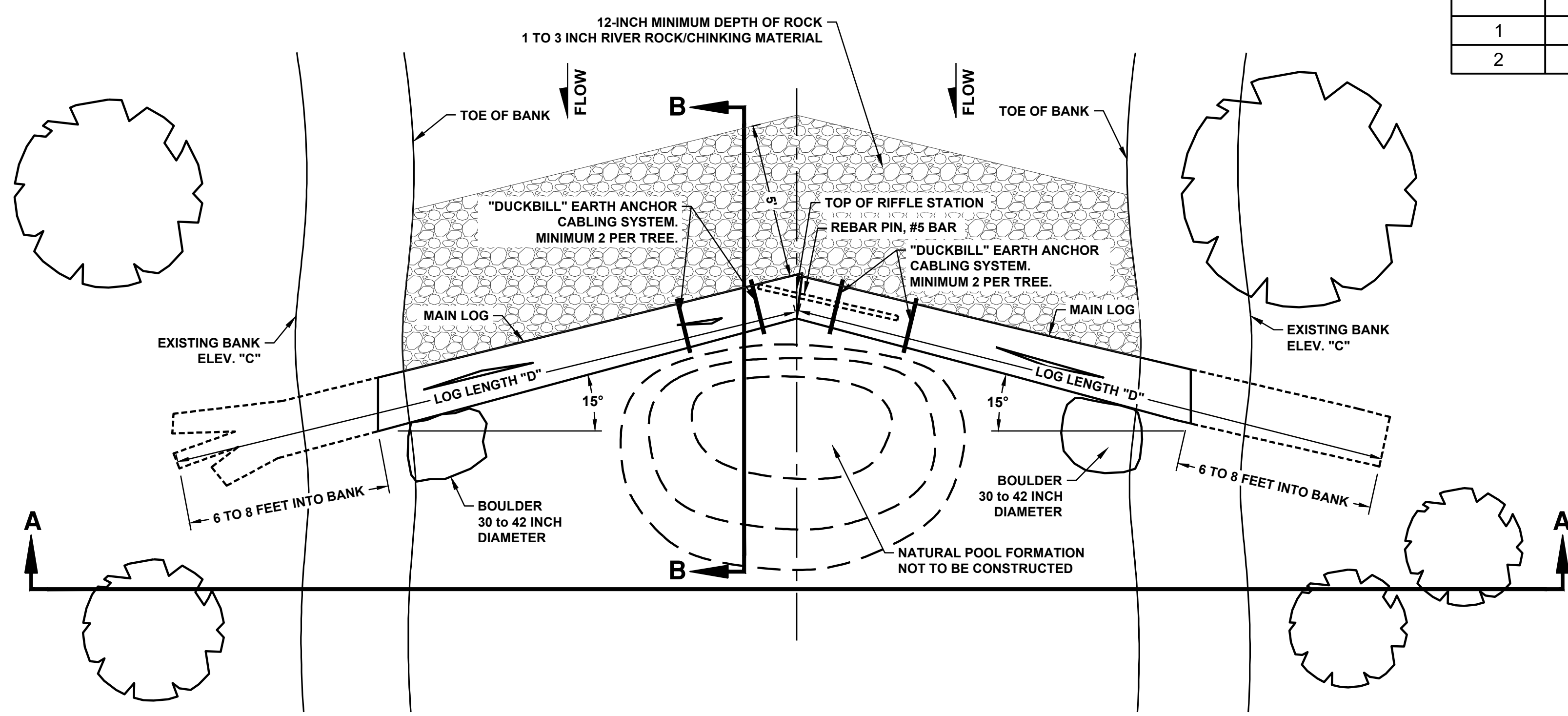
RIFFLE DETAILS

PROJECT NO. 4876-0051

SHEET 17

DETAIL TABLE

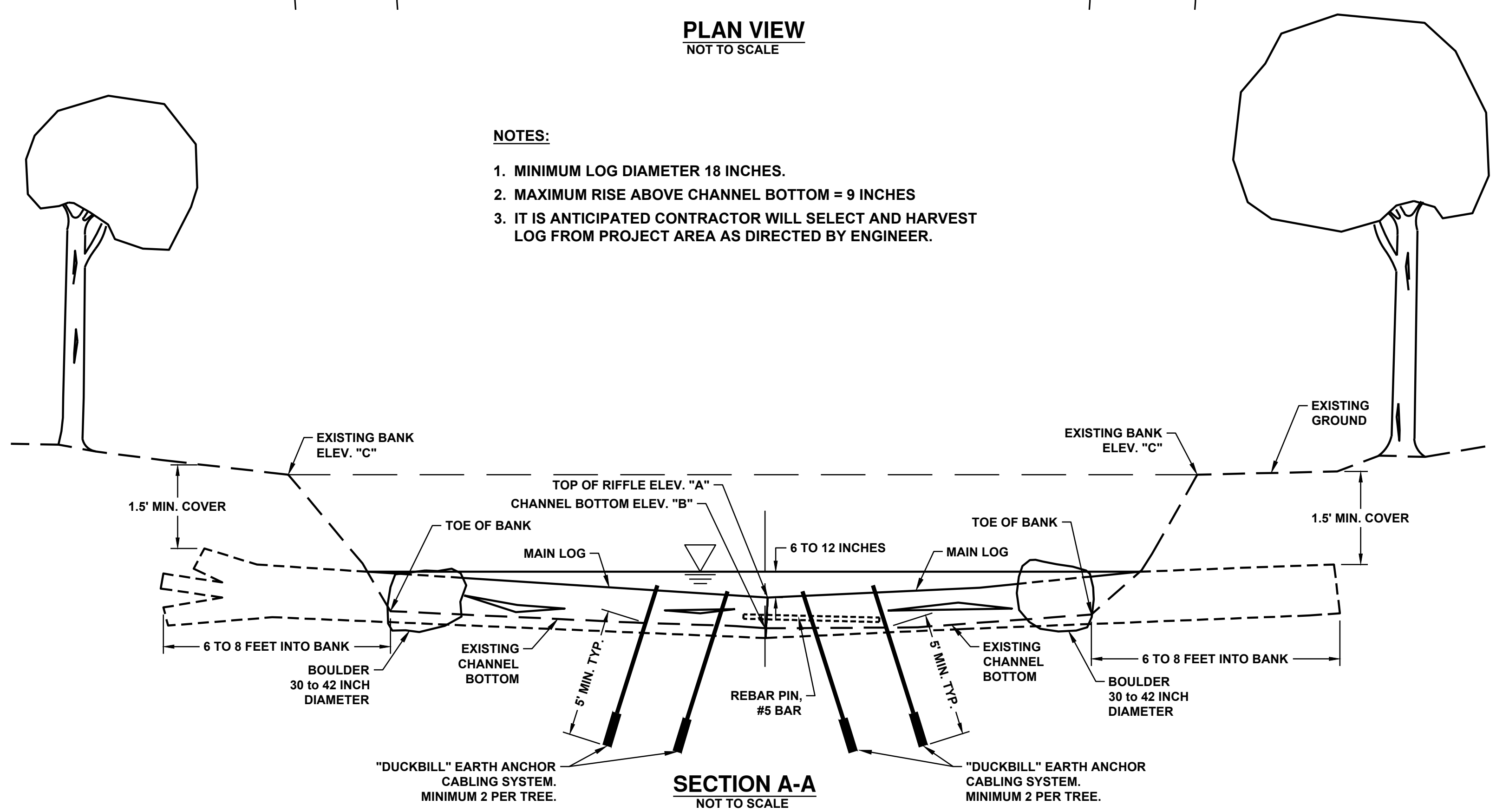
RIFFLE NO.	WOODY RIFFLE STATION	TOP OF RIFFLE ELEV. "A"	CHANNEL BOTTOM ELEV."B"	EXISTING BANK ELEV. "C"	LOG LENGTH "D"	CHINKING MATERIAL (CY)	BOULDER 30" TO 42" DIA. (EA.)
1	124+85	694.3	693.7	699.2	15 FT	2	2
2	125+50	695.2	694.5	699.6	15 FT	2	2
				TOTAL		4	4



PLAN VIEW
NOT TO SCALE

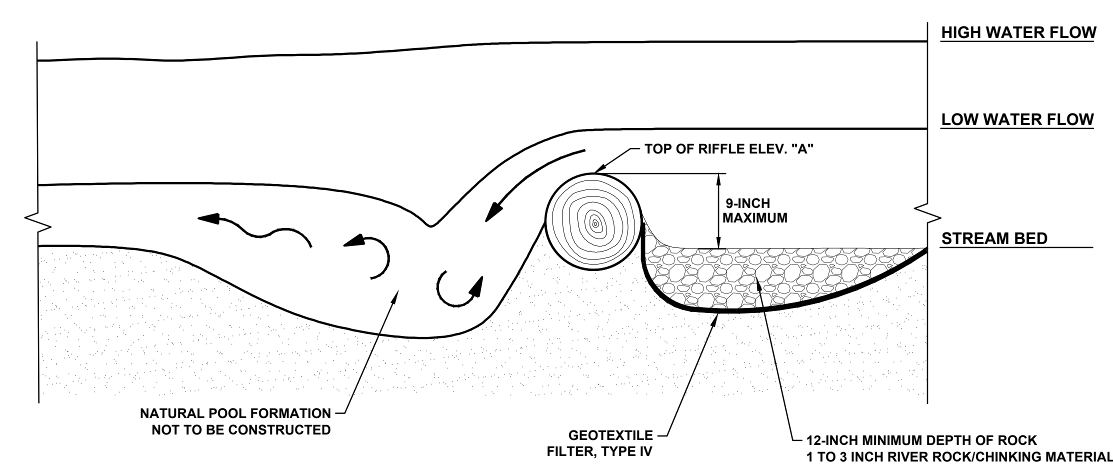
NOTES:

1. MINIMUM LOG DIAMETER 18 INCHES.
2. MAXIMUM RISE ABOVE CHANNEL BOTTOM = 9 INCHES
3. IT IS ANTICIPATED CONTRACTOR WILL SELECT AND HARVEST LOG FROM PROJECT AREA AS DIRECTED BY ENGINEER.



SECTION A-A
NOT TO SCALE

WOODY DEBRIS RIFFLE DETAIL
NOT TO SCALE



SECTION B-B
NOT TO SCALE

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

RIFFLE AND SOD MAT DETAILS
PROJECT NO. 4876-0051

SHEET 18

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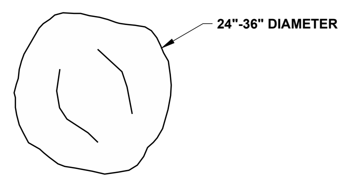
NOTES:

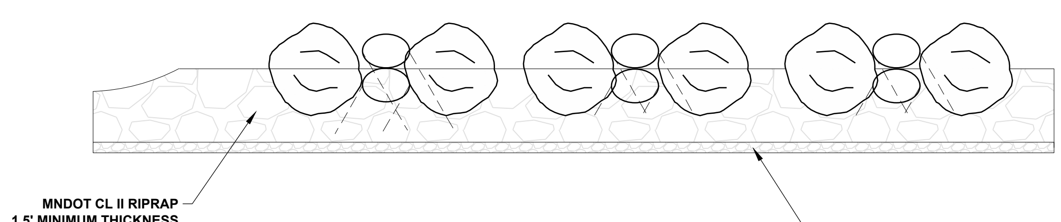
1. CHANNEL EXCAVATION REQUIRED TO PLACE MN DOT CL. II RIPRAP AND ROCK BEDDING SHALL NOT BE MEASURED FOR SEPARATE PAYMENT BUT SHALL BE CONSIDERED INCIDENTAL TO OTHER BID ITEMS.
2. A 6" THICK LAYER OF ROCK BEDDING WILL BE USED AS A FOUNDATION FOR MN DOT CL. II RIPRAP. 90% OF ROCK BEDDING SHALL CONSIST OF 1" TO 3" STONES. ROCK BEDDING WILL BE PAID ON A PER CUBIC YARD BASIS UNDER THE ROCK BEDDING BID ITEM.
3. MN DOT CL. II RIPRAP AT THE DOWNSTREAM END OF RIFFLE MUST BE SUBCUT INTO THE CHANNEL TO A DEPTH OF 1.5 FT. MN DOT CL. II RIPRAP WILL BE PAID ON A PER CUBIC YARD BASIS UNDER THE MN DOT CL. II RIPRAP BID ITEM.
4. ANY DISTURBED VEGETATED AREAS ARE REQUIRED TO BE SEEDED.
5. CLEARING AND GRUBBING WILL ONLY BE CONDUCTED AS NECESSARY TO CONSTRUCT THE LOG STEP POOL. CLEARING AND GRUBBING IS SUBSIDIARY TO THE TREE AND BRUSH REMOVAL BID ITEM.
6. VOIDS IN THE PLACED RIPRAP SHALL BE FILLED WITH A WELL GRADED MIX OF AGGREGATE VARYING FROM THE NO. 40 SIEVE UP TO 3 INCH STONES. THE MIX OF AGGREGATE SHOULD BE SUCH THAT IT IS NOT BLOWN OUT OF THE RIPRAP BY THE RIVERS CURRENT BUT INSTEAD FORCES FLOW OVER THE RIPRAP. THE AGGREGATE AND PLACEMENT OF THE AGGREGATE SHALL NOT BE MEASURED FOR SEPARATE PAYMENT BUT SHALL BE CONSIDERED INCIDENTAL TO OTHER BID ITEMS.

DETAIL TABLE

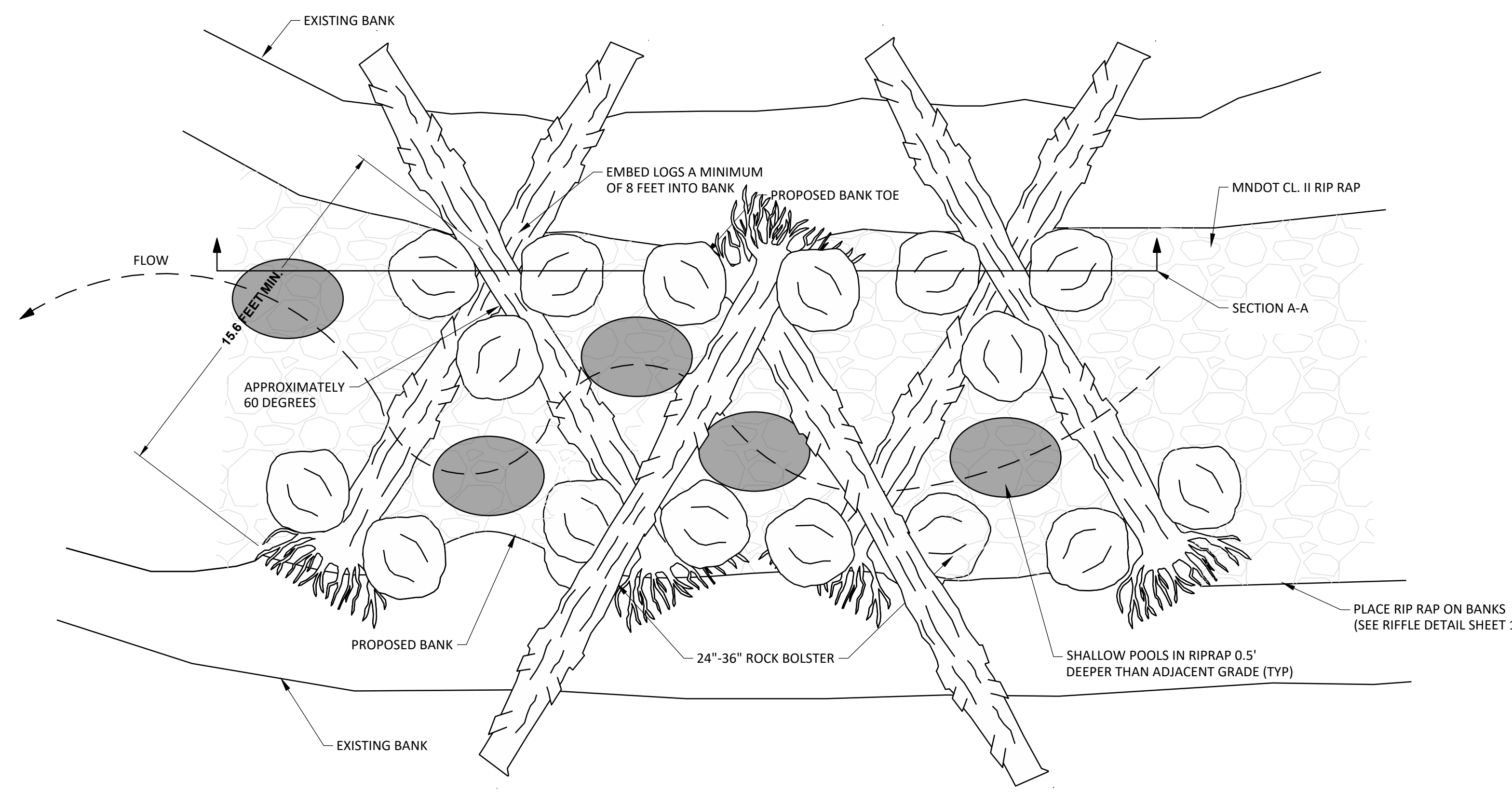
LOG STEP POOL NO.	TOP OF POOL STATION	BOTTOM OF POOL STATION	TOP OF POOL ELEV. "A"	BOTTOM OF POOL ELEV. "B"	LOG LENGTH "D"	CLASS II RIPRAP (CY)	ROCK BEDDING (CY)	CHINKING MATERIAL (CY)	LOGS (EACH)	BOULDER 24" TO 36" DIA. (EACH)
1	120+30	120+00	690.8	690.3	24 FT	22.5	7.5	15.0	6.0	16.0
2	121+90	121+60	692.3	961.9	24 FT	22.5	7.5	15.0	6.0	16.0
				TOTAL		45.0	15.0	30.0	12.0	32.0



ROCK BOLSTER DETAIL
NOT TO SCALE



SECTION A-A
NOT TO SCALE



LOG STEP POOL WITH ROCK BOLSTER DETAIL
NOT TO SCALE

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No.	Revision	Date	By

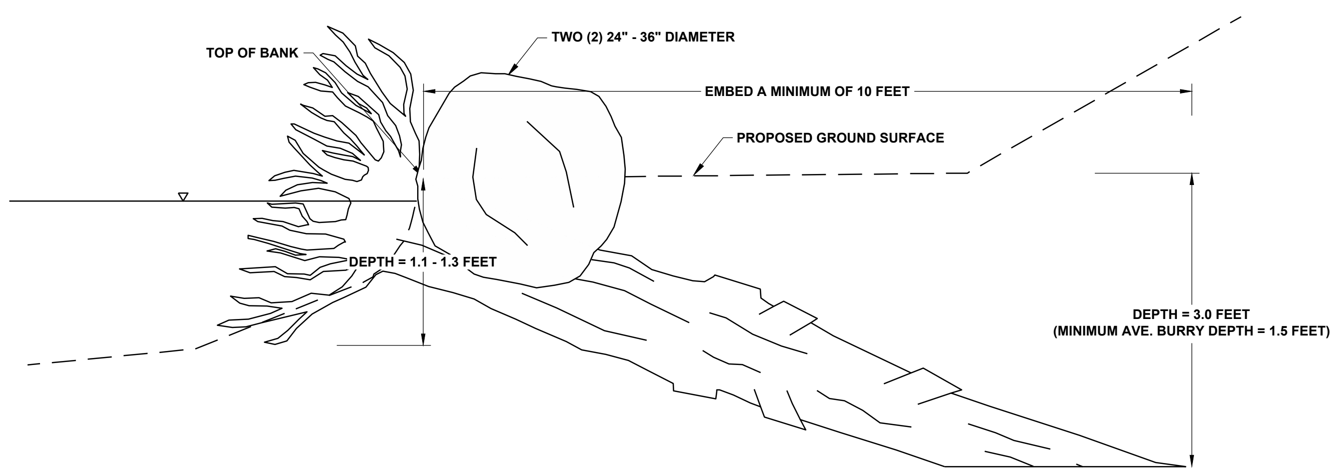
HOUSTON engineering, inc.

Drawn by	Date			
AMZ	5-5-2022	TROUT BROOK RESTORATION PHASE 3 SOUTH WASHINGTON WATERSHED DISTRICT AFTON, MN	LOG STEP POOL DETAIL PROJECT NO. 4876-0051	SHEET 19
Checked by LDO	Scale AS SHOWN			

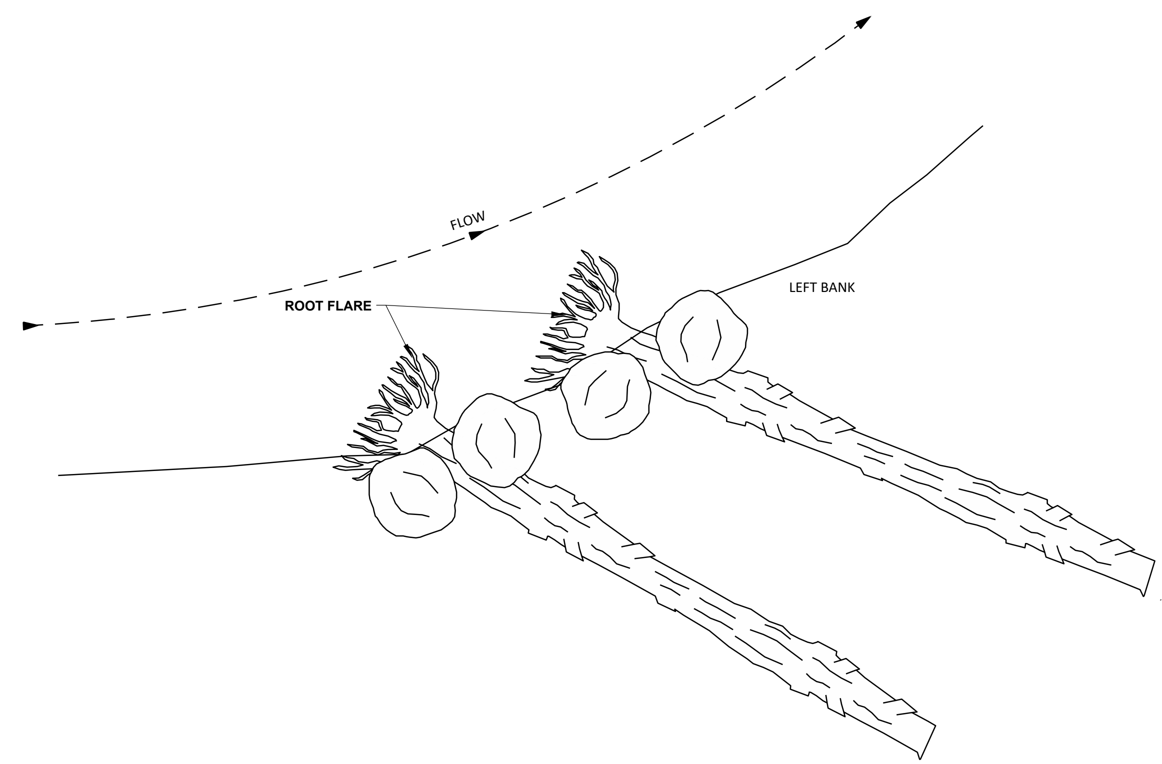
NOTES:

1. ROOT WADS SHALL BE DERIVED FROM SALVAGED MATERIAL ON-SITE. IF THERE IS INSUFFICIENT WOOD ON-SITE, QUANTITY OF ROOT WADS WILL BE REDUCED AS DIRECTED BY ENGINEER OR OWNER IN THE FIELD.
2. LARGE WOOD SHALL HAVE THE FOLLOWING MINIMUM DIMENSIONS: A DIAMETER AT BREAST HEIGHT OF 15 INCHES, LENGTH OF WOOD SHALL BE A MINIMUM OF 10 FEET.
3. ROOTWADS SHALL HAVE A DIAMETER (AT THE ROOTS) BETWEEN 4 AND 5 FEET AND A LENGTH BETWEEN 2 AND 4 FEET.
4. LARGE WOOD SHALL BE RECENTLY HARVESTED OR IN 100% ROT FREE CONDITION.
5. THE FOLLOWING SPECIES OF LARGE WOOD ARE ACCEPTABLE: COTTONWOOD, BLACK WILLOW, RED OAK, WHITE OAK, BUR OAK, WHITE ASH, SUGAR MAPLE, SILVER MAPLE, ASHLEAF MAPLE, BLACK LOCUST, AND/OR BOXELDER.
6. ROOTWADS LISTED IN THE TABLE ARE AN ESTIMATE. QUANTITY MAY INCREASE OR DECREASE, DEPENDING ON MATERIALS THAT CAN BE HARVESTED FROM THE SITE. LOCATIONS WILL BE STAKED BY PROJECT REPRESENTATIVE.

ROOTWAD NO.	STATION	SIDE OF BANK	BOULDER 24" TO 36" DIA. (EACH)	



ROOT WAD DETAIL SECTION VIEW
NOT TO SCALE



ROOT WAD DETAIL PLAN VIEW
NOT TO SCALE

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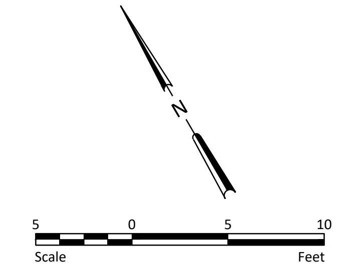
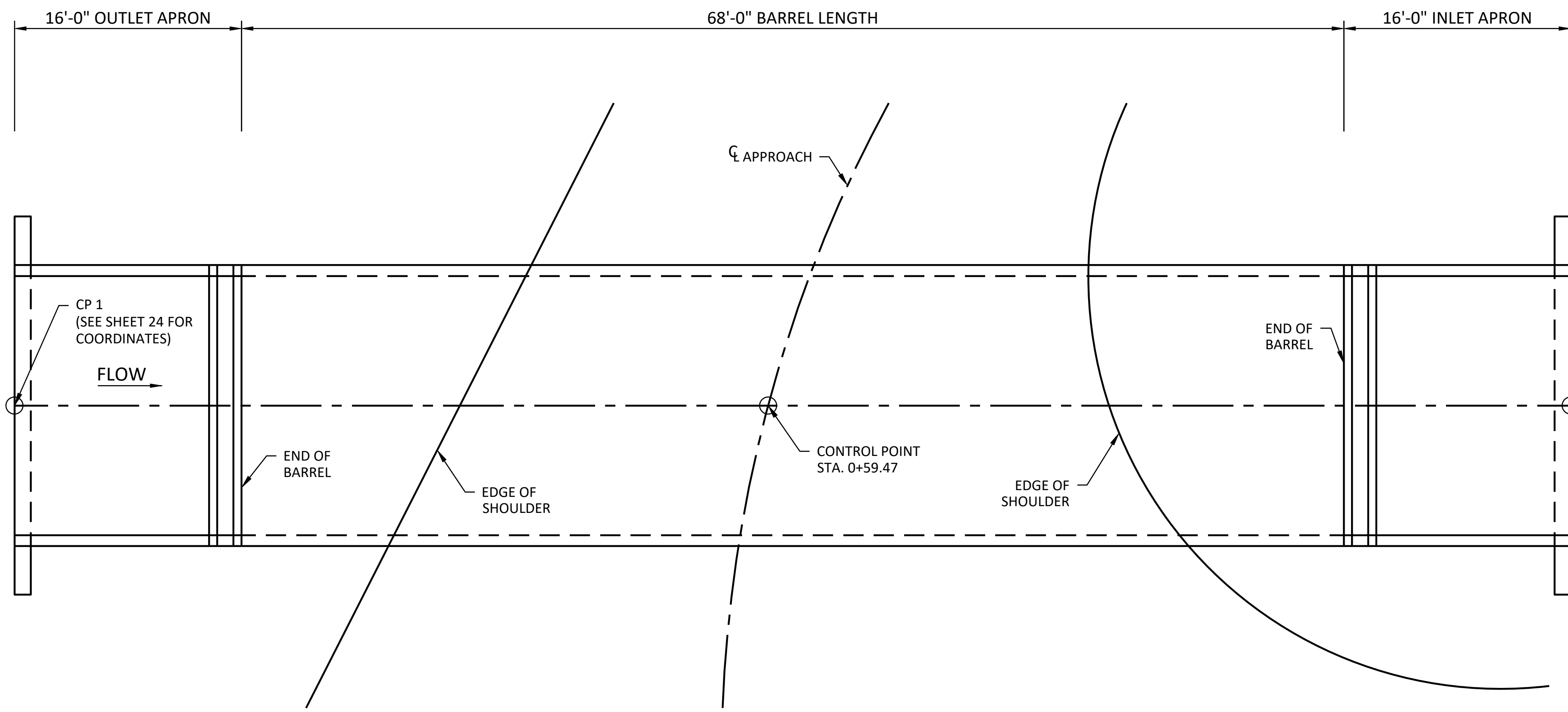
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

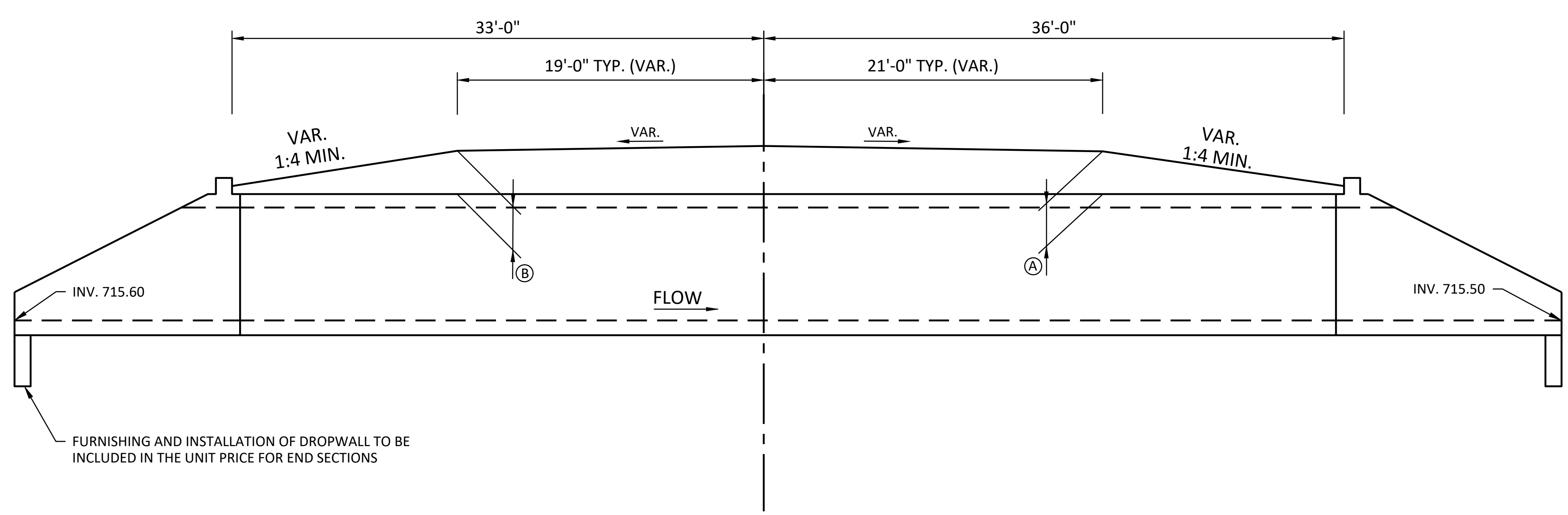
ROOT WAD DETAIL
PROJECT NO. 4876-0051

SHEET
20



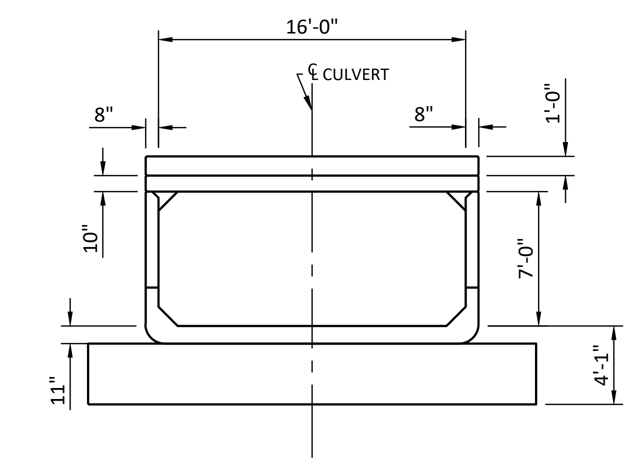


PLAN VIEW



FURNISHING AND INSTALLATION OF DROPWALL TO BE INCLUDED IN THE UNIT PRICE FOR END SECTIONS

ELEVATION VIEW



END ELEVATION

DESIGN DATA

DESIGNED IN ACCORDANCE WITH 2017 AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS AND MnDOT BRIDGE DESIGN MANUAL.

HL-93 LIVE LOAD
BARREL SPAN = 16'-0"
BARREL RISE = 7'-0"
BARREL LENGTH = 68'-0"
EST. MIN. FILL DEPTH (A) = 2.00'
EST. MAX. FILL DEPTH (B) = 2.00'
SKEW ANGLE = 0°00'00"

DESIGN SPEED = N/A MPH
CURRENT ADT = N/A
PROJECTED ADT = N/A

HL-93 LRFR
BRIDGE OPERATING RATING FACTOR RF = 1.3

CONSTRUCTION NOTES:

THE 2020 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" SHALL GOVERN.

ALL EXPOSED CONCRETE EDGES SHALL BE FORMED WITH A 1/2" OR 3/4" CHAMFER UNLESS OTHERWISE NOTED.

CONSTRUCTION SHALL BE IN ACCORDANCE WITH SPEC. 2411 AND 2412, EXCEPT AS NOTED.

REFER TO SHEET FOR EXCAVATION AND BACKFILL. SPEC. 2451.

THE BAR SIZES SHOWN IN THIS PLAN ARE IN U.S. CUSTOMARY DESIGNATIONS.

REFER TO COVER SHEET OF THE PLANS FOR SUBSURFACE UTILITY INFORMATION.

REFER TO SHEET 24 OF THE PLANS FOR CONTROL POINT (CP) COORDINATES

LOCATION: AFTON ALPS DRIVEWAY OVER TROUT BROOK

MAIN ONE LINE OF 16' x 7' MNDOT STD. PRECAST CONCRETE CULVERT

GENERAL PLAN AND ELEVATION

SEC. 3 T 027 N R 20 W

DENMARK TOWNSHIP WASHINGTON COUNTY

No.	Revision	Date	By

PRELIMINARY

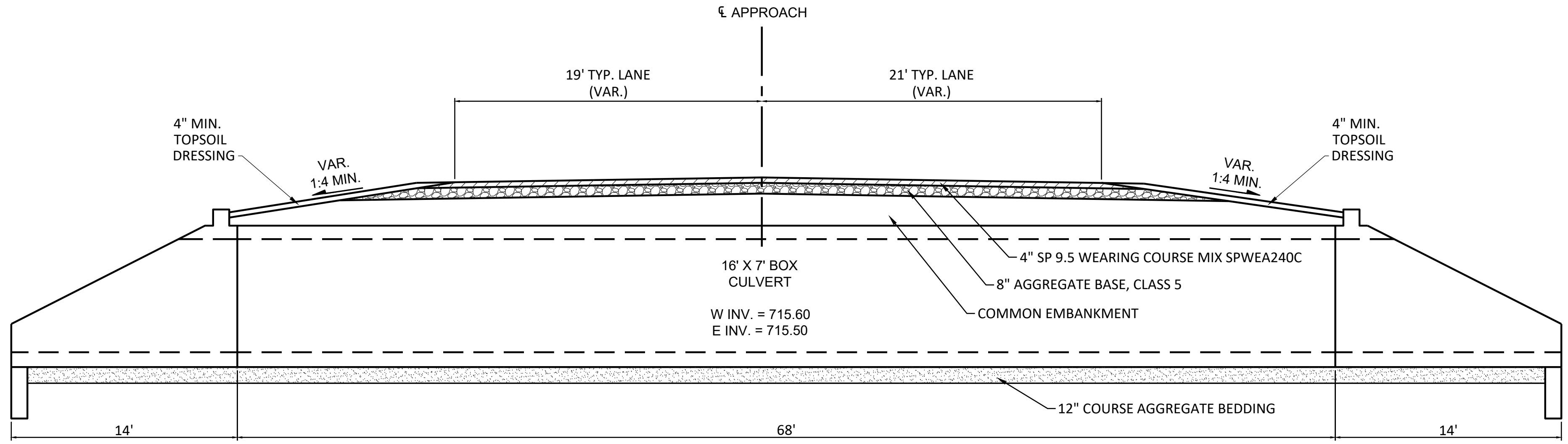
HOUSTON engineering, inc.

Drawn by	Date	Checked by	Scale
DJK	5-5-2022	WJK	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

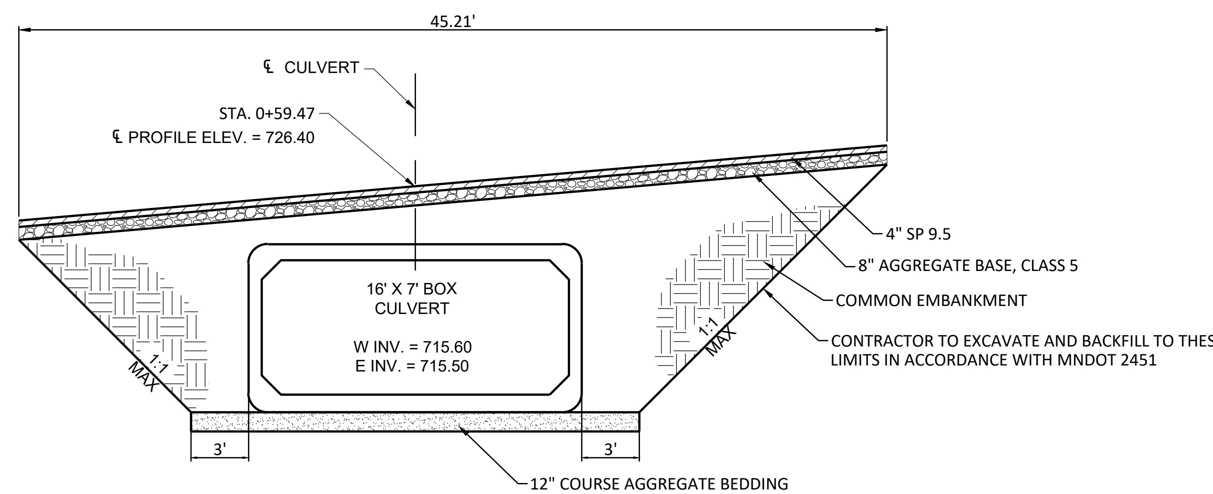
BOX CULVERT
GENERAL PLAN
PROJECT NO. 4876-0051

SHEET
21



TYPICAL SECTION APPROACH

NOT TO SCALE



SPECIAL DETAIL TO BOX CULVERT

NOT TO SCALE

H:\JBN\4800\4876\4876_0051 Trout Brook Ph3\CAD\Plans\TROUT BROOK RESTORATION PHASE 3\General Plan.dwg-22 BOX CULVERT TYPICAL SECTION-5/6/2022 4:06 PM-(klund)

No.	Revision	Date	By

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HOUSTON engineering, inc.

Drawn by: DJK | Date: 5-5-2022
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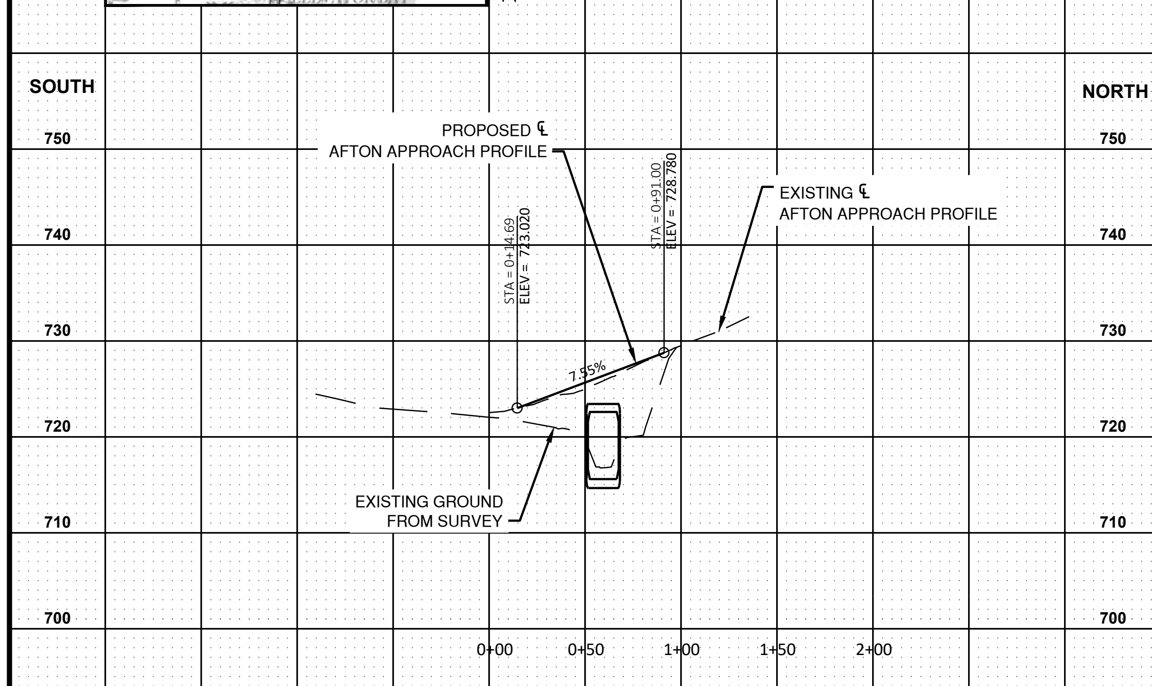
TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

BOX CULVERT
TYPICAL SECTION
PROJECT NO. 4876-0051

SHEET
22

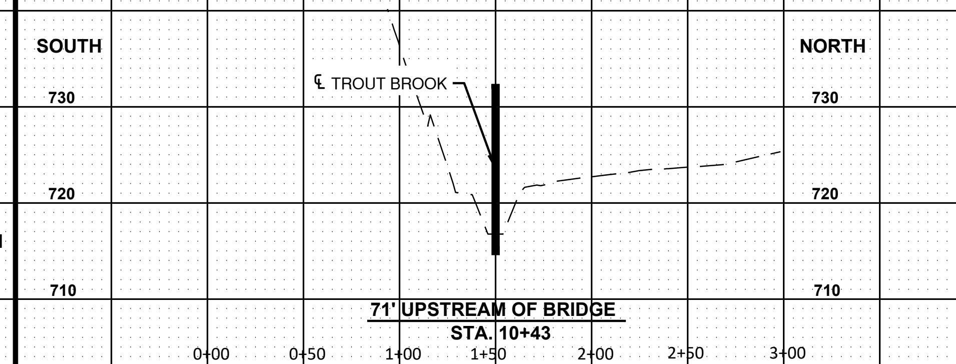
HEI NO. 4876-0051



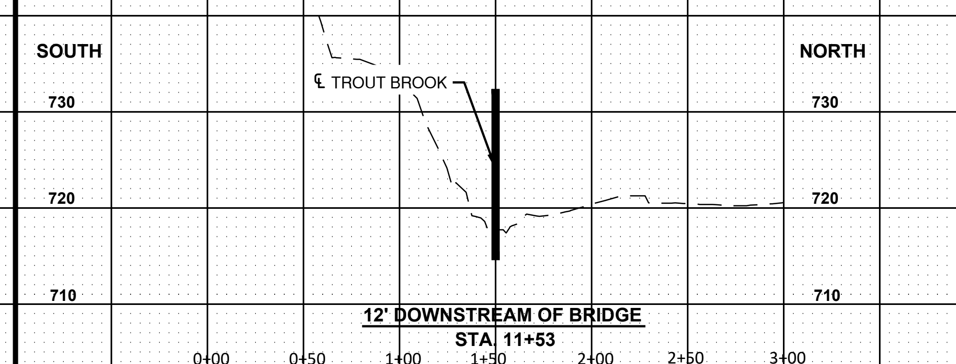
NOTE:
SEE SHEET 24 FOR ROAD PROFILE ELEVATIONS

TYPICAL SECTIONS & PERTINENT DATA

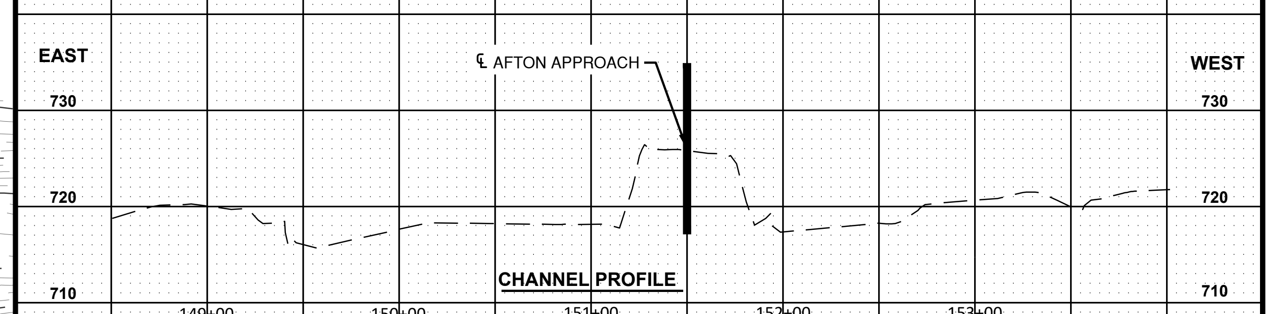
SCALES AS SHOWN



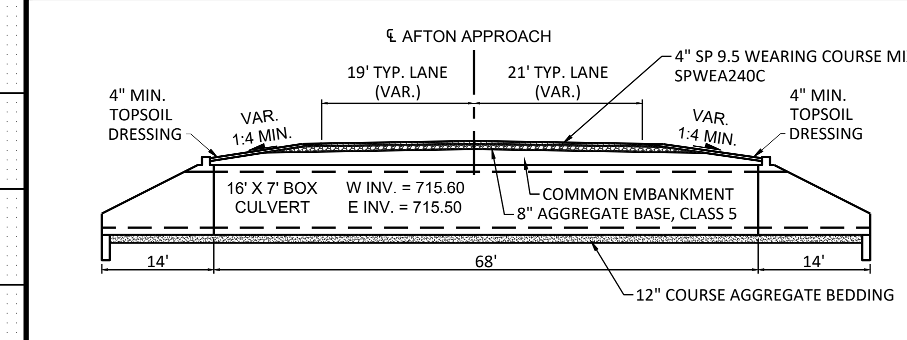
71' UPSTREAM OF BRIDGE
STA. 10+43



12' DOWNSTREAM OF BRIDGE
STA. 11+53

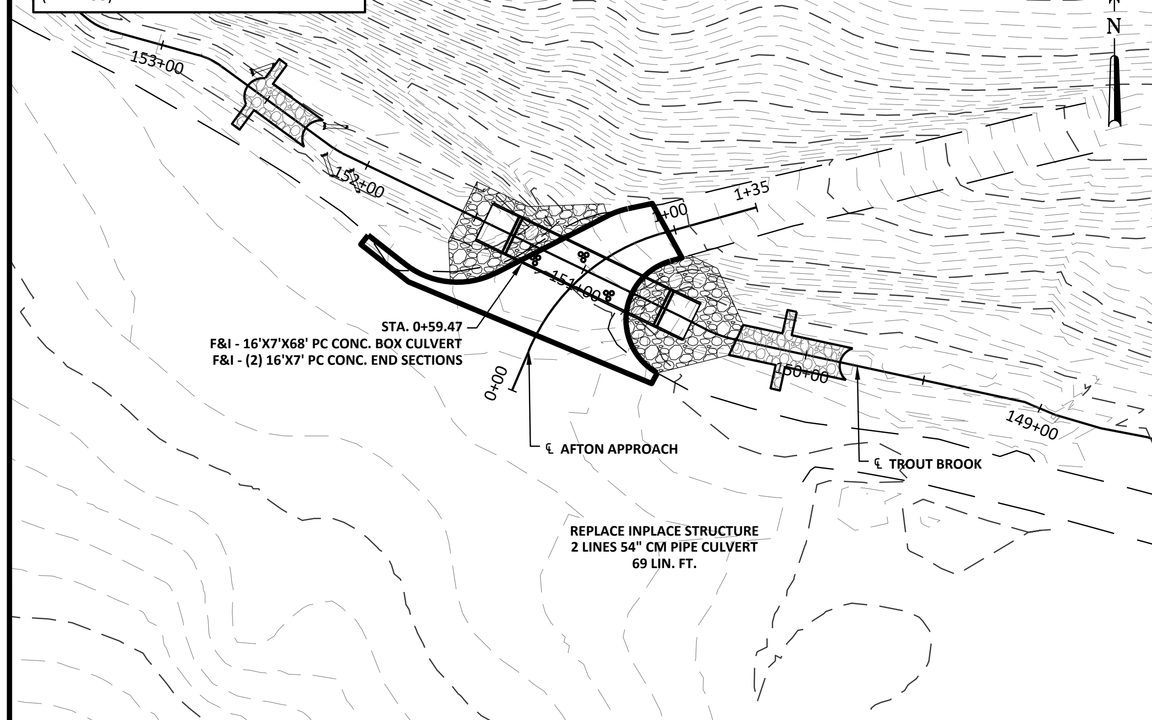


CHANNEL PROFILE



TYPICAL ROADWAY SECTION

PROJECT BENCH MARK
SOUTH EAST CORNER OF IN-PLACE DAM
ELEV. = 1314.66
WASHINGTON COUNTY, SOUTH, US FOOT
(NAVB88)



NOTE:
CONTRACTOR TO CALL GOPHER ONE PRIOR TO ANY WORK COMMENCING ON PROJECT.

HYDRAULIC DATA

LOCATION ENGINEER'S OBSERVATIONS AT BRIDGE SITE

1. Special Features: Waterfalls, dams, floods, ice, debris, sliding banks, recreational boating. N/A
2. Other bridges or culverts over the same stream (particularly structures which carry highwater without overflow of roadway): Given locations, type, length, height above highwater, cross-sectional area, etc. N/A
3. Apparent highwater elevation UNKOWN Obtained from ______
4. Other data: Approx. velocity of water at time of survey ______

FOUNDATION ENGINEER'S RECOMMENDATION

DATE ______

Bridge survey sheets made from: SURVEY DATA OBTAINED FROM HOUSTON ENGINEERING SURVEY DATED SEPTEMBER 2021

Bench mark elevation ______ (NAVD1988)

Location: ______

MINNESOTA
DEPARTMENT OF TRANSPORTATION

BRIDGE SURVEY

OVER TROUT BROOK
(T.H., C.S.A.H., C.R. etc.)

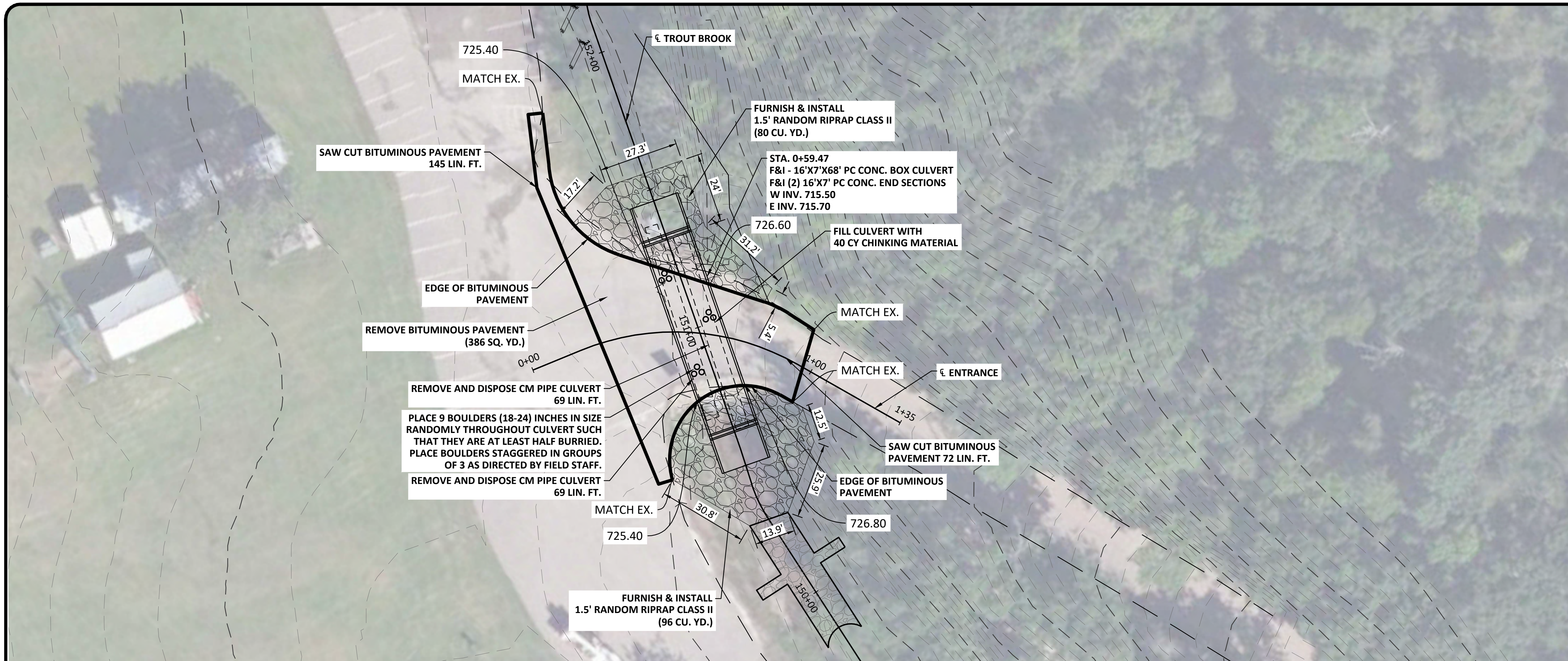
PROPOSED BRIDGE LOCATED ______

0.70 MILES NORTH OF THE JCT OF 70 ST. S.

SEC. 3 TWP. 27 N R. 20 W

TOWNSHIP DENMARK COUNTY WASHINGTON

SOUTH WASHINGTON WATERSHED DISTRICT



N

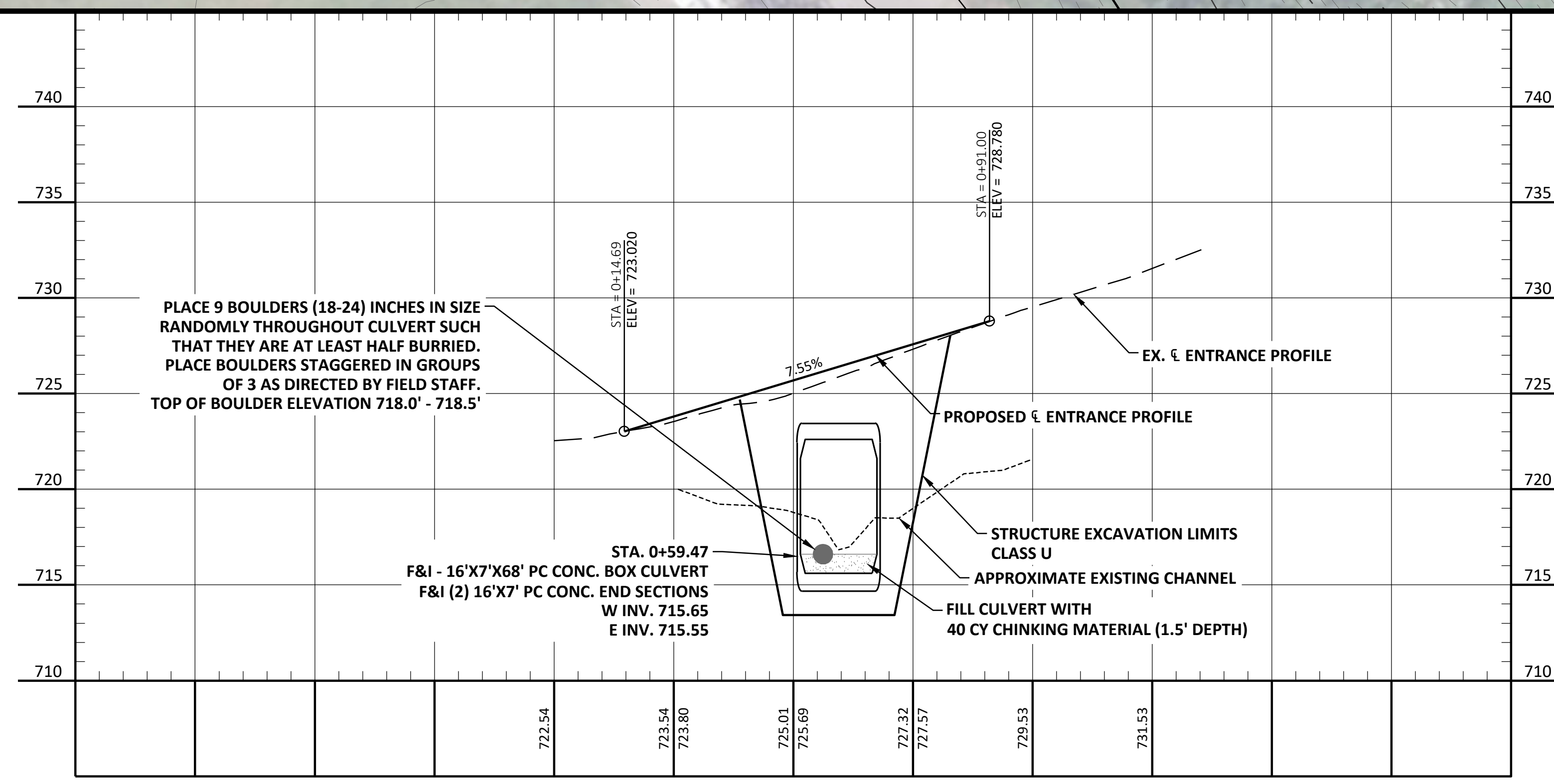
20	0	20	40

Scale Feet

COORDINATES FOR END OF BOX CULVERTS (END OF APRONS)

CP 1 : N = 140803.5140
E = 511381.1342

CP 2: N = 140761.8033
E = 511467.5994



H:\JBN\4800\4876\4876_0051 Trout Brook Ph3\CAD\Plans\TROUT BROOK RESTORATION PHASE 3\Box Culvert Plan & Profile.dwg-24 BOX CULVERT PLAN & PROFILE-5/6/2022 4:07 PM-(klund)

No.	Revision	Date	By

PRELIMINARY

HOUSTON engineering, inc.

Drawn by	Date
DJK	5-5-2022
Checked by	Scale
WJK	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

BOX CULVERT
PLAN & PROFILE
PROJECT NO. 4876-0051

SHEET
24

N

30 0 30 60
Scale Feet

MANAGEMENT PLANT COMMUNITY

- VEGETATION MANAGEMENT PLAN A
- VEGETATION MANAGEMENT PLAN B
- VEGETATION MANAGEMENT PLAN C
- SHRUB PLANING ZONE (OVERLAPS VEGETATION MANAGEMENT ZONE)
- NOT APPLICABLE

NOTES:

NOTES:
VEGETATION MANAGEMENT PLAN A: 34-361 RIPARIAN NORTHEAST

VEGETATION MANAGEMENT PLAN B:35-241 MESIC PRAIRIE GENERAL

VEGETATION MANAGEMENT PLAN C: 36-311 WOODLAND EDGE NORTHEAST

SHRUB ZONE: EVEN MIX OF: NINEBARK, ARROWOOD VIBURNUM, AMERICAN HAZELNUT, COMMON ELDERBERRY, NANNYBERRY, SAND SERVICEBERRY, GRAY DOGWOOD, AND RED OSIER DOGWOOD. PLACE AS STAKED BY ENGINEER/OWNER AT AN AVERAGE SPACING OF 5 FEET APART.

TREES: EVEN MIX OF: SUGAR MAPLE, HACKBERRY, AMERICAN BASSWOOD, RED OAK, COTTONWOOD, BUR OAK. PLACE AS DIRECTED BY FIELD STAFF AT AN AVERAGE DENSITY OF 30 TREES PER ACRE THROUGHOUT DISTURBED AREAS.

PRELIMINARY
NOT FOR CONSTRUCTION

H:\BN\4800\4876\4876_0051 Trout Brook Ph3\CAD\Plans\TROUT BROOK RESTORATION PHASE 3\Vegetation Management.dwg-25 VEGETATION MANAGEMENT & EROSION CONTROL PLAN-5/6/2022 4:08 PM-(klund)

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

VEGETATION MANAGEMENT & EROSION CONTROL PLAN
PROJECT NO. 4876-0051

SHEET 25

HEI NO. 4876-0051

30 0 30 60
Scale Feet

MANAGEMENT PLANT COMMUNITY

- VEGETATION MANAGEMENT PLAN A
- VEGETATION MANAGEMENT PLAN B
- VEGETATION MANAGEMENT PLAN C
- SHRUB PLANING ZONE (OVERLAPS VEGETATION MANAGEMENT ZONE)
- NOT APPLICABLE

NOTES:

NOTES:
VEGETATION MANAGEMENT PLAN A: 34-361 RIPARIAN NORTHEAST

VEGETATION MANAGEMENT PLAN B:35-241 MESIC PRAIRIE GENERAL

VEGETATION MANAGEMENT PLAN C: 36-311 WOODLAND EDGE NORTHEAST

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30 0 30 60
Scale Feet

PRELIMINARY
NOT FOR CONSTRUCTION

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No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

VEGETATION MANAGEMENT & EROSION CONTROL PLAN
PROJECT NO. 4876-0051

SHEET
26

HEI NO. 4876-0051

30 0 30 60
Scale Feet

MANAGEMENT PLANT COMMUNITY

- VEGETATION MANAGEMENT PLAN A
- VEGETATION MANAGEMENT PLAN B
- VEGETATION MANAGEMENT PLAN C
- SHRUB PLANING ZONE (OVERLAPS VEGETATION MANAGEMENT ZONE)
- NOT APPLICABLE

NOTES:

NOTES:
VEGETATION MANAGEMENT PLAN A: 34-361 RIPARIAN NORTHEAST

VEGETATION MANAGEMENT PLAN B:35-241 MESIC PRAIRIE GENERAL

VEGETATION MANAGEMENT PLAN C: 36-311 WOODLAND EDGE NORTHEAST

SHRUB ZONE: EVEN MIX OF: NINEBARK, ARROWOOD VIBURNUM, AMERICAN HAZELNUT, COMMON ELDERBERRY, NANNYBERRY, SAND SERVICEBERRY, GRAY DOGWOOD, AND RED OSIER DOGWOOD. PLACE AS STAKED BY ENGINEER/OWNER AT AN AVERAGE SPACING OF 5 FEET APART.

TREES: EVEN MIX OF: SUGAR MAPLE, HACKBERRY, AMERICAN BASSWOOD, RED OAK, COTTONWOOD, BUR OAK. PLACE AS DIRECTED BY FIELD STAFF AT AN AVERAGE DENSITY OF 30 TREES PER ACRE THROUGHOUT DISTURBED AREAS.

30 0 30 60
Scale Feet

PRELIMINARY
NOT FOR CONSTRUCTION

H:\BN\4800\4876\4876_0051 Trout Brook Ph3\CAD\Plans\TROUT BROOK RESTORATION PHASE 3\Vegetation Management.dwg-27 VEGETATION MANAGEMENT & EROSION CONTROL PLAN-5/6/2022 4:08 PM-(klund)

No.	Revision	Date	By

HOUSTON engineering, inc.

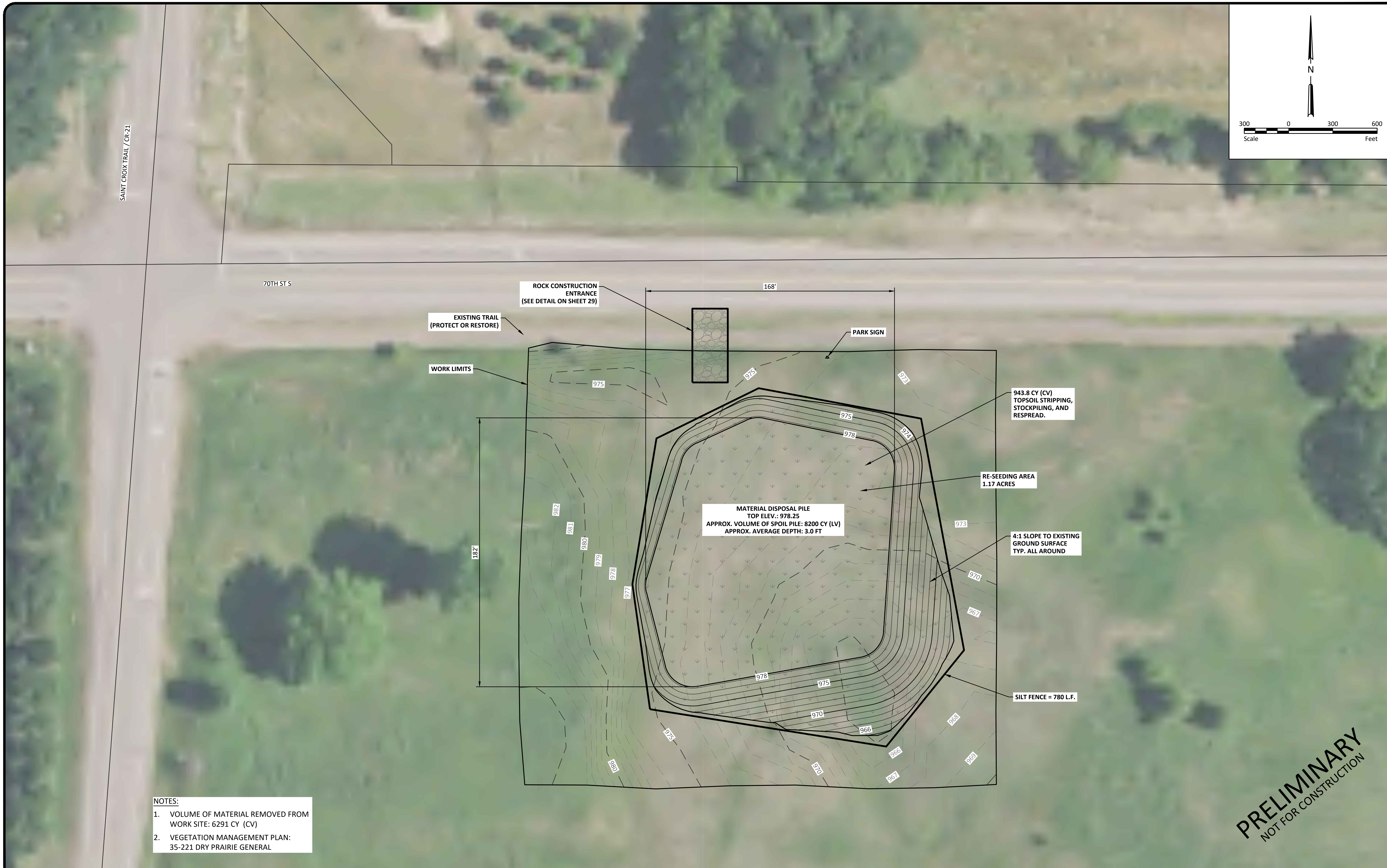
Drawn by AMZ | Date 5-5-2022
Checked by LDO | Scale AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

VEGETATION MANAGEMENT & EROSION CONTROL PLAN
PROJECT NO. 4876-0051

SHEET 27

HEI NO. 4876-0051



H:\JBN\4800\4876\4876_0051 Trout Brook Ph3\CAD\Plans\TROUT BROOK RESTORATION PHASE 3\Soil Area Stabilization.dwg-28 SOIL AREA STABILIZATION-5/6/2022 4:09 PM-(klund)

No.	Revision	Date	By

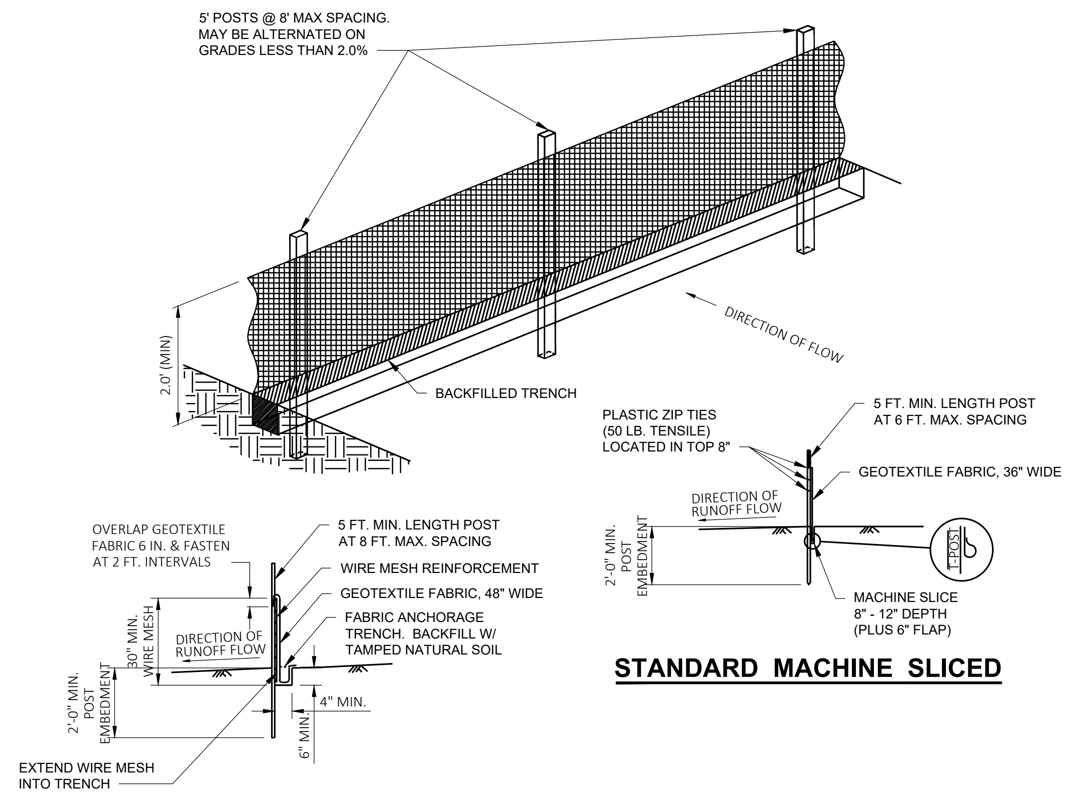
HOUSTON engineering, inc.

Drawn by	AMZ	5-5-2022
Checked by	LDO	Scale: AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

SOIL AREA STABILIZATION
PROJECT NO. 4876-0051

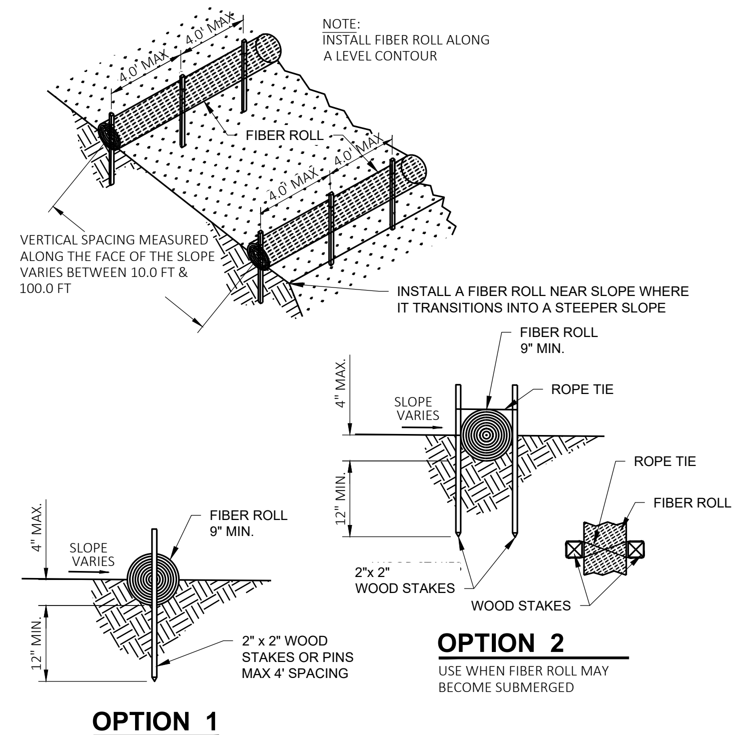
SHEET 28



NOTE:
SILT FENCE TO BE STANDARD UNLESS ACTUAL SITE CONDITIONS REQUIRE HEAVY DUTY FENCE PER BMP'S OR INDICATED ON PLANS.

SILT FENCE

NOT TO SCALE

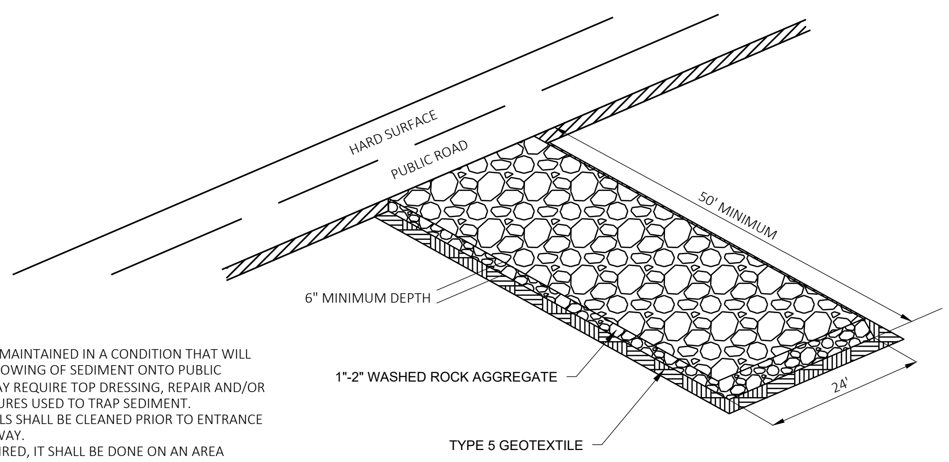


NOTE:
INSTALL FIBER ROLL ALONG A LEVEL CONTOUR

FIBER ROLL INSTALLATION

NOT TO SCALE

MATERIAL	QUANTITY REQ'D
DITCH CHECK	3 ASSEMBLIES
BIOLOG	1,048 L.F.
SILT FENCE	1,828 L.F.
SHRUBS	0.39 ACRES
SEEDING (PLAN A)	0.59 ACRES
SEEDING (PLAN B)	2.18 ACRES
SEEDING (PLAN C)	0.52 ACRES
EROSION CONTROL BLANKET	98 SQ. YDS.

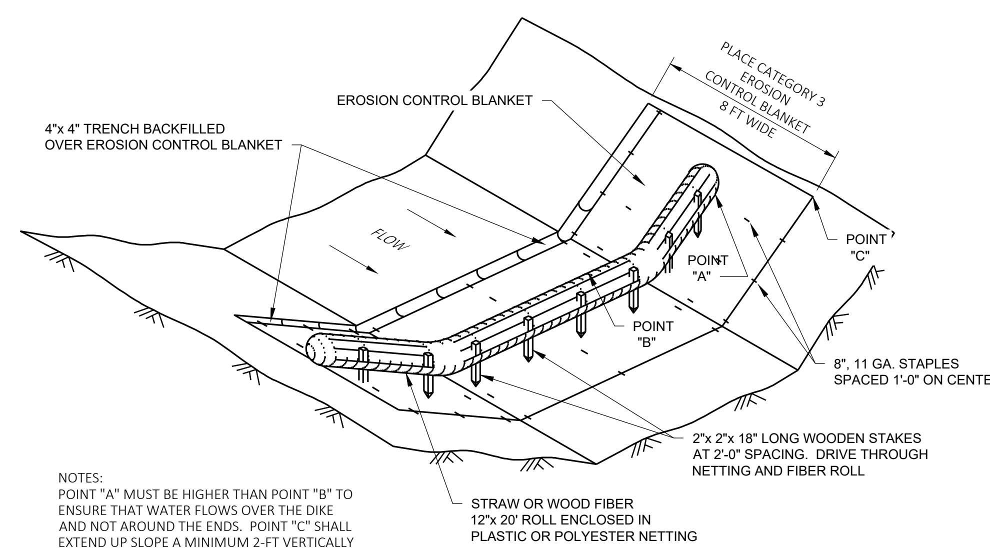


NOTES:
1. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION THAT WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHTS-OF-WAY. THIS MAY REQUIRE TOP DRESSING, REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT.
2. WHEN NECESSARY, WHEELS SHALL BE CLEANED PRIOR TO ENTRANCE ONTO PUBLIC RIGHT-OF-WAY.
3. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH CRUSHED STONE THAT DRAINS INTO AN APPROVED SEDIMENT TRAP OR SEDIMENT BASIN.

TEMPORARY ROCK OR WOOD CHIP

CONSTRUCTION ENTRANCE

NOT TO SCALE



NOTES:
POINT "A" MUST BE HIGHER THAN POINT "B" TO ENSURE THAT WATER FLOWS OVER THE DIKE AND NOT AROUND THE ENDS. POINT "C" SHALL EXTEND UP SLOPE A MINIMUM 2-FT VERTICALLY TO CONTROL EROSION AROUND END OF STRAW OR WOOD FIBER ROLL.

TEMPORARY DITCH CHECK

NOT TO SCALE

H:\BNV\4800\4876\4876_0051 Trout Brook Ph3\CAD\Plans\TROUT BROOK RESTORATION PHASE 3\SWPPP NOTES AND EROSION CONTROL.dwg-29 EROSION CONTROL DETAILS-5/6/2022 4:09 PM-(klund)

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
AMZ	5-5-2022
Checked by	Scale
LDO	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

EROSION CONTROL DETAILS

PROJECT NO. 4876-0051

SHEET 29

STORM WATER POLLUTION PREVENTION NARRATIVE

PROJECT DESCRIPTION / LOCATION

THE TROUT BROOK RESTORATION PROJECT IS LOCATED AT AFTON ALPS SKI RESORT AND AFTON STATE PARK WITHIN DENMARK TOWNSHIP OF WASHINGTON COUNTY, MINNESOTA. THE PROPOSED PROJECT PROPOSES TO RESTORE APPROXIMATELY 1,450 FT OF STREAM WHICH INCLUDES 26 ROCK RIFFLES, 2 WOODY DEBRIS RIFFLES, AN EXCAVATING ADDITIONAL FLOODPLAIN IN TWO LOCATIONS ALONG A COMBINED 700 FT OF STREAM. THE PROJECT ALSO PROPOSES TO REPLACE TWO LINES OF 54" CMP WITH A 16'X7' RCB WITH END SECTIONS.

SITE MAPS

MAPS OF THE RESTORATION CONCEPT PLAN, LAND USE, SOIL TYPE, AND AQUATIC RESOURCES CAN BE FOUND IN THE EXHIBITS OF THE ENVIRONMENTAL ASSESSMENT WORKSHEET (EAW).

ENVIRONMENTALLY SENSITIVE AREAS

THERE ARE WETLANDS ADJACENT TO THE PROJECT WORK CORRIDOR, NONE OF WHICH ARE LISTED AS A PUBLIC WATER WETLAND. MINIMAL WORK WILL BE PERFORMED IN THE WETLANDS AND WORK SHALL BE PERFORMED TO MINIMIZE FILL PLACED IN WETLANDS.

OUTSTANDING RESOURCE VALUE WATERS (ORVWs)

THERE ARE NO OUTSTANDING RESOURCE VALUE WATERS WITHIN THE PROJECT LIMITS.

CALCAREOUS FENS

THERE ARE NO KNOWN CALCAREOUS FENS WITHIN THE PROJECT LIMITS.

IMPAIRED WATERS

TROUT BROOK IS A DNR DESIGNATED PUBLIC WATERS FOR THE ENTIRE LENGTH OF THE PROJECT. TROUT BROOK IS A WATERWAY LISTED BY THE MPCA AS AN IMPAIRED FOR E. COLI.

LAND FEATURE CHANGES

TOTAL PROJECT AREA DISTURBED	3.36 ACRES
TOTAL EXISTING IMPERVIOUS SURFACE AREA	0.0 ACRES
TOTAL EXISTING PERVIOUS SURFACE AREA	3.36 ACRES
TOTAL PROPOSED IMPERVIOUS SURFACE AREA	0.0 ACRES
TOTAL PROPOSED PERVIOUS SURFACE AREA	3.36 ACRES

DRAINAGE COMPUTATIONS

NO DRAINAGE COMPUTATIONS WERE REQUIRED AS PART OF THE STORM WATER POLLUTION PREVENTION PLAN FOR THIS PROJECT. SHOULD CONDITIONS IN THE FIELD WARRANT CHANGES, THE HYDRAULICS ENGINEER SHOULD BE CONSULTED AND THE CONDITIONS NOTED IN THE CONTRACTOR'S CONSTRUCTION LOG.

PROJECT CONTACTS

GREG BOWLES, PROJECT ENGINEER (763-493-6670) OR JOHN LOOMIS, PROJECT OWNER (651-714-3714) AND THE CONTRACTOR ARE RESPONSIBLE FOR IMPLEMENTATION OF THE SWPPP AND PLACEMENT, INSPECTION AND MAINTENANCE OF THE EROSION AND SEDIMENT CONTROL BMP'S BEFORE AND DURING CONSTRUCTION.

MPCA 24 HOUR EMERGENCY NOTIFICATION: 651-649-5451 OR 800-422-0798

TIMING OF BMP INSTALLATION

THE EROSION PREVENTION AND SEDIMENT CONTROL BMP's SHALL BE PLACED PRIOR TO START OF CONSTRUCTION, AS NECESSARY TO MINIMIZE EROSION FROM DISTURBED SURFACES AND CAPTURE SEDIMENT ON SITE, AND SHALL MEET THE NPDES PERMIT PART IV CONSTRUCTION ACTIVITY REQUIREMENTS.

ONCE CONSTRUCTION ACTIVITY CEASES FOR 7 DAYS OR MORE IN AN AREA, THAT AREA WILL BE STABILIZED WITH TEMPORARY OR PERMANENT BMP's.

RECEIVING WATERS

THE RECEIVING WATER FOR THE PROJECT IS TROUT BROOK. STORM WATER RUNOFF DURING CONSTRUCTION WILL BE MANAGED WITH BMP'S FOR INLET PROTECTION, AND OTHER BMP'S FOR MANAGING SEDIMENT LADEN RUNOFF. STORM WATER RUNOFF UPON COMPLETION OF THE PROJECT WILL BE MANAGED WITH VEGETATION ESTABLISHMENT WITHIN THE FLOODPLAIN AND STEAM BANK AREA. REFER TO THE EROSION CONTROL AND TURF ESTABLISHMENT SHEETS OF THE PLAN FOR DETAILS AND LOCATIONS OF TEMPORARY AND PERMANENT BMP'S.

SPECIAL CONDITIONS

THE CONTRACTOR SHALL PROVIDE SITE PLANS FOR CRITICAL AREAS IDENTIFIED IN THE EROSION CONTROL PLANS DETAILING HIS INTENDED CONSTRUCTION, EROSION CONTROL AND FINAL STABILIZATION METHODS PRIOR TO CONSTRUCTION COMMENCING. ALL WORK SPECIFICALLY NOT NOTED AS BEING PAID FOR SEPERATELY SHALL BE CONSIDERED INCIDENTAL WORK.
SINCE WORK IS PROPOSED WITH THE STREAM THE 100 FOOT BUFFER REQUIREMENT FOR TROUT STREAMS DOES NOT APPLY.
REDUNDANT "DOUBLE" DOWN GRADIENT SEDIMENT CONTROL WILL BE REQUIRED FOR SOIL DISTURBANCE THAT CANNOT BE AVOIDED WITHIN 50 FEET OF TROUT BROOK WETLANDS ON SITE.

STORM WATER POLLUTION PREVENTION PLAN (SWPPP) NOTES

1) THE CONTRACTOR WILL WORK WITH THE PROJECT ENGINEER TO OVERSEE THE IMPLEMENTATION OF THE SWPPP, AND PLACEMENT, INSPECTION, AND MAINTENANCE OF THE EROSION PREVENTION AND SEDIMENT CONTROL BMP'S BEFORE AND DURING CONSTRUCTION.

2) THE CONTRACTOR SHALL DEVELOP A CHAIN OF RESPONSIBILITY WITH ALL OPERATORS ON THE SITE TO ENSURE THAT THE SWPPP WILL BE IMPLEMENTED AND STAY IN EFFECT UNTIL THE CONSTRUCTION PROJECT IS COMPLETE, THE ENTIRE SITE HAS UNDERGONE FINAL STABILIZATION, AND A NOTICE OF TERMINATION HAS BEEN SUBMITTED TO THE MPCA.

3) THE CONTRACTOR SHALL PROVIDE AND SUBMIT A WRITTEN, NOT ORAL, WEEKLY SCHEDULE OF PROPOSED EROSION CONTROL ACTIVITIES FOR THE PROJECT ENGINEER'S APPROVAL AS PER MN/DOT SPEC. 1803.

4) THE CONTRACTOR SHALL PREPARE AND SUBMIT A SITE PLAN FOR THE PROJECT ENGINEER'S APPROVAL AS PER MN/DOT SPEC. 1803 FOR PIPE AND STRUCTURE PLACEMENT, DEWATERING, AND AREAS SHOWN IN THE PLANS OR SPECIFIED BY THE PROJECT ENGINEER.

5) THE NORMAL WETTED PERIMETER OF ANY TEMPORARY OR PERMANENT DRAINAGE DITCH THAT DRAINS WATER FROM A CONSTRUCTION SITE, OR DIVERTS WATER AROUND A SITE, MUST BE STABILIZED WITHIN 200 LINEAL FEET FROM THE PROPERTY EDGE, OR FROM THE POINT OF DISCHARGE TO ANY SURFACE WATER. RAPID STABILIZATION MUST BE COMPLETED IMMEDIATELY AFTER CHANNEL EXCAVATION, WHERE SOD MATS OR EROSION CONTROL BLANKETS SHOULD BE PLACED IN ACCORDANCE WITH THE PLANS. THESE AREAS MUST BE KEPT STABILIZED AT ALL TIMES.

6) PIPE OUTLETS MUST BE PROVIDED WITH TEMPORARY OR PERMANENT ENERGY DISSIPATION WITHIN 24 HOURS OF CONNECTION TO A SURFACE WATER.

7) DEWATERING AND CONCRETE TRUCK WASHING RELATED TO THE CONSTRUCTION ACTIVITY THAT MAY HAVE TURBID OR SEDIMENT LADEN DISCHARGE WATER MUST BE DISCHARGED TO A TEMPORARY SEDIMENTATION BASIN ON THE PROJECT SITE. IF WATER CANNOT BE DISCHARGED TO A SEDIMENTATION BASIN PRIOR TO ENTERING THE SURFACE WATER, IT MUST BE TREATED WITH THE APPROPRIATE BMP'S, SUCH THAT THE DISCHARGE DOES NOT ADVERSELY AFFECT THE RECEIVING WATER DOWNSTREAM LANDOWNERS. THE CONTRACTOR MUST ENSURE THAT DISCHARGE POINTS ARE ADEQUATELY PROTECTED FROM EROSION AND SCOUR. THE DISCHARGE MUST BE DISPERSED OVER NATURAL ROCK RIPRAP, SAND BAGS, PLASTIC SHEETING OR OTHER ENERGY DISSIPATION MEASURES APPROVED BY THE PROJECT ENGINEER. ADEQUATE SEDIMENTATION CONTROL MEASURES ARE REQUIRED FOR DISCHARGE WATER THAT CONTAINS SUSPENDED SOLIDS.

8) ANY FUEL OR CHEMICAL TANK STORED ON THE PROJECT AREA MUST BE PROTECTED BY A SOIL BERM OR HAVE A NEGATIVE GRADIENT TO ANY WATER RESOURCE AREA, AS PER COE404. A CONTINGENCY PLAN MUST BE CREATED BY THE CONTRACTOR IN EVENT OF A SPILL OR LEAK OF ANY CHEMICAL, INCLUDING PETROCHEMICALS, DEEMED HARMFUL TO THE ENVIRONMENT, AND HAVE ON HAND THE MATERIALS NECESSARY TO CAPTURE AND CONTAIN SAID CHEMICALS.

9) A WATER APPROPRIATION PERMIT WILL BE REQUIRED FROM THE MN DNR FOR CONSTRUCTION IF DEWATERING EXCEEDS 10,000 GALLONS PER DAY.

10) ALL ERODIBLE STOCKPILES SHALL HAVE SEDIMENT CONTROL AND BE PLACED IN AREAS AWAY FROM SURFACE WATER.

11) CONTRACTOR SHALL BE RESPONSIBLE FOR CONTROLLING EROSION AS PER THE PLAN, PROJECT PROVISIONS, AND MN/DOT SPECIFICATIONS 1701, 1702, 1717, 2572, 2573, 2575.

12) TEMPORARY SEDIMENT REQUIREMENTS IS SATISFIED WITH POOLS IN OUTSIDE BENDS. CONTRACTOR MAY NEED TO COME BACK AND REMOVE ANY SEDIMENT WASHING INTO POOLS AT PROJECT COMPLETION.

13) EROSION CONTROL WILL BE ADDRESSED THROUGH ROCK CHECKS, BIOLOGS, AND SEEDING AND MULCHING WITHIN 7 DAYS OF CONSTRUCTION IN AN AREA.

LOCATION OF SWPPP REQUIREMENTS IN PROJECT PLAN

DESCRIPTION	TITLE	LOCATION
SUMMARY OF PERVIOUS AND IMPERVIOUS AREAS	SWPPP SHEET	SHEET 30
EROSION CONTROL SHEETS	VEGETATION MANAGEMENT & EROSION CONTROL PLAN	SHEETS 25-28
EROSION CONTROL DETAILS	DETAIL SHEETS	MNDOT
FINAL STABILIZATION	ESTIMATED QUANTITIES (SILT FENCE, BLANKET, SEEDING, ETC)	SHEET 29

APPENDIX D – STRUCTURE TYPE DESIGN MEMO

HOUSTON engineering, inc.

Technical Memorandum

To: John Loomis, Water Resource Manager
South Washington Watershed District

From: Wesley J Keller, PE
Houston Engineering, Inc.

Subject: Structure Concept Study

Date: January 4, 2022

Project: Trout Brook Phase III

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am duly Licensed Professional Engineer under the laws of the State of Minnesota.

Wesley J. Keller　　Date: 1/4/2022
Reg. No. 57437

OVERVIEW

The Trout Brook Phase III Restoration Project site is located on Vail properties at the Afton Alps Ski Area and on Mn DNR property (Afton State Park), in Sections 2 and 3 of Denmark Township (T27N-R20W), approximately 3 miles south of the City of Afton in Washington County. Trout Brook outlets to the St. Croix River.

One portion of the Trout Brook Phase III project consists of removing and replacing two existing 54" corrugated metal pipe (CMP) culverts located to the west of the Alps Village. The crossing provides connectivity to the Afton Alps facility for the public and staff. The objective of the replacement is to improve channel conditions at the stream crossing and create a more efficient waterway opening. The improved waterway opening of the proposed structure will match the channel bankfull width, reduce stream velocity to enhance conditions for fish passage, and reduce the likelihood of overtopping. Structure alternatives have been selected to maintain a similar channel profile, meet minimum cover requirements (2' min.) and minimize impacts to the existing roadway profile and alignment as well as the adjacent parking lot.

PURPOSE AND SCOPE

The purpose of this structure concept study is to investigate several potential structure types to be utilized at the proposed crossing and provide a brief description of the structure, pros/cons, and anticipated construction costs associated with constructing each alternative. Each structure size has been selected to best fit the site area, meet bankfull width and hydraulic requirements of the proposed channel, reduce overtopping frequency, and provide an economical structure that will best serve the area for years to come. All structures are designed to meet site needs and are in full compliance with AASHTO bridge design and loading standards for highway use. A concept structure layout sheet has been provided for each structure alternative to best estimate the required length of each structure and provide a conceptual exhibit showing type, size, and location of each structure.

The following are objectives of this document:

- Summarize structure alternatives considered to be constructed within Trout Brook channel at the upstream crossing west of the Alps Village.
- Evaluate the structure impacts to the crossing location associated with each structure type.
- Provide conceptual layout sheets for each structure alternative.
- Provide preliminary anticipated construction costs associated with each structure type.

ALTERNATIVES

Aluminum Plate Arch Pipe

Approximate Size: 14'-10" x 9'-1"
Approximate Length: 70'-0"

Aluminum structural plate arch pipes are light-weight, easy to install, and cost friendly solutions for providing drainage at stream crossings. The aluminum alloys in aluminum structural plates have proven to be excellent in corrosion resistance. Although aluminum structures were only first introduced in the 1960's, it is anticipated that up to 75 years of service life can be expected. Aluminum structural plates are corrugated, curved, and bolt-hole punched at the plant. They are typically delivered to the site un-assembled. The plates and ribs are easily bolted together during placement to form the pipe arch shape. This low-rise arch pipe shape provides greater flow where headroom is limited along with improved hydraulic capacity during low flows. With a minimum design cover of only 2'-0", arch pipes are a great alternative when existing road profiles need to be maintained. Arch pipes are great options with relatively low installation costs and light weight construction. As seen in the attached exhibit, the invert of the arch pipe has been set below the proposed channel bottom to allow for the placement of natural channel material through the structure. The estimated structure length is 70' long with standard beveled end treatments on each end.

The estimated cost range for the aluminum plate arch pipe alternative is approximately **$195,000-$220,000**. See the attached cost summary for more information.

Pros:

- Lightweight – installation will not require special lifting equipment
- Does not require headwall or special end section.
- Low Cost

Cons:

- Structure Invert - Requires placing material over invert to maintain natural channel bottom. Special care during placement will be required to ensure the lightweight aluminum plates are not damaged.
- Assembly Required – It is estimated that an aluminum structural plate arch pipe of this size would require approximately 3-5 days and a 4–5-man crew to construct.
- Serviceability – Although the anticipated service life of up to 75 years, the high number of joints/connections increases the potential for maintenance and serviceability issues.
- Backfill Requirements – Because of the lightweight nature of plate structures, they rely on the surrounding backfill material for support and require specific material and backfill requirements during installation.
- Aesthetics

Precast Concrete Arch

Approximate Size: 18'-0" x 5'-10"
Approximate Length: 74'-0"

Precast concrete arch structures come in many shapes and sizes and are fully engineered, modular systems complete with precast concrete arch sections, headwalls, and wingwalls for rapid installation on top of precast or cast-in-place concrete foundation. It is a clear span, three-sided structure that provides a natural bottom for environmental applications providing profile continuity of the stream. When considering design life, precast concrete material typically has a longer service life than that of galvanized steel and is estimated to have a service life of 75 years. The precast concrete arch section selected for the Trout Brook site spans 18' and has approximately a 6' rise. The structure consists of a precast headwall and flared wingwall sections at each end of the arch to retain the above fill and potentially reduce the required length of the structure. Because the arch is bottomless, the structure is typically supported by a precast or cast-in-place concrete footing at each end to distribute the loads. This often requires a geotechnical investigation of the existing site conditions and recommendations for allowable bearing capacity to ensure the structure is supported properly. As seen in the attached exhibit the estimated structure length is 70' long with concrete headwalls and flared wingwalls at each end.

The estimated cost range for the precast concrete arch alternative is approximately **$310,000-$335,000**. See the attached cost summary for more information.

Pros:

- Natural Channel Bottom
- Aesthetically Appealing – Provides appealing structure shape with ability to add aesthetic features to headwalls and wingwalls (architectural concrete texture and finishes, railing, etc.)
- Serviceability – 75-year service life with low maintenance costs. Precast concrete is manufactured in plant for high-quality and durability.

Cons:

- Structure Weight – Requires specialized lifting equipment for placement.
- Increased construction time due to concrete foundation.
- Increased Engineering Costs - Additional Geotechnical and Foundation Design Required
- High Structure Cost

Aluminum Plate Box Culvert

Approximate Size: 16'-8" x 7'x6"
Approximate Length: 74'-0"

Aluminum structural plate box culverts are practical and cost-efficient solutions for small bridge replacement projects. They provide flexibility in layout options to fit within the channel and meet vertical and horizontal clearance requirements. They are a similar shape as the precast concrete arch but can be constructed with a full invert to eliminate the need for a separate footing to support the structure. Like the aluminum plate arch pipe, they are light-weight and easy to install. They provided excellent corrosion resistance and anticipated service life of up to 75 years. They are typically delivered to the site un-assembled. The plates and ribs are easily bolted together during placement to form the box shape. The proposed aluminum plate box culvert is approximately 74' long with aluminum headwalls and flared wingwalls on each end. The proposed invert of the box culvert will be placed below the channel bottom to allow for the placement of natural channel material through the length of the structure.

The estimated cost range for the aluminum plate box culvert alternative is approximately **$250,000-$275,000**. See the attached cost summary for more information.

Pros:

- Lightweight – installation is not anticipated to require special lifting equipment.
- Aesthetically Appealing – Provides appealing structure shape.
- No additional foundation required.

Cons:

- Structure Invert - Requires placing material over invert to maintain natural channel bottom. Special care during placement will be required to ensure the lightweight aluminum plates are not damaged.
- Serviceability – Although the anticipated service life of up to 75 years, the high number of joints/connections increases the potential for maintenance and serviceability issues
- High Structure Cost

Precast Concrete Box Culvert

Approximate Size: 16' x 7'
Approximate Length: 68'-0"

Precast reinforced concrete box culverts can provide a long-lasting solution in terms of strength and durability when it comes to roadways crossing stream beds. Not only is concrete design life greater than that of steel, but the resiliency to resist washouts during flood events is much greater as well. With minimal installation time and little to no long-term maintenance, a precast concrete box culvert is a viable structural alternative to consider for a crossing. Precast concrete box culvert end sections are available in standard straight sections or flared wingwall style end sections to better fit the site. The proposed box culvert size for the site is a 16’ span and 7’ rise box culvert that is approximately 68’ long. The proposed invert of the box culvert will be placed below the channel bottom to allow for the placement of natural channel material through the length of the structure.

The estimated cost range for the precast concrete box culvert alternative is approximately **$210,000-$235,000**. See the attached cost summary for more information.

Pros:

- Serviceability – 75-year service life with low maintenance costs. Precast concrete is manufactured in plant for high-quality and durability.
- Matches downstream structure type.
- Provides hydraulic efficiency that matches the bankfull width that is maintained for entire height of waterway opening
- Low Cost
- Short Installation Time

Cons:

- Structure Weight – Requires specialized lifting equipment for placement.
- Structure Invert - Requires placing material over invert to maintain natural channel bottom.

CONCLUSION

All the structure alternatives discussed in this study provide structurally sound and hydraulically efficient structures for the existing location. As shown in the cost summary, the aluminum plate arch pipe and precast concrete box provide the most economical structure alternatives. Although aluminum plate arch pipe is estimated at a slightly lower cost than the precast concrete box, the arch pipe presents a greater potential for damage during placement and serviceability and maintenance issues over the life of the structure. Therefore, the precast concrete box culvert appears to provide the most economical, durable, and least risk of potential maintenance over the service life while still maintaining all site and hydraulic requirements.

ESTIMATED COST SUMMARY

Conceptual structure related costs were compiled to determine the approximate price range of each structure type. All costs below are approximate and are subject to change as design progresses. A 15% contingency has been included to all structure alternatives.

Aluminum Plate Arch Pipe

Aluminum Plate Arch Pipe				
Items	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Mobilization	LS	1	$ 15,000.00	$ 15,000.00
Dewatering	LS	1	$ 10,000.00	$ 10,000.00
Structure Excavation/Backfill	CY	815	$ 30.00	$ 24,450.00
Channel Excavation/Slope Preparation	CY	100	$ 24.00	$ 2,400.00
Aluminum Arch Pipe 14'-10" x 9'-1" (w/End Sections)	LF	70	$ 1,600	$ 112,000.00
Random Riprap	CY	65	$ 85.00	$ 5,525.00
Bituminous Pavement (4" Depth)	TON	60	$ 90.00	$ 5,400.00
Aggregate Base (8" Depth)	TON	105	$ 25.00	$ 2,625.00
			Subtotal =	**$ 177,400.00**
			Contingency (15%) =	**$ 26,610.00**
			Estimated Total =	**$ 204,010.00**
			Estimated Range	**$195,000-$220,000**

Precast Concrete Arch Pipe

Precast Concrete Arch (Con/Span O-Series)				
Items	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Mobilization	LS	1	$ 35,000.00	$ 35,000.00
Dewatering	LS	1	$ 10,000.00	$ 10,000.00
Structure Excavation/Backfill	CY	820	$ 30.00	$ 24,600.00
Channel Excavation/Slope Preparation	CY	100	$ 24.00	$ 2,400.00
Precast Concrete Arch 18'-0" x 5'-10" (w/End Sections)	LF	74	$ 2,000.00	$ 148,000.00
Concrete Foundation Footing	CY	66	$ 650.00	$ 42,755.56
Random Riprap	CY	65	$ 85.00	$ 5,525.00
Bituminous Pavement (4" Depth)	TON	60	$ 90.00	$ 5,400.00
Aggregate Base (8" Depth)	TON	105	$ 25.00	$ 2,625.00
			Subtotal =	**$ 276,305.56**
			Additional Geotech & Foundation Eng. =	**$ 20,000.00**
			Contingency (15%) =	**$ 44,445.83**
			Estimated Total =	**$ 320,751.39**
			Estimated Range	**$310,000-$335,000**

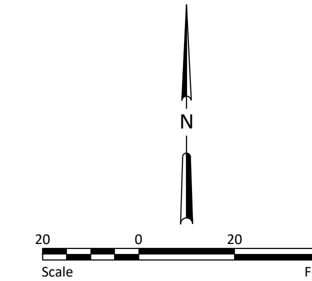
Aluminum Plate Box Culvert

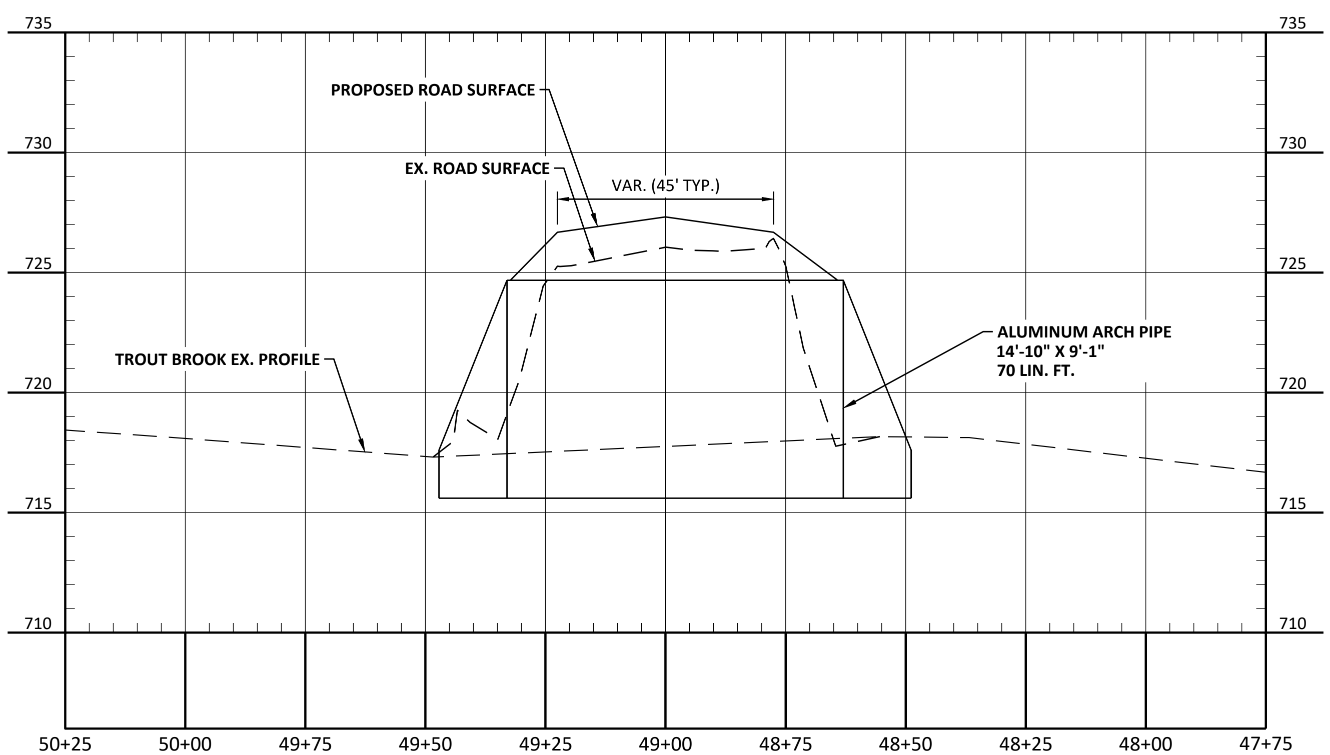
Aluminum Plate Box Culvert				
Items	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Mobilization	LS	1	$ 20,000.00	$ 20,000.00
Dewatering	LS	1	$ 10,000.00	$ 10,000.00
Structure Excavation/Backfill	CY	990	$ 30.00	$ 29,700.00
Channel Excavation/Slope Preparation	CY	100	$ 24.00	$ 2,400.00
Aluminum Box Culvert 16'-8" x 7'-6" (w/End Sections)	LF	74	$ 2,000.00	$ 148,000.00
Random Riprap	CY	65	$ 85.00	$ 5,525.00
Bituminous Pavement (4" Depth)	TON	60	$ 90.00	$ 5,400.00
Aggregate Base (8" Depth)	TON	105	$ 25.00	$ 2,625.00
			Subtotal =	**$ 223,650.00**
			Contingency (15%) =	**$ 33,547.50**
			Estimated Total =	**$ 257,197.50**
			Estimated Range	**$250,000-$275,000**

Precast Concrete Box Culvert

Precast Concrete Box Culvert				
Items	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Mobilization	LS	1	$ 20,000.00	$ 20,000.00
Dewatering	LS	1	$ 10,000.00	$ 10,000.00
Structure Excavation/Backfill	CY	925	$ 20.00	$ 18,499.65
Channel Excavation/Slope Preparation	CY	100	$ 24.00	$ 2,400.00
Precast Concrete Box Culvert 16' x 7'	LF	68	$ 1,400.00	$ 95,200.00
Precast Concrete Box Culvert End Sections	EA	2	$ 18,000.00	$ 36,000.00
Random Riprap	CY	65	$ 85.00	$ 5,525.00
Bituminous Pavement (4" Depth)	TON	60	$ 90.00	$ 5,400.00
Aggregate Base (8" Depth)	TON	105	$ 25.00	$ 2,625.00
			Subtotal =	**$ 195,649.65**
			Contingency (15%) =	**$ 29,347.45**
			Estimated Total =	**$ 224,997.10**
			Estimated Range	**$210,000-$235,000**

Aluminum Plate Arch Pipe





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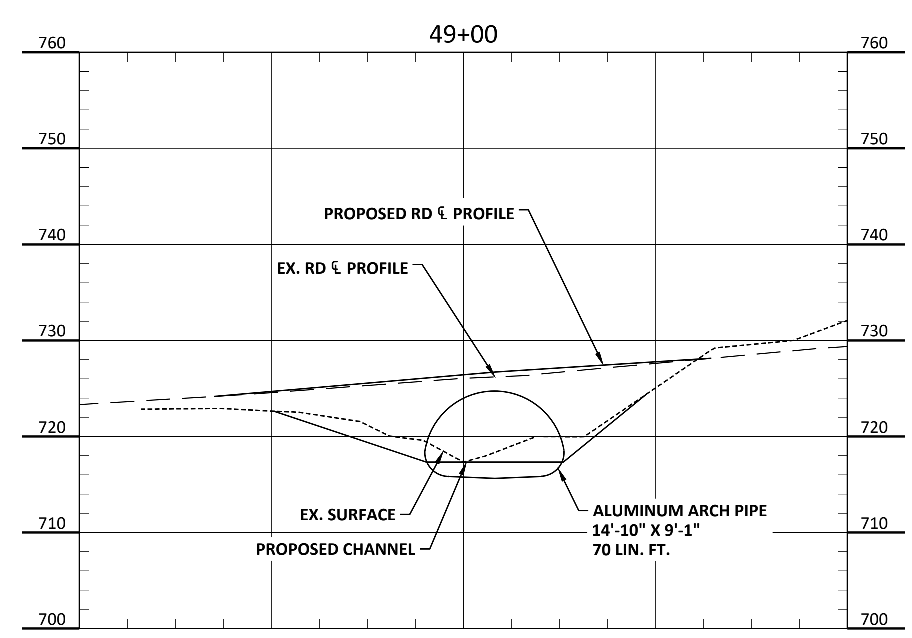

CHANNEL SECTION

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
DJK	1-3-2022
Checked by	Scale
WJK	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

ALUMINUM ARCH PIPE
14'-10" X 9'-1"

SHEET
1

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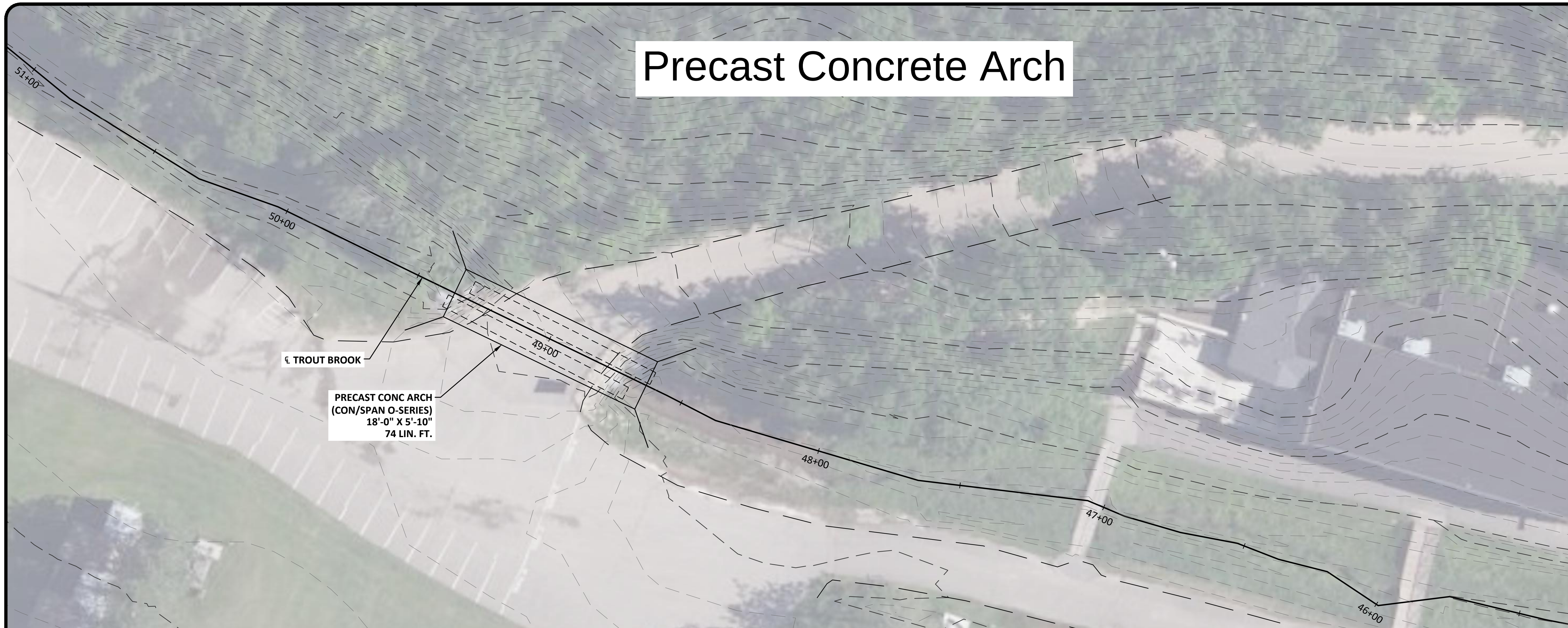
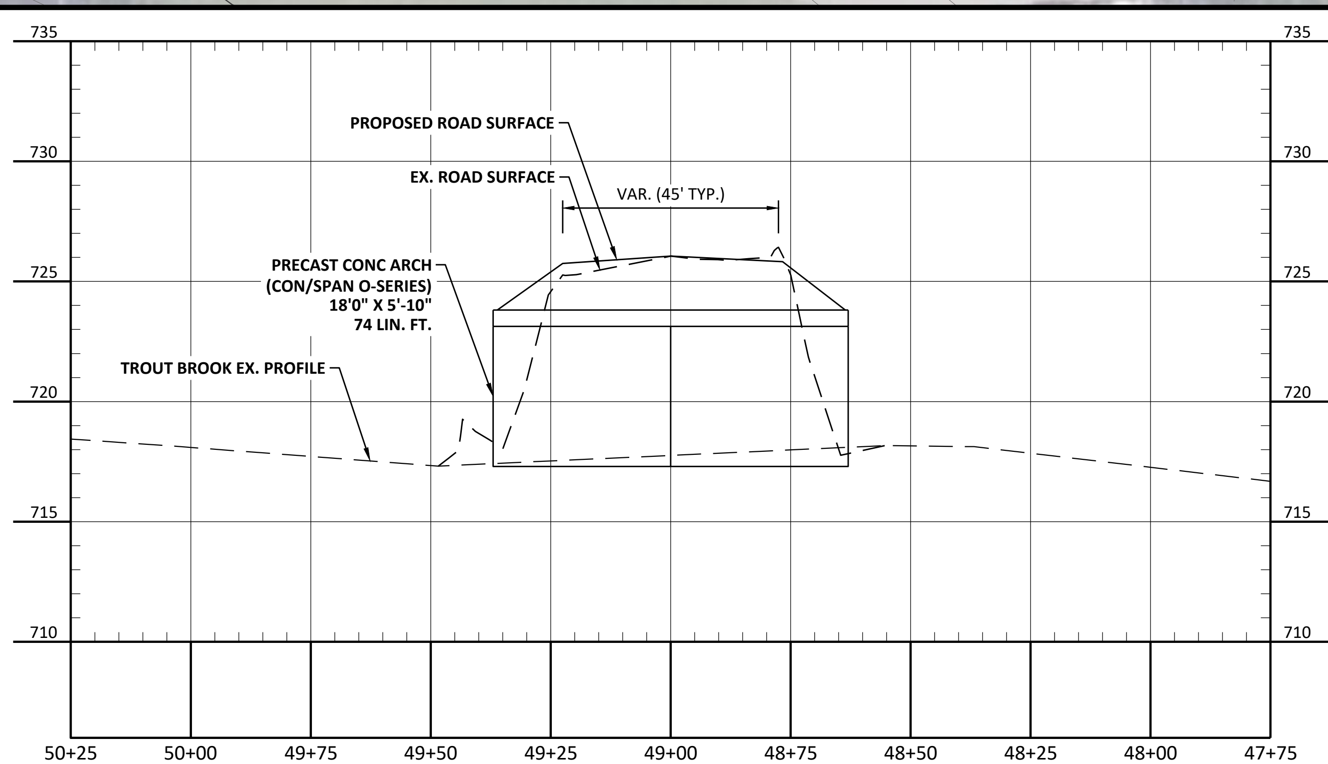
Precast Concrete Arch





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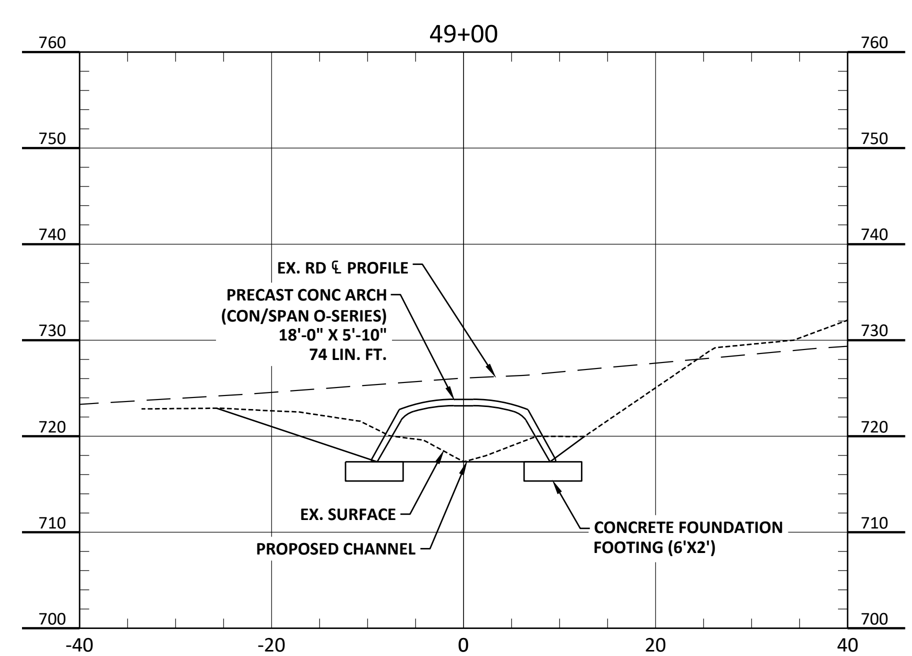

CHANNEL SECTION

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
DJK	1-3-2022
Checked by	Scale
WJK	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

PRECAST CONC ARCH
(CON/SPAN O-SERIES)
18'-0" X 5'-10"

SHEET
1

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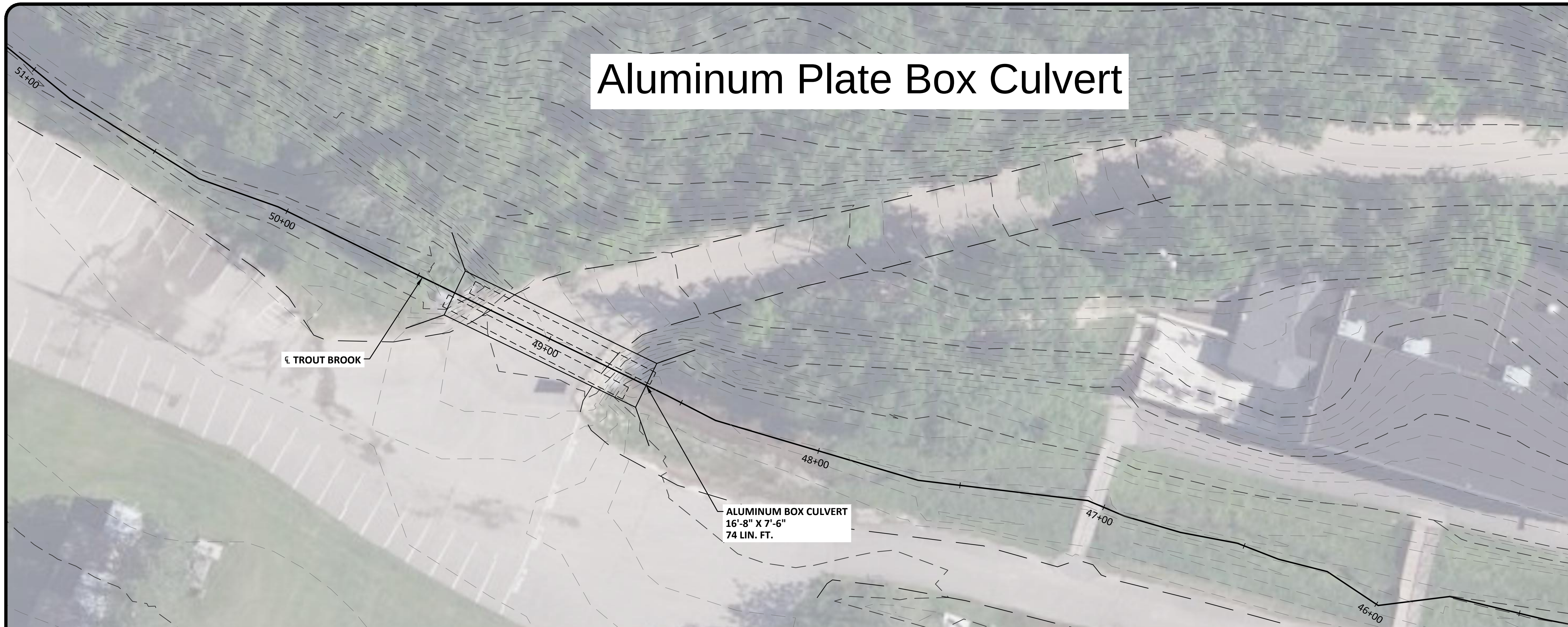
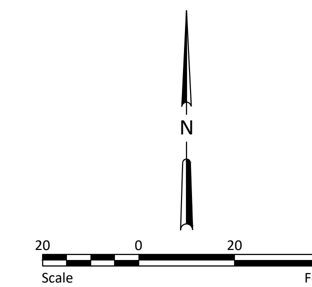
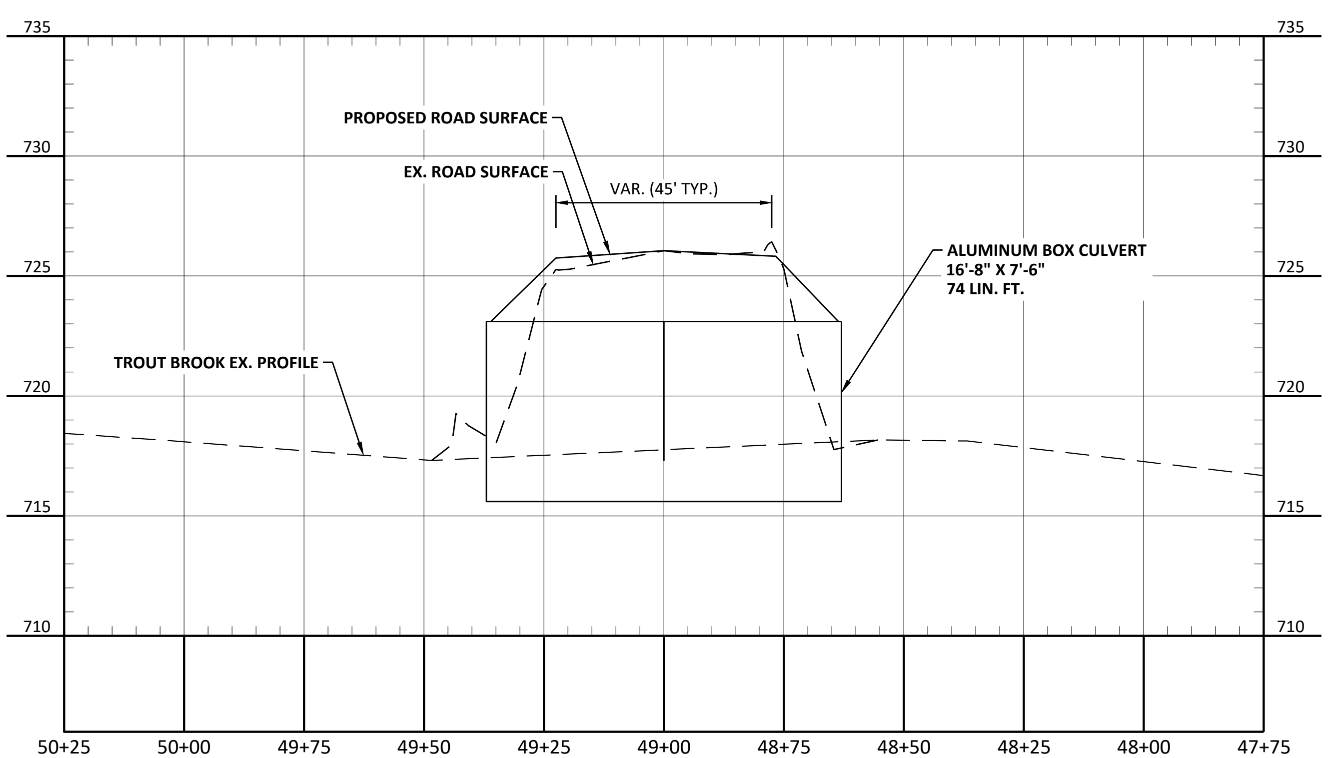
Aluminum Plate Box Culvert







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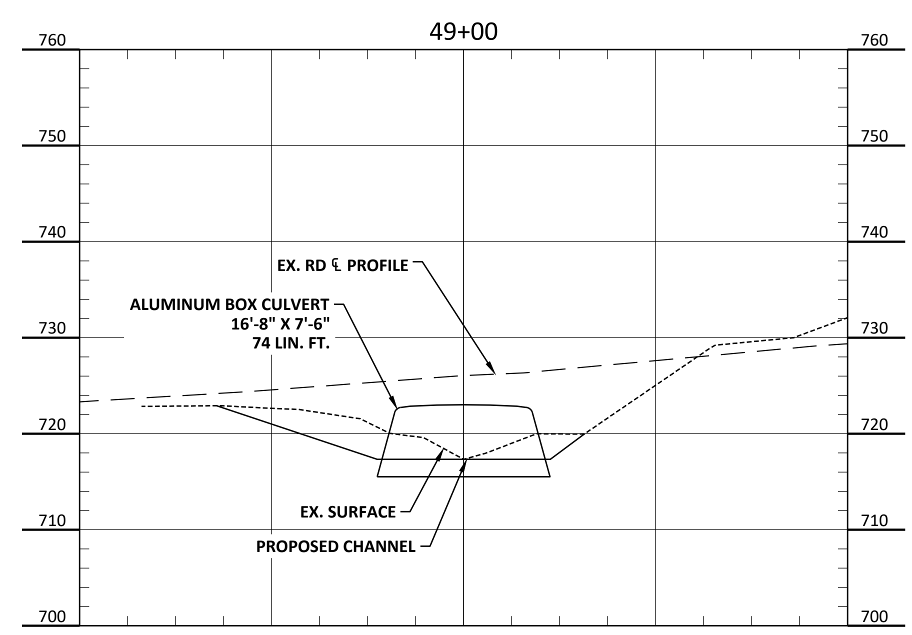

CHANNEL SECTION

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
DJK	1-3-2022
Checked by	Scale
WJK	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

ALUMINUM BOX CULVERT
16'-8" X 7'-6"

SHEET
1

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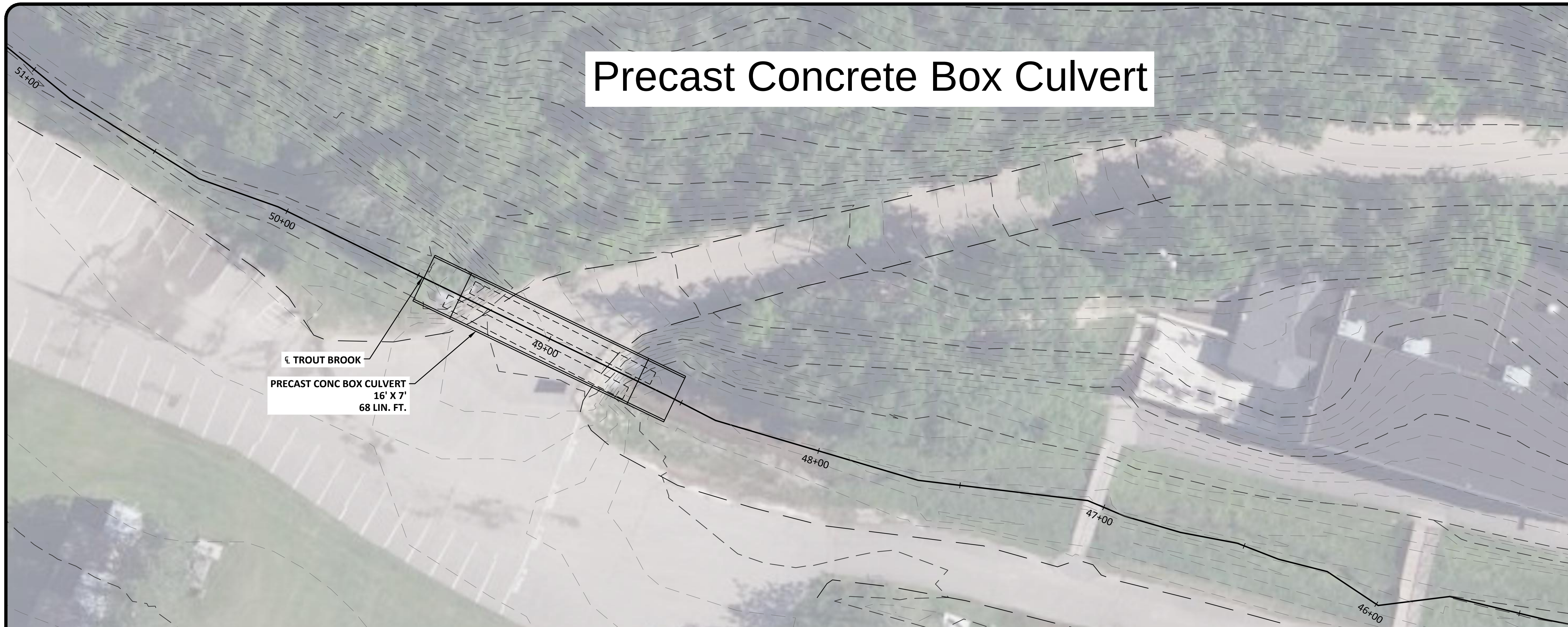
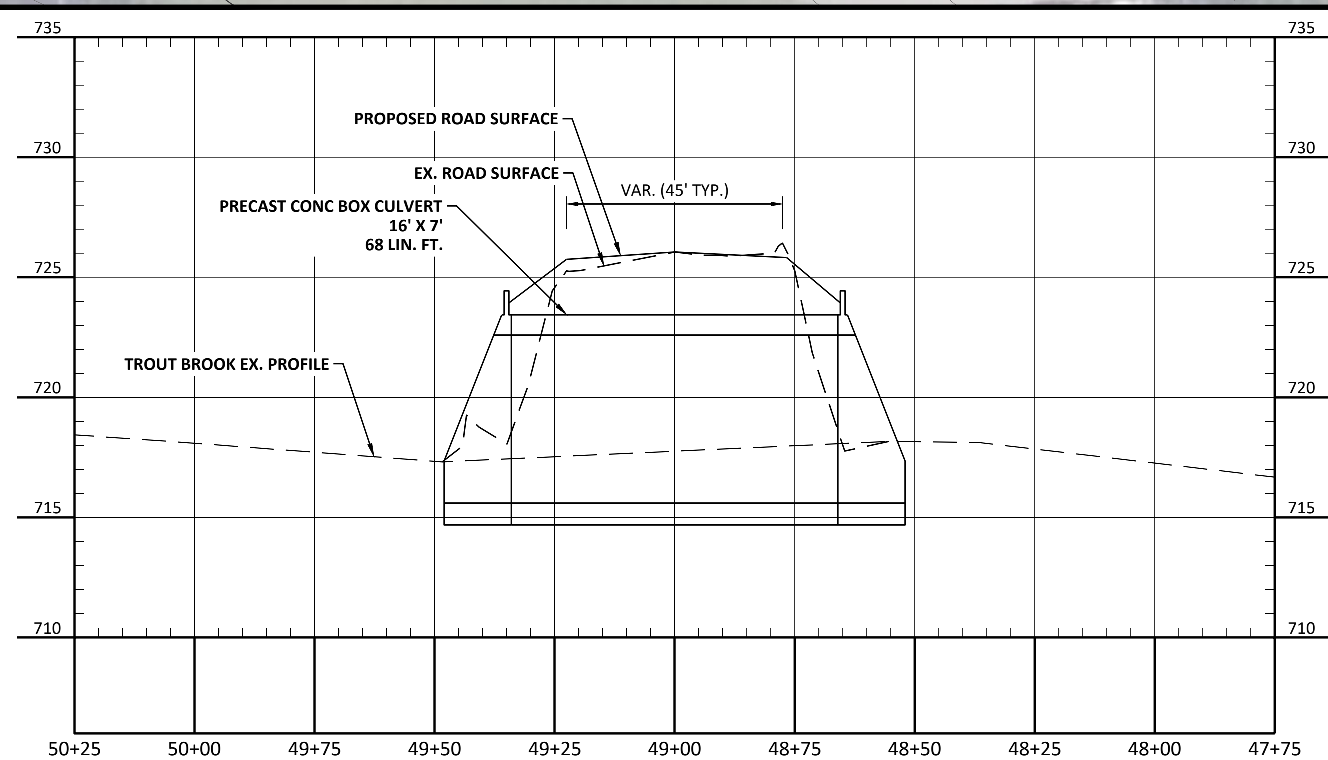
Precast Concrete Box Culvert





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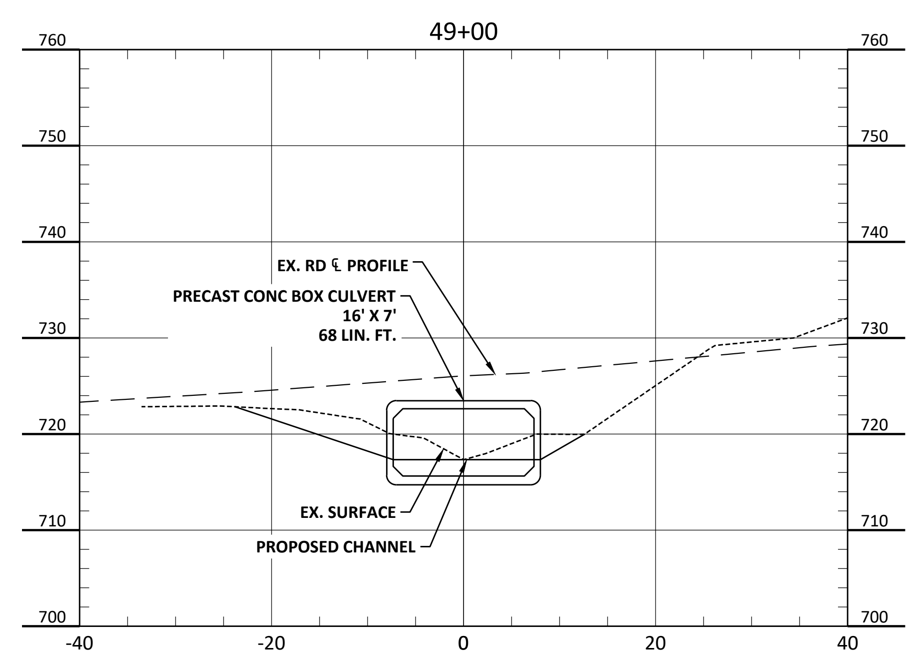

CHANNEL SECTION

PRELIMINARY
NOT FOR CONSTRUCTION

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No.	Revision	Date	By

HOUSTON engineering, inc.

Drawn by	Date
DJK	1-3-2022
Checked by	Scale
WJK	AS SHOWN

TROUT BROOK RESTORATION PHASE 3
SOUTH WASHINGTON WATERSHED DISTRICT
AFTON, MN

PRECAST CONCRETE
BOX CULVERT
16' X 7'

SHEET
1

APPENDIX E – PRELIMINARY OPINION OF PROBABLE

TROUT BROOK PHASE III - 60% DESIGN - 5-6-2022
SOUTH WASHINGTON WATERSHED DISTRICT

				Afton Park (Reach 1)		Afton Alps (Reach 2 and 3)		Culvert		Upstream Floodplain Bench (Reach 4)		Total	
No.	Item	Unit	Unit Price	Quantity	Extension	Quantity	Extension	Quantity	Extension	Quantity	Extension	Quantity	Extension
1	Mobilization	LS	$ 50,000.00	0.4	$ 20,000.00	0.15	$ 7,500.00	0.3	$ 15,000.00	0.15	$ 7,500.00	1	$ 50,000.00
2	Repairs to Trails and Access Paths	LS	$ 10,000.00	0.4	$ 4,000.00		$ -		$ -	0.6	$ 6,000.00	1	$ 10,000.00
3	Clearing, Grubbing, and Brush Removal	Acre	$ 10,000.00	1.64	$ 16,400.00	0.14	$ 1,400.00	-	$ -	0.61	$ 6,100.00	2.39	$ 23,900.00
4	Salvage rootwads	Each	$ 200.00	31.00	$ 6,200.00	29.00	$ 5,800.00	-	$ -	28.00	$ 5,600.00	88.00	$ 17,600.00
5	Remove and Dispose of CMP culvert	LF	$ 15.00		$ -		$ -	138	$ 2,070.00		$ -	138.00	$ 2,070.00
6	Saw Cut	LF	$ 2.00		$ -		$ -	217	$ 434.00		$ -	217.00	$ 434.00
7	Remove and Dispose of Bituminous	SY	$ 3.50		$ -		$ -	386	$ 1,351.00		$ -	386.00	$ 1,351.00
8	Remove and Dispose of grouted riprap and retaining wall	LS	$ 5,000.00		$ -		$ -	1	$ 5,000.00		$ -	1.00	$ 5,000.00
9	Salvage and Reinstall Aggregate Base Class 5	CY	$ 15.00		$ -		$ -	86	$ 1,286.67		$ -	85.78	$ 1,286.67
10	Control of Water	LS	$ 30,000.00	0.2	$ 6,000.00	0.3	$ 9,000.00	0.3	$ 9,000.00	0.2	$ 6,000.00	1.00	$ 30,000.00
11	Haul to Disposal Area (CV)	CY	$ 4.00	4,905	$ 19,620.00	475	$ 1,900.00		$ -	1,465	$ 5,860.00	6845.00	$ 27,380.00
12	Common Embankment (CV)	CY	$ 6.00	685	$ 4,110.00		$ -	554	$ 3,324.00		$ -	1239.00	$ 7,434.00
13	Common Excavation (CV)	CY	$ 7.00	5,590	$ 39,130.00	475	$ 3,325.00	-	$ -	1,465	$ 10,255.00	7530.00	$ 52,710.00
14	Topsoil stripping, stockpiling, and respread	CY	$ 24.00	2,267	$ 54,408.00	113	$ 2,712.00	-	$ -	492	$ 11,808.00	2872.00	$ 68,928.00
37	Common Topsoil Borrow	CY			$ -		$ -	-	$ -		$ -	0.00	$ -
15	AGGREGATE BASE CLASS 5	TON	$ 25.00		$ -		$ -	155	$ 3,875.00		$ -	155.00	$ 3,875.00
16	TYPE SP 12.5 WEARING COURSE MIXTURE (2,C)	TON	$ 200.00		$ -		$ -	90	$ 18,000.00		$ -	90.00	$ 18,000.00
17	16X7 PRECAST CONCRETE BOX CULVERT END SECTION	EACH	$ 24,000.00		$ -		$ -	2	$ 48,000.00		$ -	2.00	$ 48,000.00
18	16X7 PRECAST CONCRETE BOX CULVERT	LIN. FT.	$ 2,200.00		$ -		$ -	68	$ 149,600.00		$ -	68.00	$ 149,600.00
19	STRUCTURE EXCAVATION, CLASS U (P)	CU. YD.	$ 22.00		$ -		$ -	1,252	$ 27,544.00		$ -	1252.00	$ 27,544.00
20	COURSE AGGREGATE BEDDING (CV) (P)	CU. YD.	$ 80.00		$ -		$ -	81	$ 6,480.00		$ -	81.00	$ 6,480.00
21	Large wood (Woody Riffle, 15-foot minimum), install only	Each	$ 1,200.00		$ -	4.00	$ 4,800.00		$ -		$ -	4.00	$ 4,800.00
22	Large wood (Step Log Structure, 24-foot minimum), install only	Each	$ 500.00		$ -	12.00	$ 6,000.00		$ -		$ -	12.00	$ 6,000.00
23	Large wood (Rotwad, 10-foot minimum), install only	Each	$ 500.00	31.00	$ 15,500.00	29.00	$ 14,500.00	-	$ -	28.00	$ 14,000.00	88.00	$ 44,000.00
24	Boulders (24-36 inches)	Each	$ 120.00	62.00	$ 7,440.00	90.00	$ 10,800.00	-	$ -	56.00	$ 6,720.00	208.00	$ 24,960.00
25	Boulders (30-42 inches)	Each	$ 240.00			4.00	$ 960.00					4.00	$ 960.00
26	GEOTEXTILE FILTER, TYPE 4	SQ. YD.	$ 4.50		$ -		$ -		$ -		$ -	0.00	$ -
27	Rock Bedding	CY	$ 80.00	73	$ 5,840.00	122	$ 9,760.00	59	$ 4,693.33	-	$ -	253.67	$ 20,293.33
28	Chinking Material	CY	$ 75.00	149	$ 11,175.00	253	$ 18,975.00	40	$ 3,000.00	-	$ -	442.00	$ 33,150.00
29	Random Riprap Class II	CY	$ 100.00	222	$ 22,200.00	45	$ 4,500.00	176	$ 17,600.00	-	$ -	443.00	$ 44,300.00
30	Random Riprap Class III	CY	$ 100.00	-	$ -	433	$ 43,300.00		$ -		$ -	433.00	$ 43,300.00
31	Trees	Each	$ 700.00	35	$ 24,500.00		$ -		$ -	19	$ 13,300.00	54.00	$ 37,800.00
32	Planting - shrub	Each	$ 95.00	666	$ 63,270.00		$ -		$ -		$ -	666.00	$ 63,270.00
33	Rock Construction Entrance	Each	$ 1,500.00	2.00	$ 3,000.00		$ -		$ -		$ -	2.00	$ 3,000.00
34	Ditch check	Each	$ 1,000.00	2.00	$ 2,000.00	1.00	$ 1,000.00		$ -		$ -	3.00	$ 3,000.00
35	Machine sliced silt fence	LF	$ 4.00	1,190	$ 4,760.00		$ -		$ -	296	$ 1,184.00	1486.00	$ 5,944.00
36	Bioroll	LF	$ 4.00	410	$ 1,640.00		$ -		$ -	296	$ 1,184.00	706.00	$ 2,824.00
38	Erosion control blanket, category 3N	SY	$ 3.00		$ -		$ -	98	$ 294.00		$ -	98.00	$ 294.00
39	Hydraulic Matrix, Fiber Bonded Hydro-mulch	SY	$ 2.00	5,726	$ 11,451.44	678	$ 1,355.20	-	$ -	3,098	$ 6,195.20	9500.92	$ 19,001.84
40	Seeding and Mulching "Cover Crop Seed Mix"	Acre	$ 550.00	2.35	$ 1,294.15	0.14	$ 77.00	-	$ -	0.64	$ 352.00	3.13	$ 1,723.15
41	Seeding and Mulching "Riparian Seed Mix"	Acre	$ 1,500.00	0.39	$ 585.00	0.14	$ 210.00	-	$ -	0.12	$ 180.00	0.65	$ 975.00
42	Seeding and Mulching "Mesic Prairie Seed Mix"	Acre	$ 1,500.00	0.79	$ 1,189.50		$ -	-	$ -	-	$ -	0.79	$ 1,189.50
43	Seeding and Mulching "Dry Prairie General"	Acre	$ 1,501.00	1.17	$ 1,756.17		$ -		$ -		$ -	1.17	$ 1,756.17
44	Seeding and Mulching "Woodland Seed Mix"	Acre	$ 1,500.00	-	$ -	-	$ -	-	$ -	0.52	$ 780.00	0.52	$ 780.00
PROJECT CONSTRUCTION COSTS					**$ 347,469.26**		**$ 147,874.20**		**$ 316,552.00**		**$ 103,018.20**		**$ 914,913.66**
	Contingency (~15%)				$ 52,130.74		$ 22,225.80		$ 47,548.00		$ 15,481.80		$ 137,286.34
TOTAL PROJECT CONSTRUCTION COSTS with Contingency (~15%)					**$ 399,600.00**		**$ 170,100.00**		**$ 364,100.00**		**$ 118,500.00**		**$ 1,052,200.00**
	Engineering and Construction Management				$ 158,500.00		$ 70,000.00		$ 65,000.00		$ 44,000.00		$ 337,500.00
	Legal and Administrative Costs (5%)				$ 17,400.00		$ 7,400.00		$ 15,800.00		$ 5,200.00		$ 45,800.00
TOTAL PROJECT COSTS					**$ 575,500.00**		**$ 247,500.00**		**$ 444,900.00**		**$ 167,700.00**		**$ 1,435,500.00**