Geomorphic Report and Embankment Removal Recommendations for Jolicoeur Creek

Prepared for the Fond du Lac Band of Lake Superior Chippewa Environmental Program, Bailey Richards and Nancy Schuldt

Final Report for Star Grant Project Number 20-306-08J

Photo 1: Upstream Impoundment Looking North

Written by: Rebecca Eiden, River System Strategies and Keith Anderson, Beaver River Consulting

Federal funds under award NA20NOS4190088 from the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce provided to the Minnesota Department of Natural Resources (DNR) for Minnesota's Lake Superior Coastal Program.

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Introduction and Background

Jolicoeur Creek is a cold-water tributary to Otter Creek, a Minnesota-designated trout stream. Currently, two impoundments, created by what is thought to be historical logging operations, have flooded the area and have resulted in the warming of the water, which impacts brook trout. The Fond du Lac (FDL) Office of Water Protection has created a habitat disturbance index for its streams, and Jolicoeur Creek has the lowest score of any stream in the Reservation.

This study aims to set the stage for removing the embankments and restoring a natural channel through the area. The study and report are funded through the MN DNR Coastal Program Star Grant. The final project will remove the embankments and associated impoundments and restore the channel and riparian vegetation in Jolicouer Creek from Wheaton Road and downstream of the impoundments. Project partners include Fond Du Lac Band, Carlton County, and the City of Cloquet. Figure 1 illustrates the approximate project area and parcel boundaries.

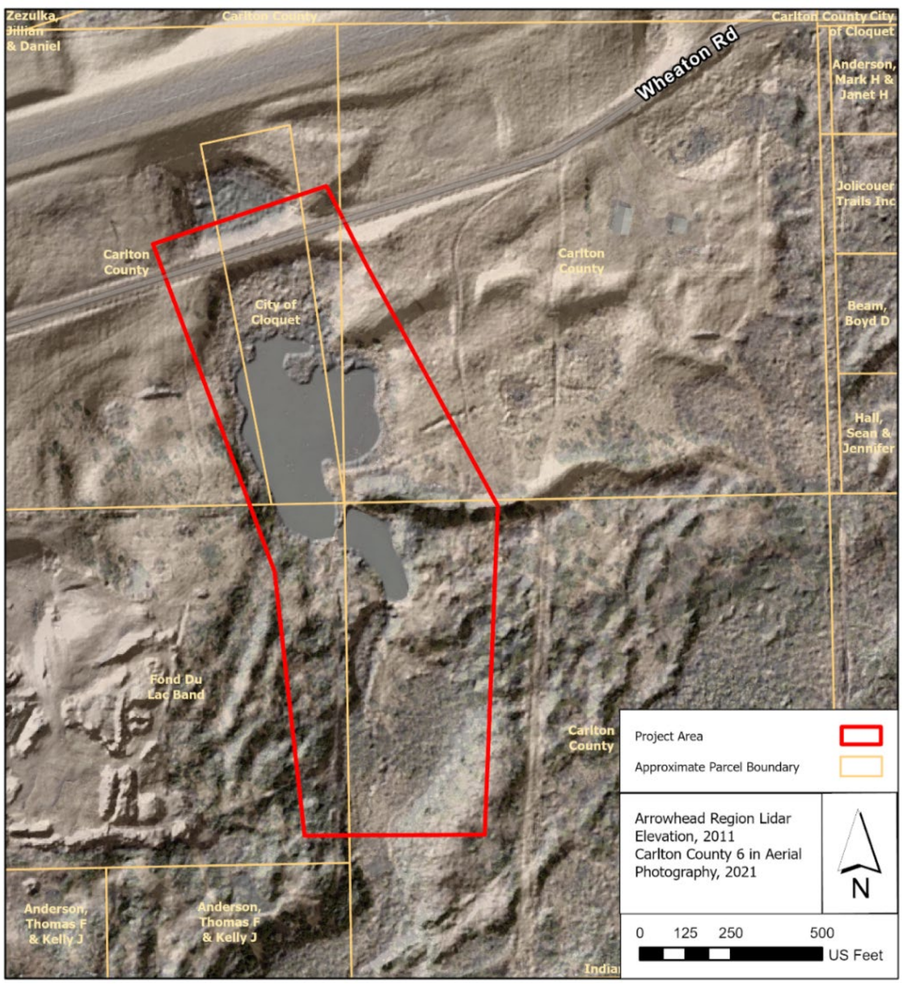

Figure 1: Project Area with Parcel Ownership

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Project Goals

The following goals are based on the Fond du Lac Tribe's goals and the Five Watershed Components framework developed by the International Instream Flow Council and supported by the MN DNR watershed health assessment protocol.

- Water Quality: Decrease water temperatures warmed by the impoundments and create cold water refugia for brook trout.
- Connectivity: Improve habitat connectivity within and between Jolicouer Creek and Otter Creek by removal of the embankments and reestablishing a stream system
- Geomorphology: Restore a stable channel emphasizing reconnecting streams to groundwater and floodplains.
- Biology: Improve trout habitat by restoring the stream and riparian areas by removing embankment areas.

Other Factors

Tribal Importance: Brook trout are an important cultural and food resource for Fond du Lac Band members. Restoring Jolicouer Creek will allow for increased trout harvest opportunities for Band members.

Community Outreach: Research, monitoring, and assessment of the project site can be conducted to compare pre-and post-restoration monitoring data to create opportunities for education and outreach through water quality, habitat quality, and biological monitoring programs. Project signage could be considered to inform the local community of the project and its importance to the area of brook trout and stream resources.

Watershed Description

The 0.47 square mile watershed of Jolicouer Creek extends north beyond Wheaton Drive to Prospect Ave W, encompassing Third Lake. The 1939 historical photo shows that Wheaton Road's alignment was further north of the project site, and the riparian corridor was forested (Figure 2). The current land use within the watershed includes managed grasses, mixed forests, gravel mining, impervious surfaces from the airstrip, roads, and housing development (Figure 3).

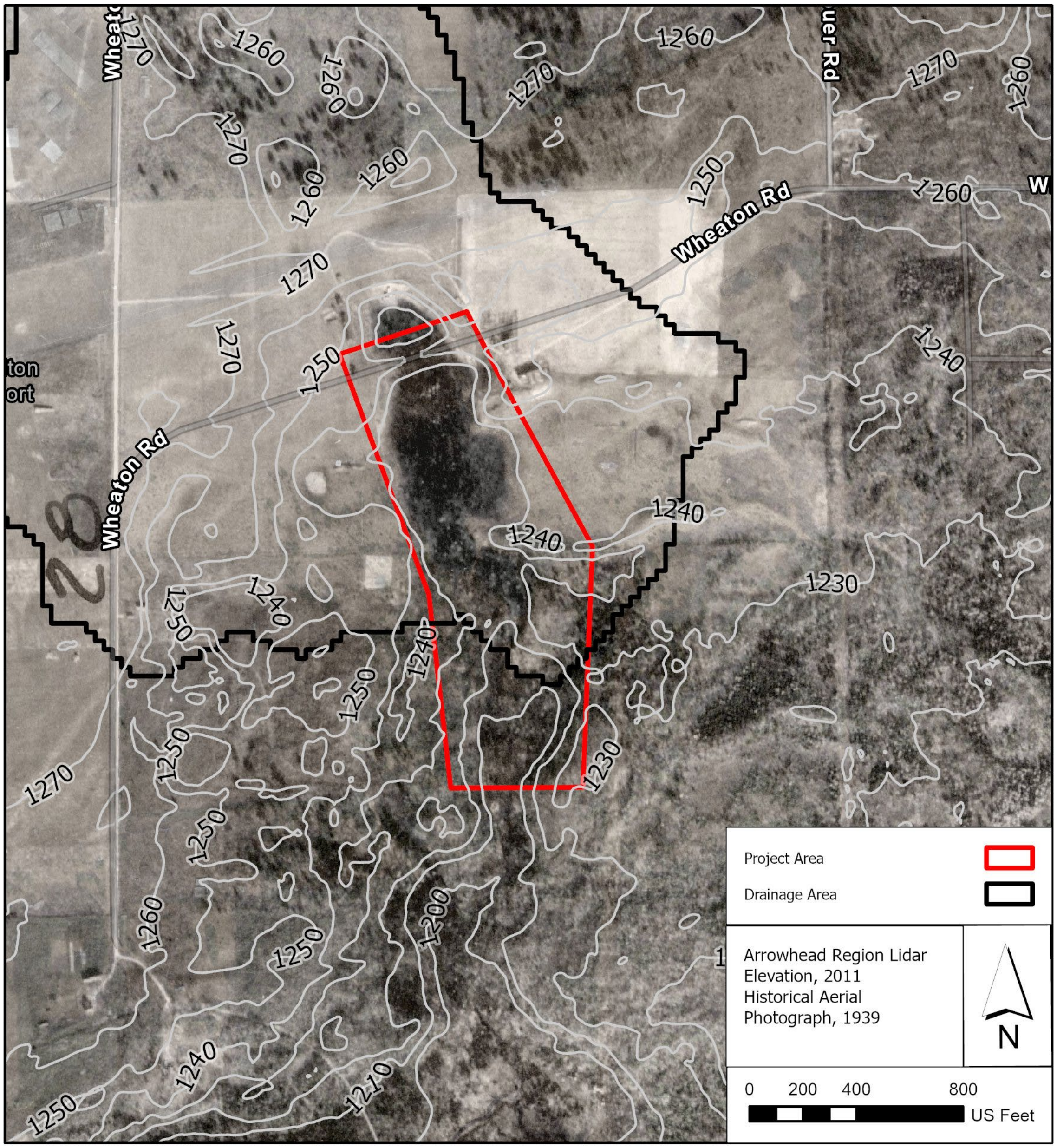

Figure 2: Historical 1939 Aerial Photograph

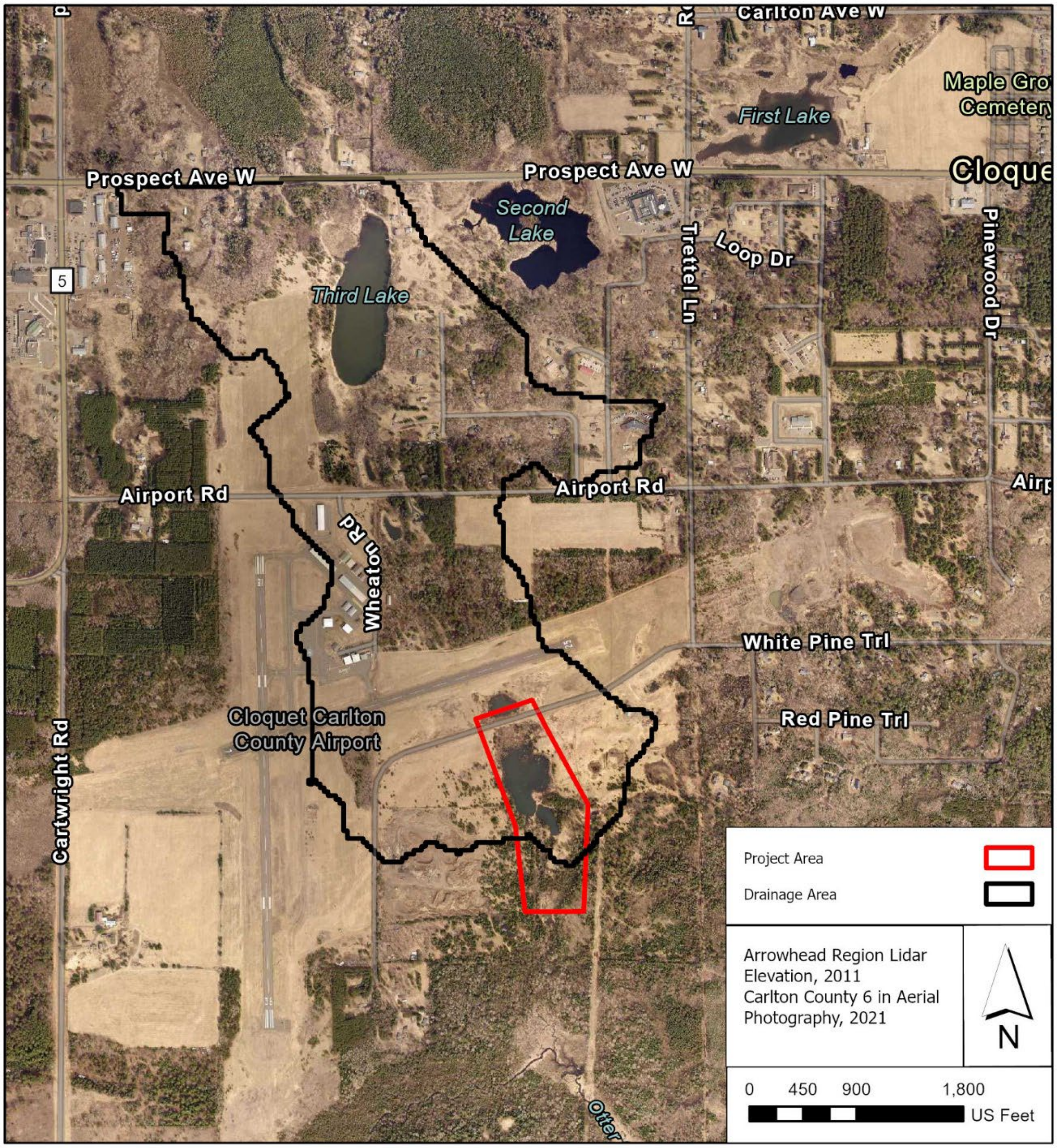

Figure 3: Drainage Area

Geology

The Minnesota Geological Society County Atlas Series, Atlas C-19 Part A, identifies this area as the Barnum Outwash Formation. The project site is on the edge of an ice-margin moraine consisting of fine- to coarse-grained sand and gravel deposited by streams carrying meltwater from the ice. This moraine is formed by sediment deposition in a subaqueous environment around the edge of the active glacier. Geologic Map Series 3 identifies this area as the Cloquet Moraine. The Cloquet Moraine is a strip of irregular topography trending southwest from Cloquet. This feature is a pitted ice-contact slope that leads to the frontal outwash plain, expressed as kames, eskers, and kettle lakes (Figure 4).

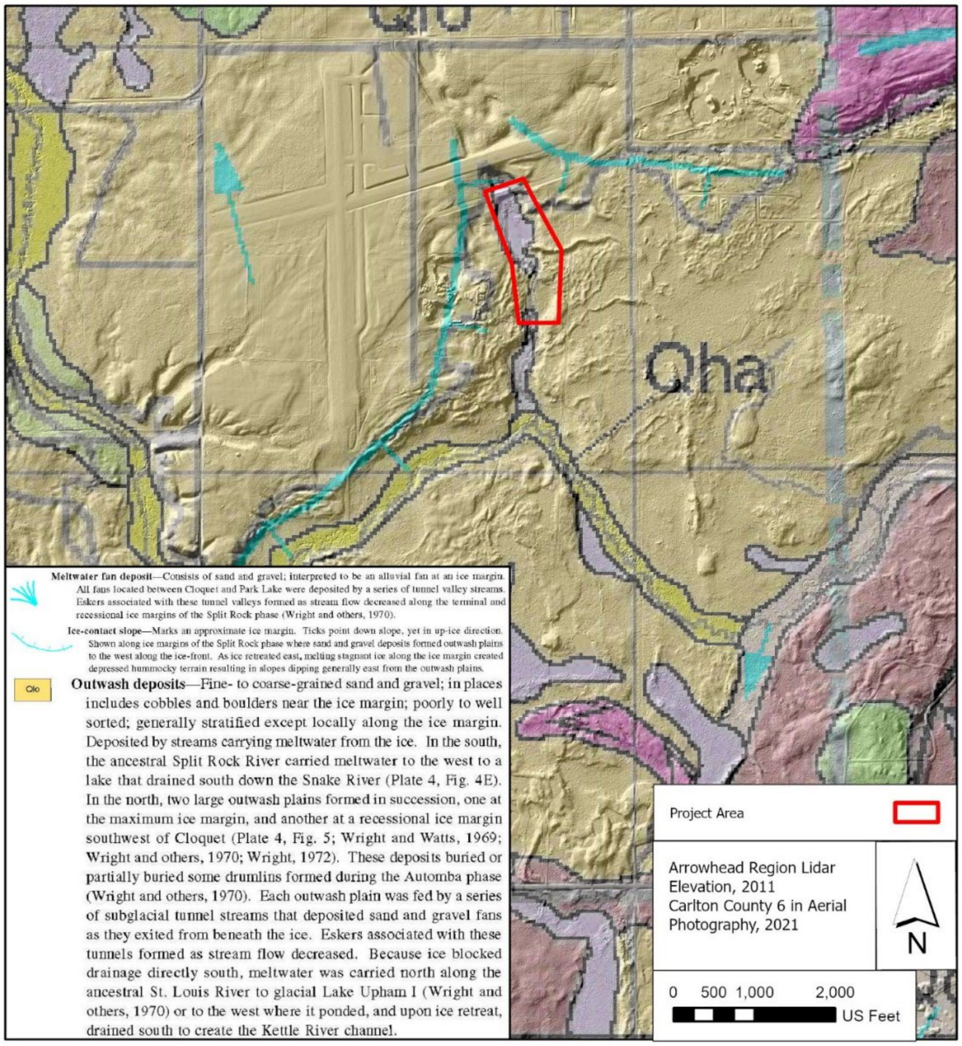

Figure 4: Regional Surficial Geology – Adapted from the Atlas C-19 Part A

Groundwater

The Minnesota Well Index shows an observation well approximately 20 feet east of the project location installed in 1992. The well log notes that the surface water is at an approximate elevation of 1228 ft asl, approximately four feet above the existing impoundment, and the gradient results in cool groundwater input into Jolicouer Creek. The geologic setting creates a system where cool groundwater feeds the stream year around. The streamflow downstream from the lower embankment had high baseflow during the drought conditions of June 2023, indicating a stream with a high groundwater contribution.

Geomorphic Assessment

A geomorphic assessment was carried out for the project area to provide the baseline data needed for recommendations for a design plan. The geomorphic assessment included a site survey. The survey involved a longitudinal profile and cross-sections of the stream downstream of the lower embankments. This information was then used for recommendations for the final design of the removal of the embankments and restoration of Jolicoeur Creek. The site was surveyed with a Trimble R10 Survey grade GPS along with a Trimble total station where tree cover did not allow for adequate GPS signal.

A preliminary plan and profile sheets have been developed for the project to highlight the slopes and detail around the embankments as presented in Appendix A. This information can be utilized in the final design of the project. The site profile was taken from the far upstream portion of the impoundment downstream from Wheaton Road. The profile information was inserted into Auto CAD Civil 3D and RiverMorph software to analyze slopes and other geomorphic parameters. With these two sets of information, cross-sections and a site profile were analyzed.

Site Profile

Adding the survey data meshed with the lidar data a profile was generated in Auto CAD, as Appendix A shows, for the entire site length. The stream profile through the site is anticipated to be relatively uniform, but this is not known since no bathymetric survey was conducted. The valley naturally constricts near the embankment areas, and the channel may have naturally been a steeper B-type channel. However, for this analysis, it is assumed that the overall valley slope through the site is around 0.95-1.6 % slope, as shown in the figure. This slope indicates a typical C-type meandering channel observed downstream from the project site. The profile also displays the water surface elevations at the time of the survey and the drop of approximately 1.8 feet through the first embankment and 7.5 feet through the second embankment. The elevation head differential is substantial, if this embankment were to be breached the downstream channel may be impacted.

Reference Reach

A reach of the stream downstream from the embankment was located to survey as a reference reach to inform the design recommendations for the stream post-embankment removal. This is a typical process in the Natural Channel Design approach that is not covered in detail in this report but recommended for the final design. The reference profile is shown below in Figure 5. The water surface slope of the reference reach was 1.6 percent, with a noticeable meandered pattern. Currently, the stream in this reach is absent of defined pools of sufficient depth to support good trout habitat. But the slope, cross sections, and pattern can be utilized in the design. The absence of pools may be attributed to the altered hydrology caused by the embankments mitigating the peak flows that would result in deep pool formation. This was also noted due to the very small bankfull areas and distance from the water surface to bankfull flats as measured in the field.

Cross sections were taken at three riffles with the compilated data shown below. This is thought to be on the small side of what the bankfull cross-sectional areas should be but indicates what we may find upstream of the embankments once the impoundments are dewatered. For this analysis, the final design should start the higher cross-sectional area of 4.6 square feet and incorporate them into the design of the channel through the impoundments.

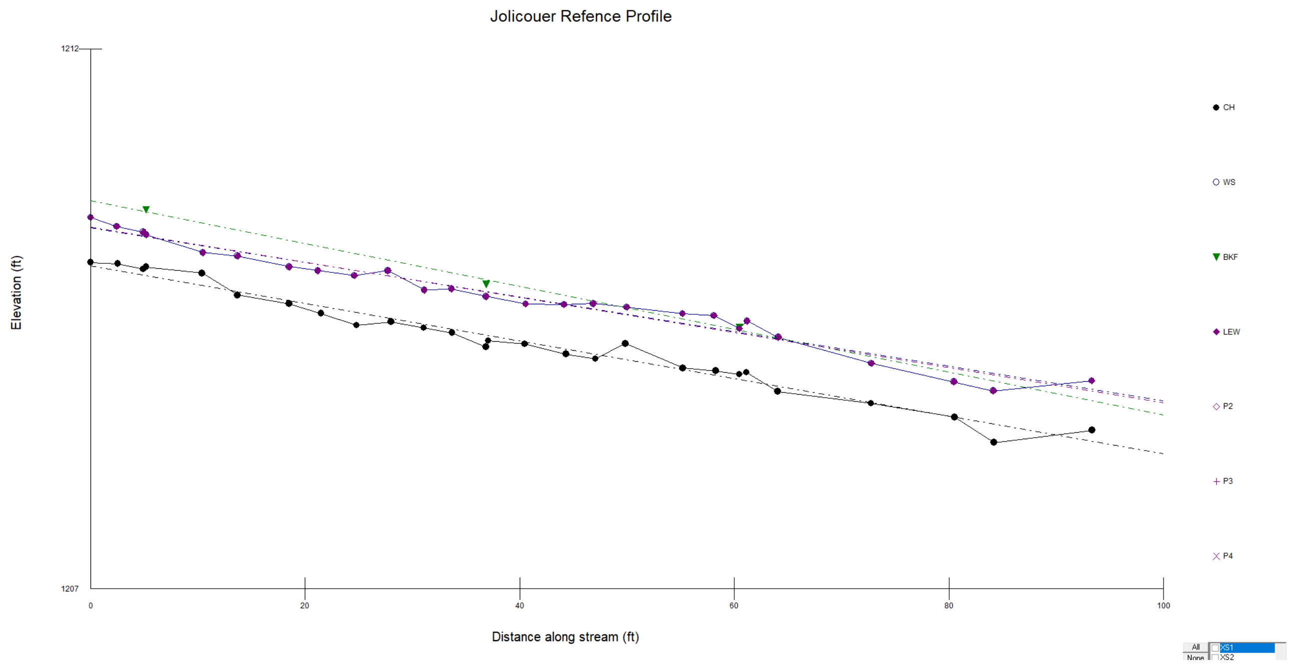

Figure 5, Profile of Reference Located Downstream of Dam SIte

Table 1: Reference Riffle Geomorphic Parameters

Variable	Mean	Min.	Max
Floodprone Width (ft)	30	30	30
Riffle Area (Sq ft)	3.31	2.21	4.63
Max Riffle Depth (ft	0.71	0.53	1.03
Mean Riffle Depth (ft)	0.47	0.35	0.66
Riffle Width (ft)	7.09	6.29	7.97
Riffle W/D Ratio	16.34	10.61	20.44

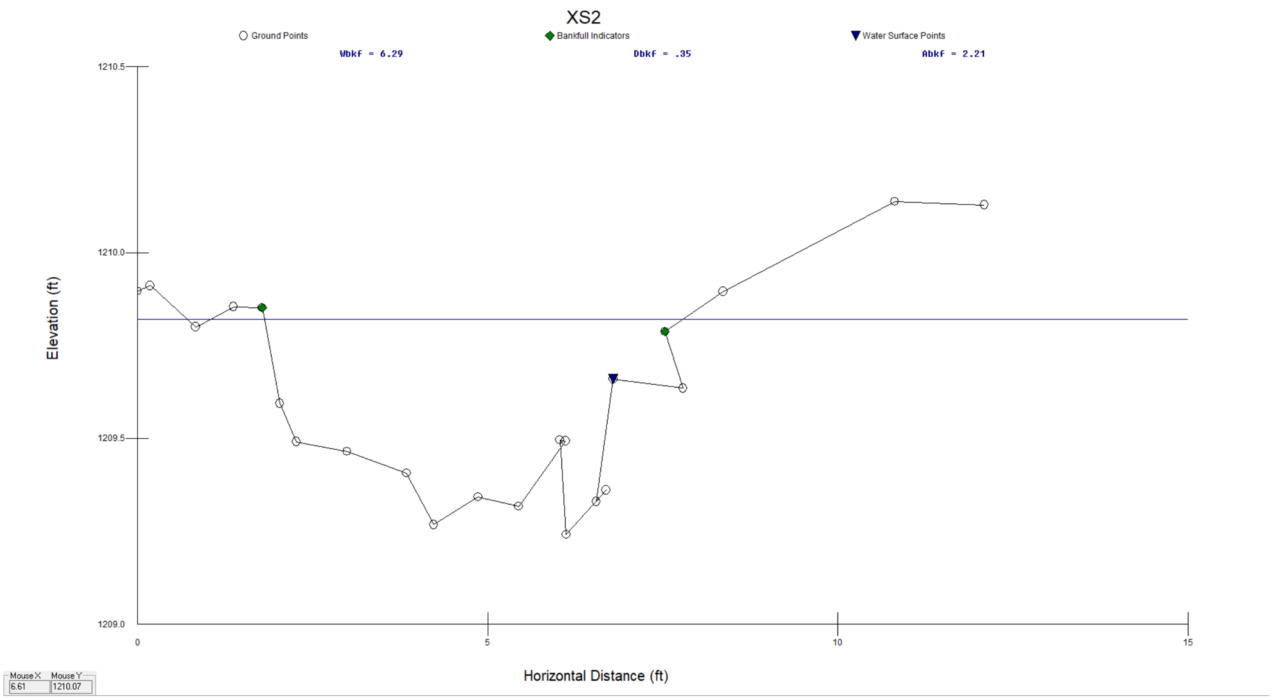

Figure 6: Reference Riffle Cross-section

Riffle Substrate Size

Riffle substrate should be added to the newly created riffles to emulate the pebble count in the reference reach, as shown below. The D50 was approximately 6 mm, and the largest particle size was greater than 90 mm.

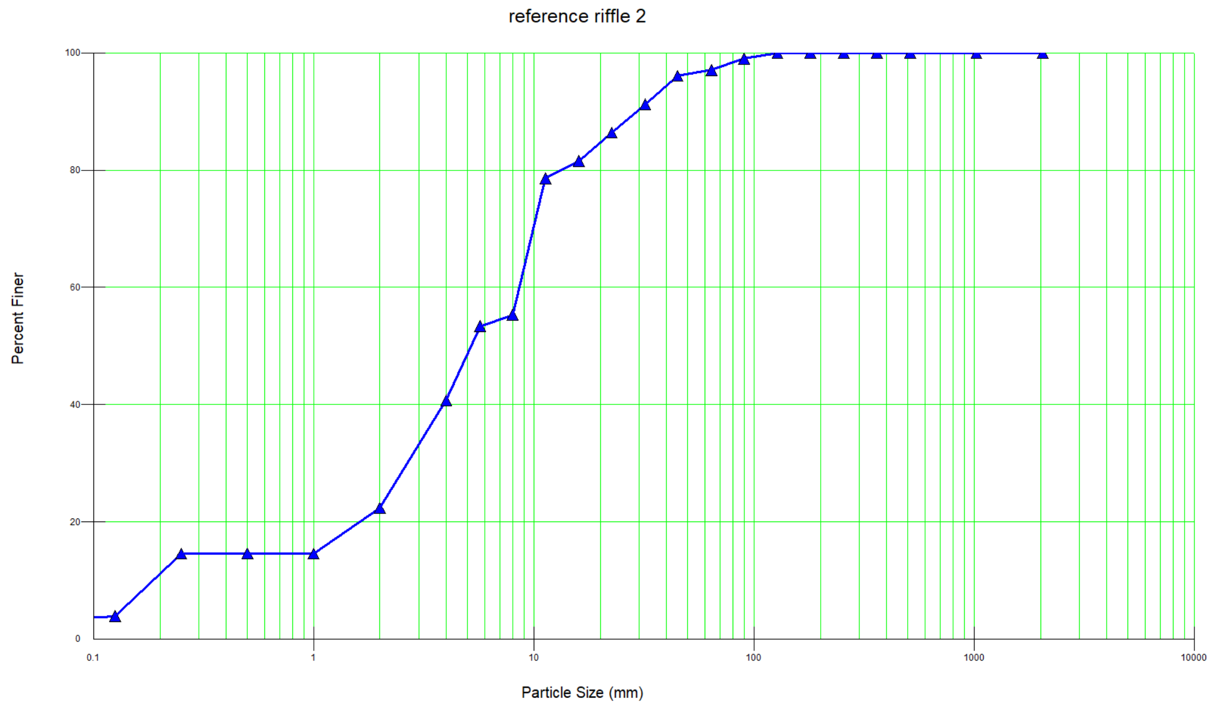

Figure 7: Grain Size Distribution

Embankment Removal and Design Recommendations

The Jolicouer Creek embankment removal will ultimately result in a stream system capable of producing cold water conditions conducive to a brook trout stream. Like any dam (embankment) removal, the actual design and technical details will detail the final design of the restoration. The project should commence in the following manner.

1. Preparation of plans and specifications for use in bidding on the project to a contractor utilizing natural channel design techniques
2. Review and application of required permits
3. Bidding project with final plans and specifications
4. Planned Dewatering of basins
5. Removal of earthen embankments and existing piping infrastructure.
6. Observation of historic stream channel
7. Planting of native trees, shrubs, forbs, and grasses to support the establishment of a native vegetative community.
8. Prepare an adaptive management plan to assist with establishing a stream channel if one is not present post-dam removal.
9. Management of invasive species
10. Monitoring of aquatic biology and water quality if funding allows.

Recommendations on Final Design

The final design is recommended to focus first on dewatering the basins so that the downstream channel is not negatively impacted. This can be done by establishing a siphon-type system or pumping the basins with a flow rate less than bankfull, predicted to be 9.6 cfs as calculated at a reference riffle using Manning's equation. Both basins are thought to be dewatered simultaneously to not place a risk on the upstream embankment if the downstream dam were dewatered before the upstream basin.

Once the basins are dewatered, the embankment embankments can be removed without the risk of sending large amounts of water downstream. This can be accomplished with an excavator with a soil disposal site that could be located nearby. The design would include creating a channel with an initial cross-sectional area of 4.5 square feet at the riffle (recommend the higher 4.5 due to the embankment effects on the reference as previously discussed). Not knowing exactly what will be encountered under the impoundments, it could be assumed to reestablish a channel through the embankments and between them for a valley distance of around 300 feet. An assumed sinuosity of 1.2 would create 360 feet of the new channel. Upstream for the inundated areas flooded by the embankments, allowing the stream channel to restore itself passively is recommended. Due to the location high in the watershed, it is not anticipated that the impoundments will have a large sediment deposition above the embankments. Once the embankments are removed, the upstream channel conditions can be assessed, but it is recommended that the channel will find its path over a period of years. If this is not feasible, the stream channel can be restored through this area.

After removing the impoundments and restoring the stream through those areas, a further recommendation for geomorphic data is recommended. Passive restoration (wait and see approach) is recommended to occur upstream of the embankments that reference cross sections, and a profile of the newly opened stream is performed. This data can be used to monitor the site for movement of the channel. This information can then be used to develop an adaptive management plan for the channel currently inundated. This will inform the project team whether additional work should be performed post-project.

Vegetative Restoration Recommendations

It is observed that the floodplain was previously forested with a floodplain forest community. There are standing dead ash trees on the upper impoundment. With emerald ash boring in the area, alternative tree species such as black ash, alder, willow, and cedar should be considered along with the seeding of native grasses and forbs. It is also recommended that considerations are made to monitor the site for invasive species, such as reed canary grass that will ultimately move into and colonize the newly created floodplain.

References

Boerboom, Terrence J.. (2009). C-19 Geologic atlas of Carlton County, Minnesota [Part A]. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/58760.

Minnesota DNR Observation Well 09004 (1994). Retrieved from the Minnesota Department of Health, https://mnwellindex.web.health.state.mn.us/mwi/index.xhtml?wellId=0000243645

Wright, H.E. Jr; Mattson, L.A.; Thomas, J.A.. (1970). Geologic Map Series 3. Geology of the Cloquet Quadrangle Carlton County, Minnesota. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/57305.

Appendix A, Plan Profile Sheets of Project Area

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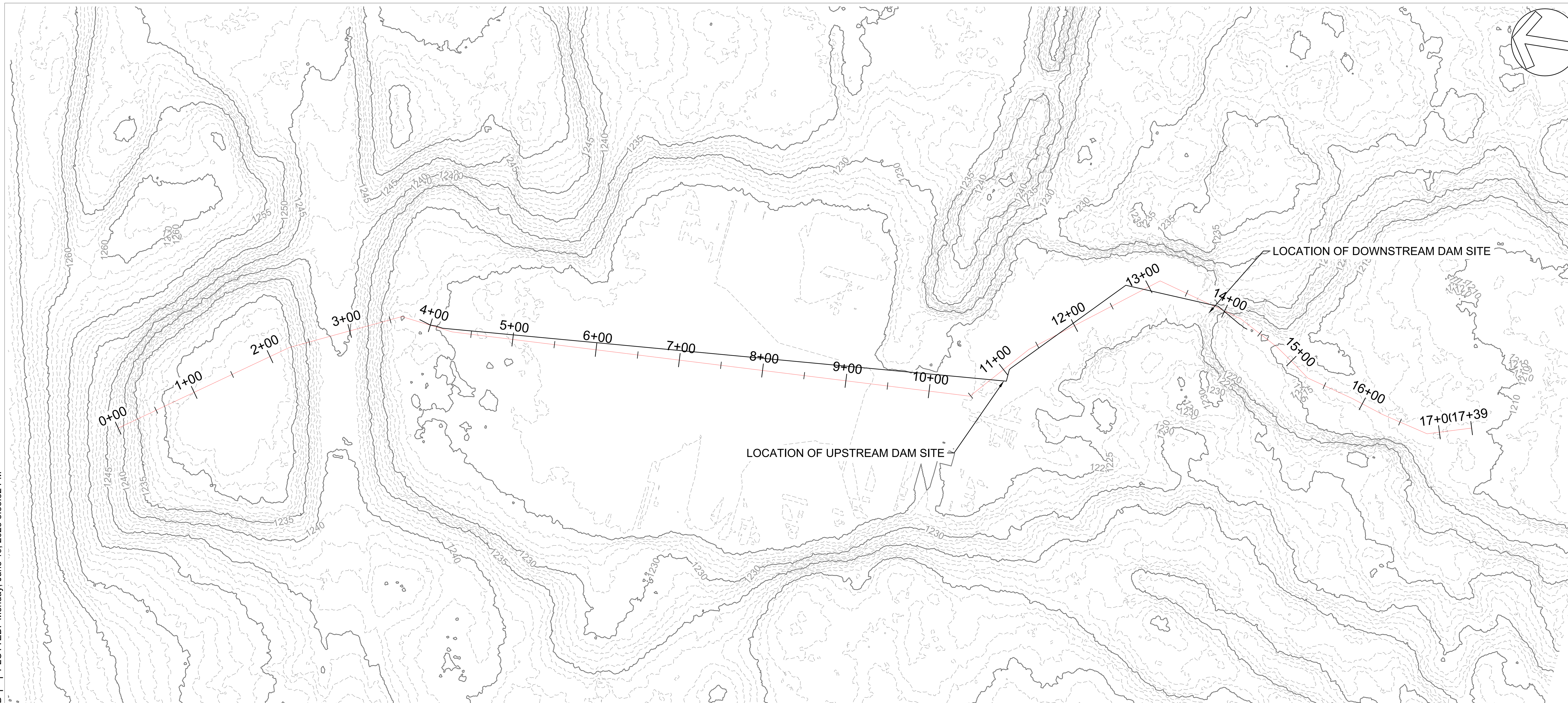
River System Strategies

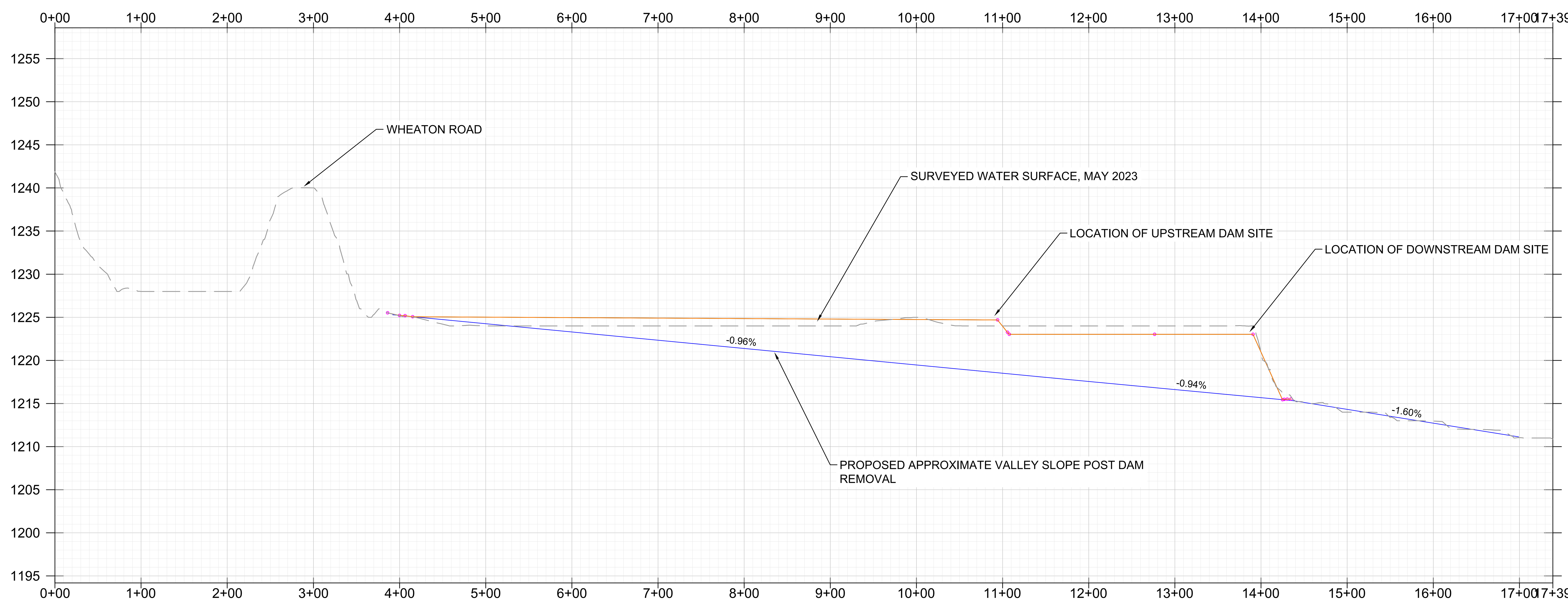


PLAN LEGEND

PROPOSED STREAM CENTER LINE
PROPOSED BANKFULL
(483) PROPOSED MAJOR CONTOUR
PROPOSED MINOR CONTOUR
479 EXISTING MAJOR CONTOUR
EXISTING MINOR CONTOUR

PROFILE LEGEND

PROPOSED STREAM CENTER LINE
PROPOSED BANKFULL
EXISTING GROUND



site Profile - SCALE: HOR 1" =30'; VERT 1"= 3'

NOT TO SCALE

DRAWN BY: XXX	CHECKED BY: XX	APPROVED BY: XX

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-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

JOLICOUER CREEK DAM REMOVAL RECOMENDATIONS
FOND DU LAC RESERVATION
CARLTON COUNTY, MN

CONCEPT DESIGN-NOT FOR CONSTRUCTION

Value

BEAVER RIVER CONSULTING

BEAVER RIVER CONSULTING
5752 EAGLE VIEW DRIVE
DULUTH, MN 55803

DATE: 06/19/23
SCALE (34"X22"): 1" = 80'
SCALE (17"X11"): 1" = 160'

0 80 160
SCALE IN FEET

SHEET NUMBER
1 OF XX

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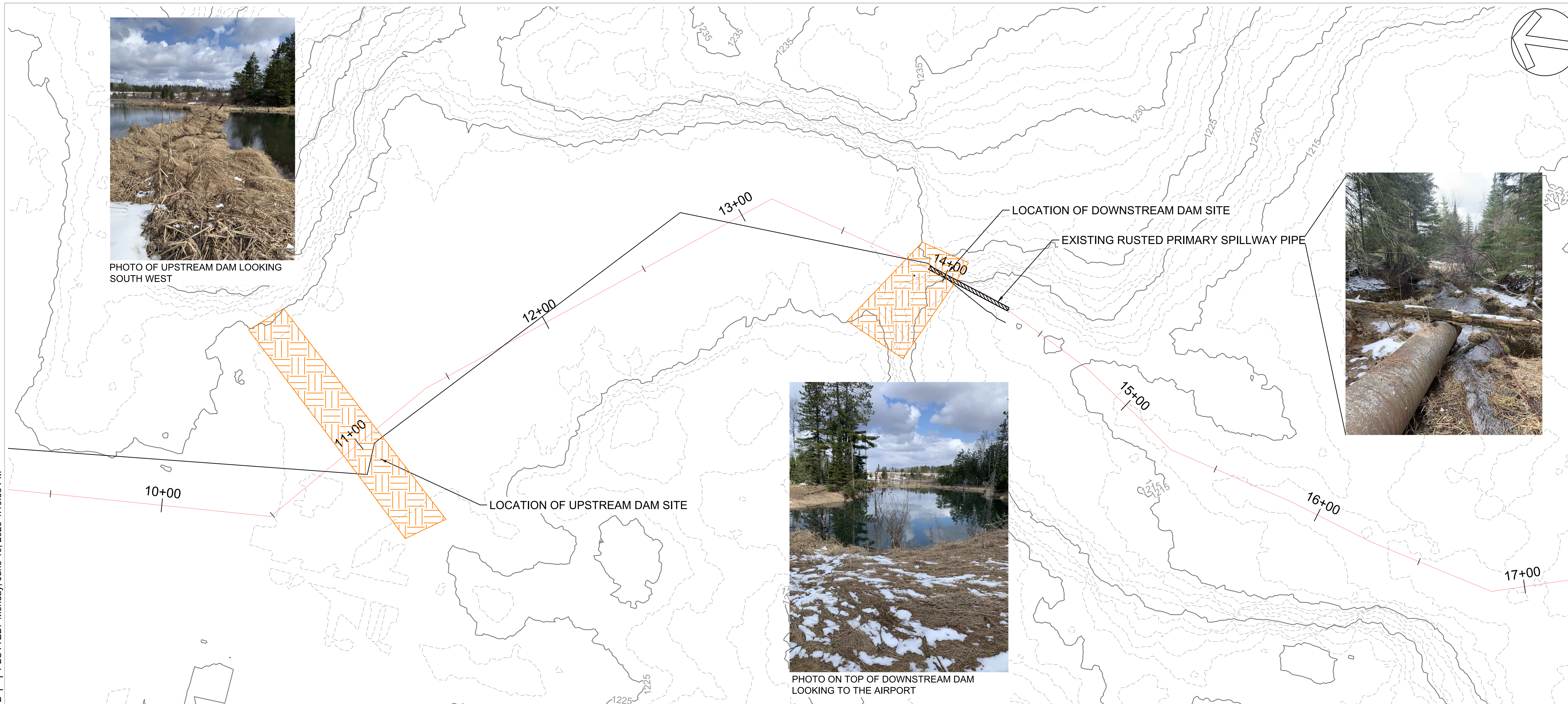
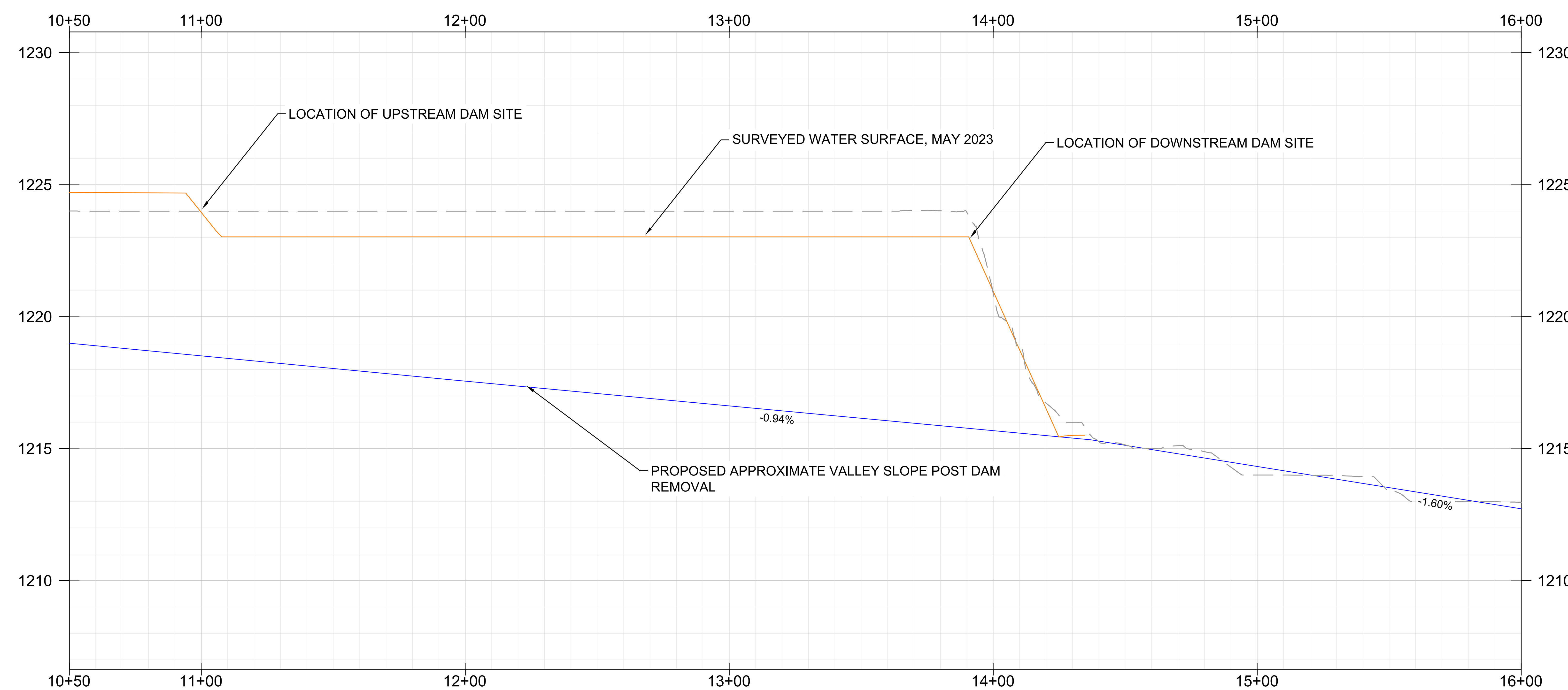


PLAN LEGEND

PROPOSED STREAM CENTER LINE
PROPOSED BANKFULL
(483) PROPOSED MAJOR CONTOUR
PROPOSED MINOR CONTOUR
479 EXISTING MAJOR CONTOUR
EXISTING MINOR CONTOUR

PROFILE LEGEND

PROPOSED STREAM CENTER LINE
PROPOSED BANKFULL
EXISTING GROUND



site Profile - SCALE: HOR 1" =30'; VERT 1"= 3'

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CHECKED BY: XX
APPROVED BY: XX

JOLICOUER CREEK DAM REMOVAL RECOMENDATIONS FOND DU LAC RESERVATION CARLTON COUNTY, MN

CONCEPT DESIGN-NOT FOR CONSTRUCTION

Value

BEAVER RIVER CONSULTING

BEAVER RIVER CONSULTING
5752 EAGLE VIEW DRIVE
DULUTH, MN 55803

NOT TO SCALE

DATE: 06/19/23
SCALE (34"X22"): 1" = 30'
SCALE (17"X11"): 1" = 60'

0 30 60
SCALE IN FEET

SHEET NUMBER
1 OF XX

Appendix B, Reference Reach Hydraulics

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Jolicouer**	Location:	**Reach - downstream reference**
Date:	Stream Type: **C4**	Valley Type:	**-1**
Observers:		HUC:	

INPUT VARIABLES

Bankfull Riffle Cross-Sectional AREA	3.10	A_{bkf} (ft^2)
Bankfull Riffle WIDTH	7.97	W_{bkf} (ft)
D_{84} at Riffle	19.33	Dia. (mm)
Bankfull SLOPE	0.0160	S_{bkf} (ft / ft)
Gravitational Acceleration	32.2	g (ft / sec^2)
Drainage Area	0.5	DA (mi^2)

OUTPUT VARIABLES

Bankfull Riffle Mean DEPTH	0.39	d_{bkf} (ft)
Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	8.51	W_p (ft)
D_{84} (mm) / 304.8	0.06	D_{84} (ft)
Hydraulic RADIUS A_{bkf} / W_p	0.36	R (ft)
Relative Roughness R(ft) / D_{84} (ft)	5.71	R / D_{84}
Shear Velocity $u^* = (gRS)^{½}$	0.430	u* (ft/sec)

ESTIMATION METHODS

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	3.08	ft / sec	9.56	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2} / n$ n = 0	0.00	ft / sec	0.00	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2} / n$ n = 0.031	3.09	ft / sec	9.58	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$, $n = 0.39*S^{0.38}*R^{-0.16}$ n = 0.095 **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3	1.01	ft / sec	3.12	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	3.30	ft / sec	10.22	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrusion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Appendix C, Site Photos

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NAH-GAH-CHI-WA-NONG
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River
System
Strategies

Photo 2: Embankment Looking East

Photo 3: Outlet of Downstream Embankment

Photo 4: Downstream Impoundment looking North

Photo 5:Looking South