

Rugg Pond Dam Removal Site Assessment and Existing Conditions Report

SUBMITTED TO

Kalkaska County and Conservation Resource Alliance

OCTOBER 2026

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OCTOBER 2026

Executive Summary

Kalkaska County, in partnership with Conservation Resource Alliance (CRA), retained Inter-Fluve and a team of subconsultants to provide geomorphic, ecological, and engineering services to support the removal of Rugg Pond Dam. The dam is located at the confluence of the Rapid River and Little Rapid River in Kalkaska County, Michigan. This report documents the findings of the data collection and reporting phase of the project, including existing data review, topographic and bathymetric survey, geomorphic assessment, sediment analysis, and other supporting investigations. Inter-Fluve also reviewed data collected by others during prior studies on Rugg Pond Dam and its impoundment.

Rugg Pond Dam was built in 1904 and provided power until the 1950s, when ownership was transferred to Kalkaska County. Repairs were made to the spillway structures in the 1980s. The condition of the 22.5-foot-tall dam has deteriorated over time and the impoundment has substantially filled in with sediment. In 2019, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) conducted a dam safety inspection and rated Rugg Pond Dam as having a fair condition overall and a high hazard potential. In 2024, Kalkaska County passed a resolution to pursue dam removal. The goals of the Rugg Pond Dam Removal Project include eliminating deteriorating dam infrastructure, restoring approximately one mile of river channel with reconnected floodplains, managing impounded sediment, and replacing an aged, undersized culvert at the Hanson Road crossing on the Little Rapid River.

The Inter-Fluve team visited the site in May 2026 to conduct survey and assessment work. The dam impoundment extends upstream on the Little Rapid River approximately 500 feet upstream of Hanson Road and on the Rapid River to a location about 100 feet downstream of an old stream crossing on private property (2,450 feet upstream of the dam). A geomorphic assessment was completed in the project area and upstream and downstream reaches. In reaches not influenced by the impoundment, large wood strongly influences stream morphology, maintaining grade control and forcing multiple flow paths. In channelized or dammed reaches, simplified channels exist with homogenous bedform and poor in-stream habitat.

Depth of refusal probing revealed a possible relic channel bed profile through the impoundment with a gradient closely matching the upstream reaches. The estimated volume of impounded sediment, calculated by comparing Inter-Fluve's 2026 bathymetric and depth of refusal survey data, is 214,000 cubic yards. A preliminary investigation of impounded sediments was conducted by Great Lakes Environmental Center, Inc. (GLEC) in 2020. Laboratory testing by GLEC on eleven samples revealed that EGLE screening levels were exceeded for selenium in all samples, along with exceedances of arsenic and polycyclic aromatic hydrocarbons (PAHs) in several samples. Additional sampling and lab analysis will likely be required in future project phases.

Future project phases will include analysis of sediment management alternatives, sediment core collection and analysis, hydraulic modeling, preliminary engineering, and final design for dam removal, river restoration, and replacement of the Hanson Road stream crossing.

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1. Introduction

Kalkaska County, in partnership with Conservation Resource Alliance (CRA), retained Inter-Fluve to provide geomorphic, ecological, and engineering services to support the removal of Rugg Pond Dam. The dam is an aging earthen dam structure that generated electricity in the first half of the 20th century but has been decommissioned since 1953. After evaluating potential alternatives for the dam, the Kalkaska County Board of Commissioners passed a resolution to remove the dam in September 2024. Inter-Fluve's design team includes subconsultants Wightman Associates (Wightman) for structural engineering, Heimlich Consulting for historical and cultural investigations, and Materials Testing Consultants (MTC) for geotechnical investigations and engineering. This report documents the findings of the data collection and reporting phase of the project, including existing data review, topographic and bathymetric survey, geomorphic assessment, sediment analysis, and supporting investigations. Future project phases will include sediment management alternatives evaluation, preliminary design, permitting, and final design.

1.1 PROJECT SETTING

Rugg Pond Dam (NID #MI00518), is located at the confluence of the Rapid and Little Rapid Rivers in Kalkaska County, Michigan, three miles northwest of the Village of Kalkaska. The dam is owned by Kalkaska County and is located within the Rugg Pond Natural Area, a 102-acre County-owned public park (Figure 1). The dam forms a 20-acre impoundment with a listed storage of 160 acre-feet. The dam consists of an earthen embankment approximately 685 feet long and has two spillways that pass flow downstream into separate channels that converge about 300 feet downstream of the dam. The dam has a structural height of 24 feet and maintains a head of approximately 19 feet during typical flows. According to the most recent dam safety report, the dam's height as defined by Part 315 (the difference in elevation from the design flood elevation to the invert of the outlet channel) is 22.5 feet (DeVaun, 2019). At the time of the last dam inspection in 2019, the dam had a high hazard potential and was in fair condition overall (DeVaun, 2019). Rugg Pond Dam is located approximately nine miles upstream of the confluence of the Rapid River and the Torch River, the short waterway that connects Torch Lake with Lake Skegemog and Elk Lake, which are part of the Elk River Chain of Lakes (ERCOL). The Rapid River is listed as a premier trout stream by the Michigan Department of Natural Resources (MDNR).

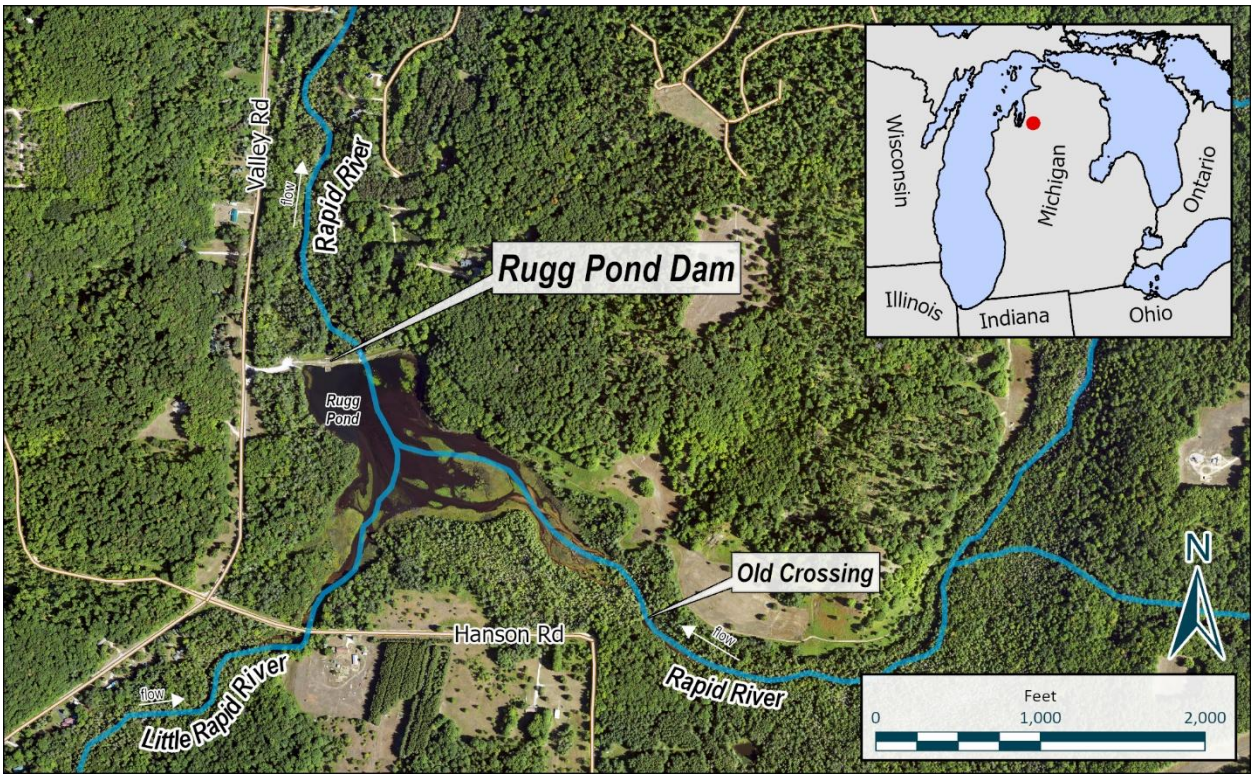


Figure 1. Overview of the project area.

1.2 DAM HISTORY

Ambrose E. Palmer founded the Kalkaska Light and Power Company and built Rugg Pond Dam from 1905 to 1906 to provide power to the Village of Kalkaska and the surrounding area. Figure 2 and Figure 3 show photos taken during dam construction, including pile driving operations and a railroad built to haul materials to the site. In 1950, Consumers Power purchased the Kalkaska Light and Power Company, soon discontinued power generation, then sold the dam and land to Kalkaska County in 1953 for $1 (Kalkaska County, n.d). The United States Army Corps of Engineers (USACE) condemned the dam in 1980. Two years later, citizens formed the Save Rugg Pond Natural Area organization to advocate for maintaining the pond. The dam was repaired and the original powerhouse demolished in 1985 (Gosling Czubak Associates, 1985). Following a dam inspection in 2019 (DeVaun, 2019), safety deficiencies were found that would require expensive repairs and the Rugg Pond Steering Committee was re-established to identify a path forward for the site. Following feasibility evaluations by Spicer Group in September 2024, the Kalkaska County Board of Commissioners passed a resolution to remove the dam.



Figure 2. Pile driving during construction of Rugg Pond Dam. Photo is taken from the west side of the dam (Source: Traverse Area District Library).



Figure 3. Photo of dam construction. View is looking west from the dam's eastern abutment (Source: Traverse Area District Library).

1.3 PROJECT GOALS AND BENEFITS

Kalkaska County and CRA have identified the overall project goal of removing Rugg Pond Dam and restoring affected reaches of the Rapid and Little Rapid Rivers. To reach the overall project goal, project objectives were established. Project objectives include:

- Remove dam infrastructure.
- Replace the Hanson Road stream crossing on the Little Rapid River.
- Restore approximately 1 mile of river channel and floodplain habitat upstream of the dam.
- Manage the impounded sediment that has accumulated behind the dam.
- Establish native vegetation and manage invasive species on site.
- Provide space for recreational opportunities on site following dam removal.

Primary project benefits include reconnecting 21.6 miles of habitat on the Rapid and Little Rapid Rivers with downstream reaches and eliminating dam safety risks and associated ongoing maintenance obligations. Additional benefits include:

- Improving the undersized road/stream crossing at Hanson Road.
- Addressing warm-water inputs and degraded habitat within the dam's impoundment.
- Re-establishing beneficial river processes within the impoundment.
- Enhancing recreational opportunities in the existing County-owned Rugg Pond Natural Area.

2. Watershed Context

2.1 WATERSHED CHARACTERISTICS

The Rapid River is the largest and fastest flowing tributary within the ERCOL watershed, with an overall contributing drainage area of 142.7 mi^2 (Figure 4). The Rapid River flows for 18 miles, originating north of the Village of Kalkaska, and travels through valleys formed by glacial meltwater in the townships of Rapid River, Cold Springs, and Clearwater before emptying into the Torch River between Torch Lake and Skegemog Lake (Kazanski, n.d.; Tip of the Mitt Watershed Council, 2026). The Little Rapid River is the largest tributary of the Rapid River, flowing 4.6 miles. Upstream of Rugg Pond Dam, the contributing watershed areas are 101.4 mi^2 for the Rapid River and 17.8 mi^2 for the Little Rapid River. Both rivers receive consistent groundwater supplying cold, clear water and have a high groundwater to surface water ratio.

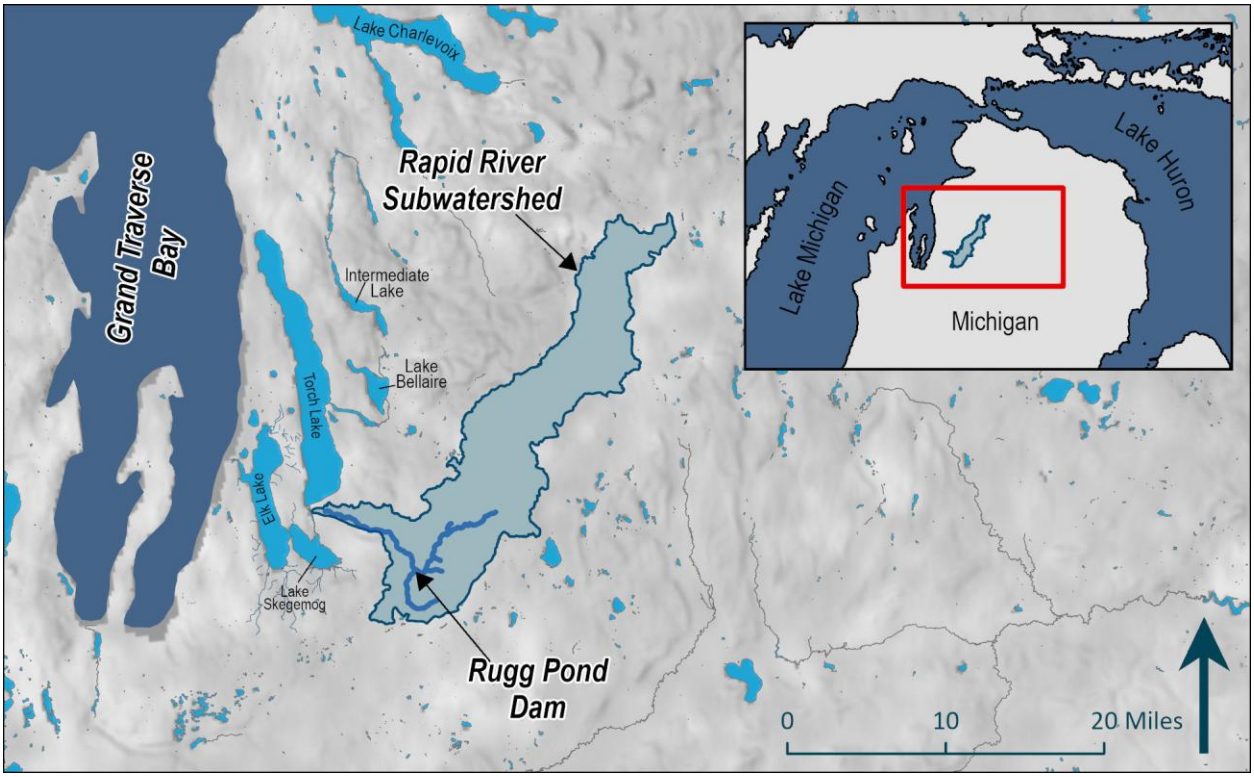


Figure 4. Map of the Rapid River watershed.

The Rapid River watershed is 53% forested, 9% developed land, 21% shrub and grassland, 13% agricultural land, and 3% wetlands (Stroud Water Research Center, 2025). The upper third of the watershed is largely state public land, while the lower portion of the watershed contains natural areas including the Seven Bridges Preserve and Freedom Park (Conservation Resource Alliance, 2025).

2.2 HISTORIC WATERSHED CONDITIONS

Historic conditions detailed in Government Land Office (GLO) surveys from 1839 and 1851 show the Rapid River as a wide, wet valley with "Numerous Islands and much fallen timber in stream"(Figure 5; Lyon & Surveyor General Office, 1851). Natural Features Inventory biologists interpreted the vegetation cover from these maps. Their findings indicate that vegetation communities in the project area were dominated by cedar swamp within the riparian zones and beech-sugar maple-hemlock forest in upland areas (Comer & Albert, 1997). Soils in the vicinity of the project area are dominated by sandy soils and sandy loam (MSU, 1981; Schneide, 1956). The GLO maps suggests that pre-dam conditions correspond with field observations made in 2026 by Inter-Fluve of reaches upstream of the dam's influence where substantial instream large wood creates vegetated islands and complex flow paths.

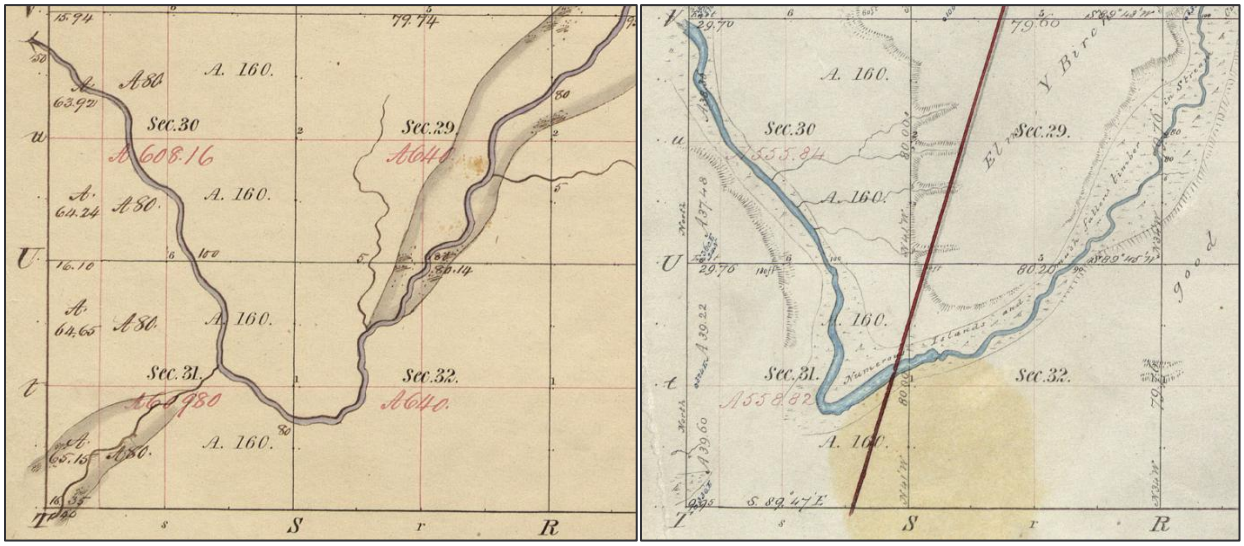


Figure 5. GLO maps from 1839 (original survey; left) and 1851 (resurvey; right) show pre-dam conditions (Source: Bureau of Land Management).

Review of aerial photographs from 1937 and 1954 that indicates substantial logging and land clearing occurred within the Rapid River watershed after dam construction (Figure 6). Forest clearing increases erosion by removing stabilizing root systems along slopes and removing canopies to expose bare ground to rainfall and surface runoff, especially in areas with steep topography. Subsequent re-forestation would have reduced sediment inputs. Logging and clearing activities after dam construction suggest increased sediment inputs to the Rugg Pond Dam impoundment and may explain the relatively large volume of sediment stored within the impoundment given the relatively large percentage of the watershed that is currently forested.



Figure 6. Aerial photo of Rugg Pond from 1954 (Source: USGS).

2.3 GEOLOGIC HISTORY

At Rugg Pond, the bedrock is fine-grained, relatively impermeable shale of the Coldwater Shale formation, aged between 544 and 286 million years (Michigan Dept. of Environment et al., 2025). The bedrock is buried below 400 to 500 feet of coarse-grained glacial deposits (Soller & Garrity, 2018). These deposits of relatively high topographic relief, permeability, and thickness are remnants of the northward retreat of the Lake Michigan Lobe of the Laurentide Ice Sheet at the end of the Wisconsin Glaciation, between 15,000 and 11,000 years ago.

Glacial advance, stagnation, and retreat shaped the topography of the landscape of Michigan's Lower Peninsula by redistributing rock and sediment forming features such as end moraines, glacial outwash and till plains, and drumlins (Clayton & Moran, 1982). Intermittent advances during glacial retreat created a series of parallel moraines that delineate the past glacial extents and define the local watershed boundaries. Moraines form where sediment accumulates during periods of relatively stable ice front positions as the glaciers relocate sediment consistently over extended periods of time. For example, the Crawford Lake Moraine, trending northeast-southwest and located between the present-day cities of Kalkaska and Cotton, represents the southern extent of the glacial lobe approximately 12,500 years ago. As the lobe retreated, the next moraine to form was the Rapid River

Moraine, located between present day Rapid City and Kalkaska. These moraines bound the Rapid River-Boardman Plain, a glacial outwash valley through which the Rapid and Little Rapid Rivers flow (Figure 7).

Ice retreating from the region triggered surface rebound as the weight of ice was removed, and the fluctuation of lake levels in response to meltwater and shifting lake outlet positions shaped much of the topography and the paths of rivers. The historic Rapid and Little Rapid rivers had different courses than the present-day rivers. During the formation of the Rapid River Moraine, the rivers flowed south-southwest past Kalkaska between the ice sheet margin and Crawford Lake Moraine through the Rapid-River Boardman Plain (Ver Wiebe and Berquist, 1927). The outwash plain was approximately four miles wide and consisted of coarse-grained glacial material. The historic Rapid River and Boardman River united and flowed into glacial Lake Algonquin, which formed south of the retreating Michigan Lobe (Ver Wiebe and Berquist, 1927).

As the ice continued its retreat, volumes of meltwater increased and the lake continued to grow. At its maximum stage 11,000 years ago, glacial Lake Algonquin had an area of 100,000 mi^2 and covered modern Lake Michigan (22,300 mi^2), Lake Huron, and parts of Lake Superior (Colman et al., 1994; Schaetzl et al., 2002). The water surface elevation was 605 feet above sea level (asl), or 30 feet above the present-day elevation of Lake Michigan (Ver Wiebe and Berquist, 1927). Continued glacial retreat and isostatic rebound eventually revealed northern outlets to Lake Algonquin which led to a decrease in lake levels (Chippewa-Stanley Lake Stage; 230 feet asl). However, the decline in lake levels was short lived and the following post-glacial lake stage (the Nipissing Stage; 605 feet asl) saw elevated lake levels which persisted for 3,000 years.

During the stages of higher lake levels, the shoreline extended further inland than the present-day shoreline along Lake Michigan and was significantly closer to the modern-day Rugg Pond. The exact paleo-shorelines cannot be determined due to erosional processes of the Rapid River (Farrand & Bell, 1982, 1984). However, the presence of lake sediments observed four miles upstream from the current mouth of the river implies that the mouth of the historic Rapid River was once further inland, which corresponds to the elevated lake levels during Lake Algonquin and the Nipissing Stage.

Pre-Lake Algonquin, the Rapid River flowed south-southwest. However, the combination of glacial retreat, isostatic rebound, fluctuations in lake surface elevations, and undercutting by small streams on the lake-side of the moraine as lake levels fell, contributed to the diversion of the Rapid River. These factors caused the river to deviate from its south-southwest trajectory parallel to the moraine to its modern path flowing northwest and cutting through the Rapid River Moraine. After its diversion, the historic Rapid River flowed within a river valley approximately three miles wide. Over time, the river has incised through the glacial outwash plain and moraine, forming two levels of terraces, 30 feet and 70 feet above the current channel (Ver Wiebe and Berquist, 1927). As lake levels began to fall for the final time, the path of the Rapid River extended to reach the Elk-Skegemog Chain of Lakes.

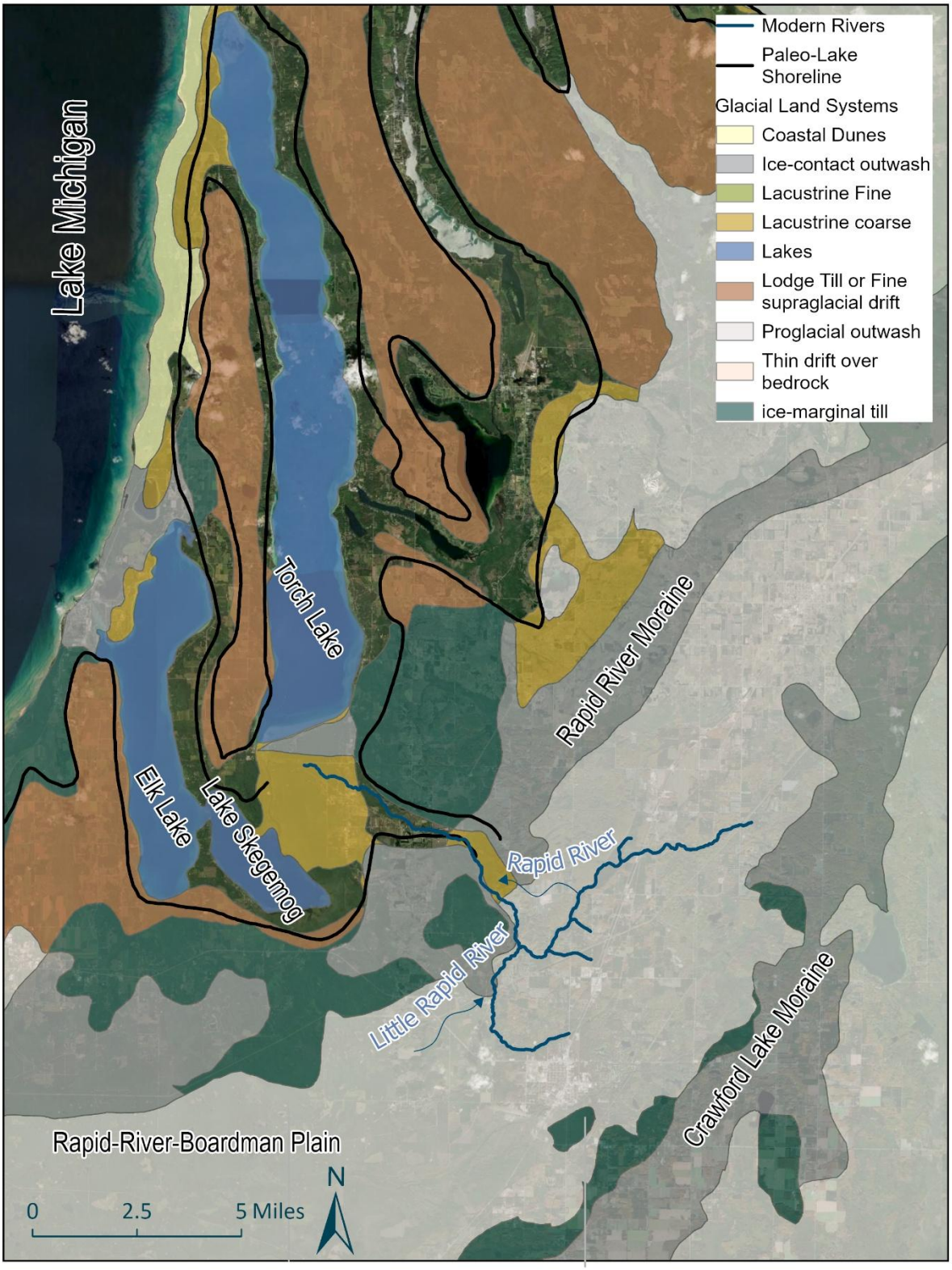


Figure 7. Quaternary geology features (Farrand and Bell, 1982) and paleo-lake shoreline (Farrand and Bell, 1984) overlayed on aerial imagery.

2.4 HYDROLOGY

Hydrologic analyses for this study included field measurements of streamflow, flow estimates provided by EGLE of low flows and flood flows, and analysis of peak flood flows in similar watersheds with stream gages. No FEMA Flood Insurance Studies are available for the project area.

2.4.1 Flow Measurements

Stream flow measurements were conducted by Inter-Fluve on May 14, 2026 using a Marsh McBirney Flo-Mate 2000 velocimeter at two cross-section locations: the Rapid River approximately 400 feet downstream of Rugg Pond Dam, and the Little Rapid River about 2,000 feet upstream of Hanson Road. Velocity measurements were taken at approximately 15 locations along each cross-section. Discharge estimates were calculated using the end-area method with the velocity measurements and corresponding water depths. The resulting flow estimates for May 14th, 2026 were 100 cfs on the Rapid River downstream of the dam and 28 cfs on the Little Rapid River. A water balance between these values implies an estimated flow of 72 cfs on the Rapid River upstream of the dam, assuming limited groundwater inputs in the distance between measurement locations.

2.4.2 Typical Flows

Monthly flow estimates for the Rapid and Little Rapid Rivers were provided by EGLE (process number 20260168, March 2, 2026). EGLE calculated monthly exceedance flows using correlation and drainage area ratio relationships from gage data on the Pigeon and Big Sable Rivers. Monthly exceedance flows (Figure 8) indicate the percentage of time a certain flow is exceeded each month. Baseflows are typically largest in April, with monthly median (50% exceedance) flows of 85 cfs in the Rapid and 30 cfs in the Little Rapid. The Rapid and Little Rapid Rivers are characterized by high groundwater inputs that create constant elevated baseflows, which typically range from 66 to 80 cfs in the Rapid River and 14 to 25 cfs in the Little Rapid River.

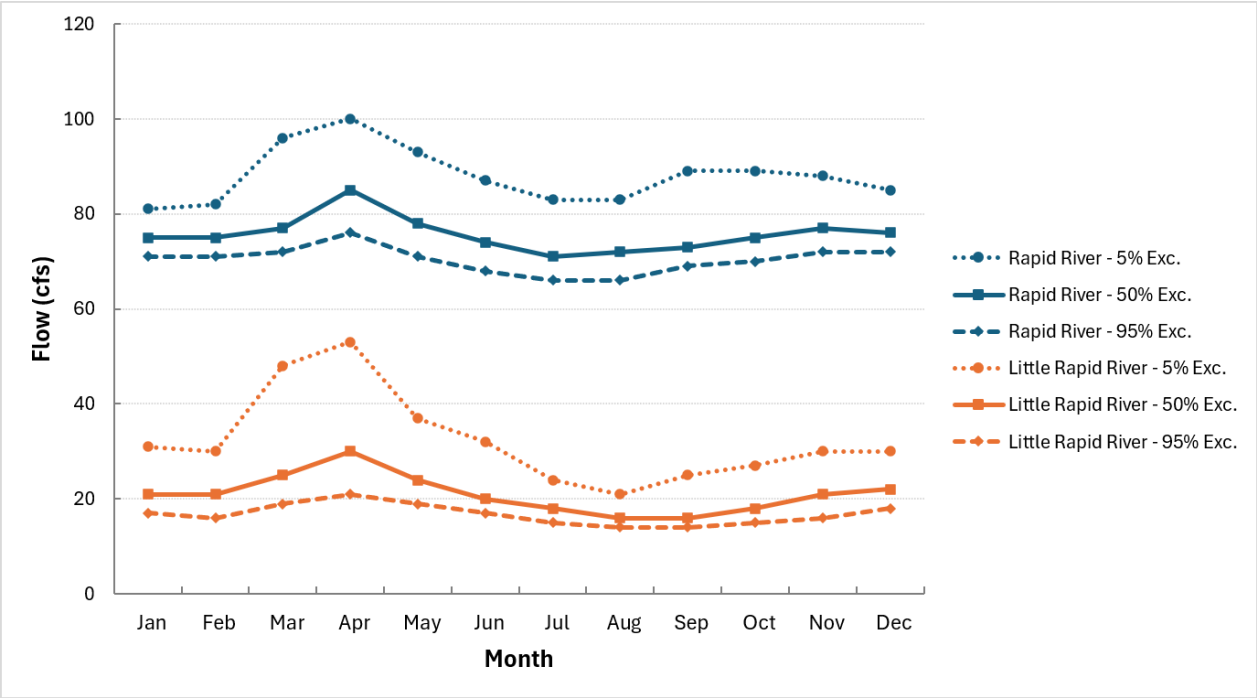


Figure 8. Monthly exceedance flow estimates provided by EGLE for the Rapid and Little Rapid Rivers.

2.4.3 Peak Flood Flows

Flood flow estimates were also provided by EGLE, which were calculated using a rainfall-runoff method that does not take baseflow into account. Baseflow values were added to the estimated flood flows to estimate peak flood flows. The baseflow values added were assumed to equal the harmonic mean of the exceedance flow data provided by EGLE: 76 cfs for the Rapid River and 21 cfs for the Little Rapid River.

To develop another estimate of peak flood flows, Inter-Fluve performed a flood frequency analysis on a gaged watershed with similar characteristics and conditions, then transferred those statistics to the Rapid and Little Rapid Rivers using drainage area ratios. The Boardman River was selected due to its similarities to the Rapid River watershed including geology, climate, land use, and slope. Annual peak flood discharges were calculated at USGS gaging station #04126970 on the Boardman River above Brown Bridge Road near Mayfield using the full period of record (1998 to 2026). Peak flood discharges were computed using USGS Bulletin 17C methodology (England et al., 2019) using the USACE HEC-SSP Version 2.2 software package. Calculated flood quantiles were scaled by drainage area ratio from the Boardman River gage, which has a drainage area of 140 mi^2. Estimated peak flood flows provided by EGLE and those calculated using basin transfer methods are provided in Table 1. Proposed conditions modeling will consider the values produced by both methods.

Table 1. Peak flood flow estimates for the Rapid and Little Rapid Rivers provided by EGLE and estimated using drainage area ratio (DAR) analysis on the Boardman River.

Return Period (years)	Annual Exceedance Probability	Peak Flood Flow (cfs)			
		Rapid River		Little Rapid River	
		EGLE	Boardman DAR	EGLE	Boardman DAR
2	50%	236	626	41	22
5	20%	331	776	58	31
10	10%	412	876	72	51
20	5%	506	976	89	91
50	2%	654	1,076	115	141
100	1%	789	1,126	138	201
200	0.5%	947	1,226	166	281
500	0.2%	1,199	1,276	210	421

2.5 AQUATIC ECOLOGY AND BIOLOGY

The Rapid River is a designated trout stream by the MDNR and supports naturally-reproducing populations of Brook trout (*S. fontinalis*), Brown trout (*S. trutta*), and Rainbow trout (*O. mykiss*), having also been stocked with Steelhead (lake-run *O. mykiss*), Brook, Rainbow, and Brown trout at various times between 1947 and 1992 (Hettinger, 2017). Other prominent species observed by the MDNR include Slimy Sculpin (*C. cognatus*), White Sucker (*C. commersonii*), Logperch (*Percina*), Yellow Perch (*P. flavescens*), lamprey ammocoetes, Central Mudminnow (*U. limi*), and tiger trout (*S. trutta x S. fontinalis*). Torch Lake has been stocked with Atlantic Salmon (*S. salar*) fingerlings by the DNR, but few angler observations have seen spawning Atlantic Salmon in the Rapid River (Hettinger, 2017). In 2025, a MDNR fish survey recorded its first naturally produced Atlantic salmon (H. Hettinger Pers. Comm., 2026). Naturally reproducing trout populations in the Rapid River use gravel-bottomed, spring-fed, well-oxygenated tributaries to spawn in the fall. After spawning, adults return to Torch Lake to over-winter. Eggs hatch in the spring and take approximately 1.5 to 2.5 years to mature, and the trout live for an average of six years.

The Rapid River has high-quality habitat required for trout survival. Such conditions include water temperatures between 52° to 56° Fahrenheit, unchlorinated water, minimal sedimentation, a pH of 7, low levels of ammonia and nitrates, and dissolved oxygen levels greater than 7.0 parts per million. The Rapid River also provides a diverse food base, appropriate shelter, and quality spawning habitat including a mix of riffles and pools with various depths, velocities, and substrates. Multiple life stage fish habitats are present including gravel beds, gravel bars, glacial lag boulders and pocket water, complex wood accumulations, undercut bank habitat, scour pools, and multi-story canopy stream bank vegetation. Numerous habitat enhancements (deflectors, digger logs, and log covers) have been installed in the upper reaches of the river; however, effectiveness was limited because the enhancement types were not well suited to the river's geomorphology (Hettinger, 2017).

The Elk River Chain of Lakes Watershed Management Plan (ERCOL-WPIT, 2022) characterized the Rapid River benthic macroinvertebrate community as 'fair,' which is described in the report as indicating "…stressed areas with an overall reduction in stream quality…".

There are no documented publicly available freshwater native mussel surveys in the Rapid River. Invasive, non-native zebra mussel (*Dreissena polymorpha*) are reported in the watershed, though there are no specific observations in the Rapid River (ERCOL-WPIT, 2022).

3. Existing Site Conditions

3.1 RUGG POND DAM

Rugg Pond Dam consists of an earthen embankment (Figure 9) and two spillways that pass flow downstream into separate channels that converge about 300 feet downstream of the dam (Figure 10). Engineering drawings of the spillways are available from the 1985 dam repairs prepared by Gosling Czubak Associates. These drawings are provided in Appendix A. Elevations reported in those drawings appear to be about two feet lower than surveyed elevations. This discrepancy is not accounted for in a datum difference (e.g., NAVD88 versus NGVD29). Where surveyors could safely access dam structures, surveyed elevations are referenced herein. Structural elevations obtained from the drawings are approximate only.



Figure 9. Rugg Pond Dam and impoundment, seen from the parking area. Photo taken 5/11/2026.



Figure 10. Confluence of the west and east spillway channels downstream of Rugg Pond Dam. Photo taken 5/11/2026.

3.1.1 East Spillway

The east spillway includes a 10-feet-wide, 42-feet-long concrete spillway with concrete wing walls, a sheet pile wall at the inlet, a trash rack upstream of two stoplog sections, and a sloped ramp to the tailwater (Figure 11 and Figure 12). The west stop log section is 7.95 feet wide with a bottom elevation of approximately 828.5 feet; the east section is 2.9 feet wide with a bottom elevation of about 826.2 feet. Each section has removable 4-inch by 4-inch stop logs that allow the impoundment water level to be managed. Three rows of steel sheet pile protection are provided: at the inlet (40 feet long), in plane with the trash rack (13 feet either side of spillway), and at the outlet (40 feet long). The spillway section is fitted with an 8-inch concrete slab and railings to provide access across the spillway.

At both the west and east sections of the downstream steel sheeting, the tops of walls have been leaning toward downstream, which seems to be a condition that has existed for some time. As the wall leaned forward, the gap between concrete and steel grew. During the spring melt and storm events in early April 2026, flow was high and water was able to find a path between the wall and the sheet pile, follow the sheet pile wall, and then outlet to the stream. The County responded to this issue by placing gravel, riprap, and bentonite clay behind and in front of the wall. With the additional protections and lowered water behind the dam, the new flow path has been blocked off.



Figure 11. East spillway inlet. Photo taken 5/11/2026.



Figure 12. East spillway outlet, with newly placed riprap on the right side of the photo. Photo taken 5/11/2026.

3.1.2 West Spillway

The west spillway includes a steel sheet pile inlet box that empties into a concrete box connected to a 76-inch diameter steel penstock pipe. The top of the sheet pile wall was surveyed at an elevation of 831.7 feet. When impoundment water levels are high enough to overtop the sheet pile wall (as seen in Figure 13), water flows over the wall and through a grate into the penstock inlet. Fieldstone riprap is placed between the steel and concrete walls. The south side of the sheet pile wall is equipped with an underspill opening, containing 4-inch by 4-inch stop logs that allow the impoundment water level to be managed. Within the stop log section is a rectangular, grated opening approximately 21 inches tall by 29 inches wide that allows cool water from lower down in the impoundment to be passed downstream. Unless closed by the stoplogs, the underspill opening is the lowest inlet elevation in the dam, at approximately 821 feet. The penstock outlets into the west channel at an invert elevation of 814.3 feet (Figure 14). The pipe outlet is supported with piling and is perched approximately two feet above a riprap apron. The tailwater bed elevation immediately below the penstock outlet is approximately 811.5 feet, with channel elevations around 808 feet within the west channel approximately 30 feet downstream. Figure 15 shows a cross section and profile of the of the west spillway from the 1985 as-built drawings (see Appendix A for the full drawing).



Figure 13. West spillway inlet. Photo taken 5/13/2026.



Figure 14. West spillway outlet. Photo taken 5/11/2026.

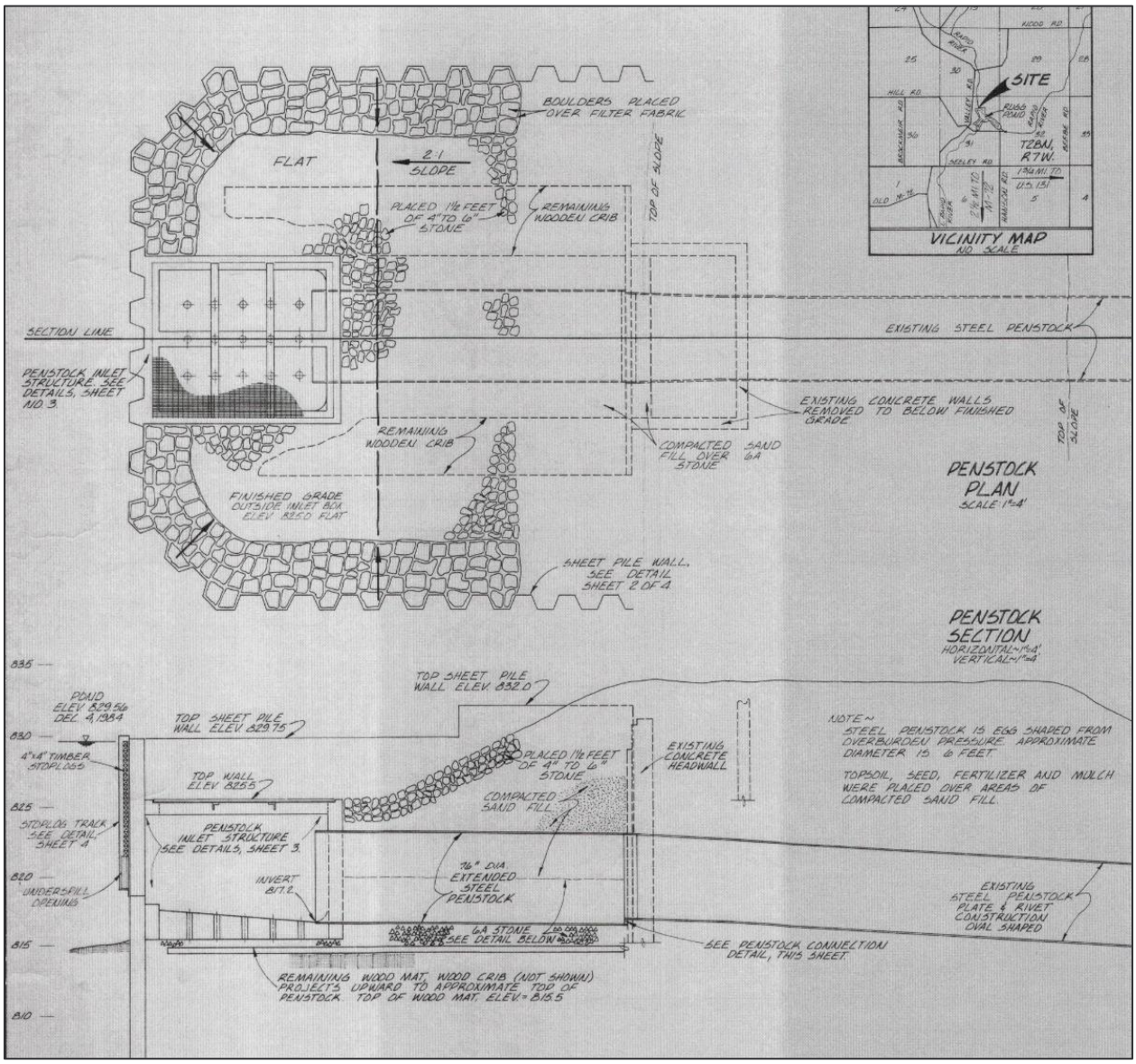


Figure 15. Selection of the 1985 Gosling Czubak dam repair as-built drawings showing the west spillway.

During the snowmelt and spring rains in April 2026, water was high and flowing over the sheet pile wall. Prior to that, the top grating slowly filled in with vegetation and debris reducing the total opening area for water flow. The grating and beam were overloaded, failed, and fell to the bottom of the concrete box. Shortly after failure, the grating was replaced with full span sections that bear on the north and south concrete box walls. The concrete box east walls are in poor condition around the opening with exposed vertical and horizontal rebar. The remaining area of this spillway is in fair to good condition following the grating replacement.

3.1.3 Earthen Embankment

The earthen embankment has a length of approximately 685 feet and a height of approximately 24 feet. The width of the embankment crest ranges from 10 to 25 feet. The upstream slopes of the

embankment are approximately 2H:1V. The downstream slopes vary from 2H:1V to 1H:1V. Seeps are visible at the toe of the downstream slope and have been noted on previous dam inspections. Spicer Group prepared a Rugg Pond Dam Seepage & Stability Study (Spicer Group, 2022). Review of the study indicated that options are available to reduce the possibility of dam failure due to seepage.

Historic photos and notes on plans indicate that the dam was built on a wood crib with large cobble stone. Sheet 1 of the 1985 as-built plans (Appendix A) notes that the cribbing projects up to approximately 815.5, or just below the concrete box on the pipe spillway (west). Soil boring B-04, collected by Materials Testing Consultants (MTC) (see Section 4.2.2 and Appendix C) indicates an impenetrable layer at an elevation of 809.7 feet that corresponds to large stone or cobble feature.

3.2 HANSON ROAD CROSSING

Hanson Road is a gravel County local road connecting Valley and Seeley Roads. Hanson Road crosses the Little Rapid River approximately 0.3 miles south of Rugg Pond Dam. At the Little Rapid River crossing, a 5-foot diameter, 31-feet-long corrugated metal pipe culvert with timber head walls provides water passage (Figure 16). Riprap is found around both the upstream and downstream headwalls. The road width averages 30 feet within this section, and the top of road elevation is approximately 12 feet above the thalweg of the downstream channel and 9 feet above the upstream thalweg.

The culvert has heavy corrosion with wall penetrations along the water line, especially at the downstream sections of pipe. The culvert is in poor condition and undersized for the flow. The headwalls and wingwalls are not soil tight, and soil has eroded out from under the walls in all four quadrants and allows water to flow beneath the headwalls on the upstream side. On the downstream side, the wingwall on river left is missing wooden slats and has small trees growing from exposed soil (Figure 17). Immediately downstream of the culvert is a scour hole about three feet deep, which is undermining the culvert. Due to the flow contraction through the culvert and resulting high velocities, the Hanson Road culvert poses a challenge to fish passage.

Due to the near 8% slope of the road east of the culvert, stormwater and gravel have repeatedly washed down the road into the southwest quadrant of the culvert, creating the need for more gravel on the road. Drainage improvements for Hanson Road should be a design consideration for new structure design.



Figure 16. Hanson Road culvert upstream inlet. Photo taken by CRA 12/10/2024.



Figure 17. Hanson Road culvert downstream inlet. Photo taken 5/11/2026.

3.3 UTILITIES

The Inter-Fluve team completed a utility locate request and surveyed marked utilities in potential project work areas in May 2026. Limited utilities are found within the road right-of-way in this portion of Kalkaska County. Valley Road utilities include overhead electric, AT&T, and fiber. Along Valley Road, from Hanson Road to the Rugg Pond Natural Area entrance, overhead electric follows the eastern right-of-way north across the Rugg Pond Natural Area entrance and then crosses to the west side of the road. AT&T and fiber are buried along the east side of the road. No utilities are known to feed the Rugg Pond Dam site.

Hanson Road utilities include overhead electric, telephone, and fiber. From Valley Road east to the top of the hill on Hanson Road, overhead electric is along the north side of the road then cuts diagonally across the road at the culvert location to the south side and then east up the hill on the south side of the road. AT&T buried cable follows the north side of the road and under the Little Rapid River, marked 14 feet north of the gravel road shoulder. Buried fiber follows the south side of the road and over the culvert at the Little Rapid River crossing. Surveyed utilities are included in the project's basemap to be used for 30% design development.

3.4 LAND OWNERSHIP

Rugg Pond Dam is located in the County-owned Rugg Pond Natural Area which has an area of 102 acres. This public land is bordered on all sides by private parcels (Figure 18). Access to the Rugg Pond Natural Area is via a small parking lot off of Valley Road, which runs along the western edge of the County-owned parcel. The Little Rapid River immediately upstream of Hanson Road is located within private parcels.

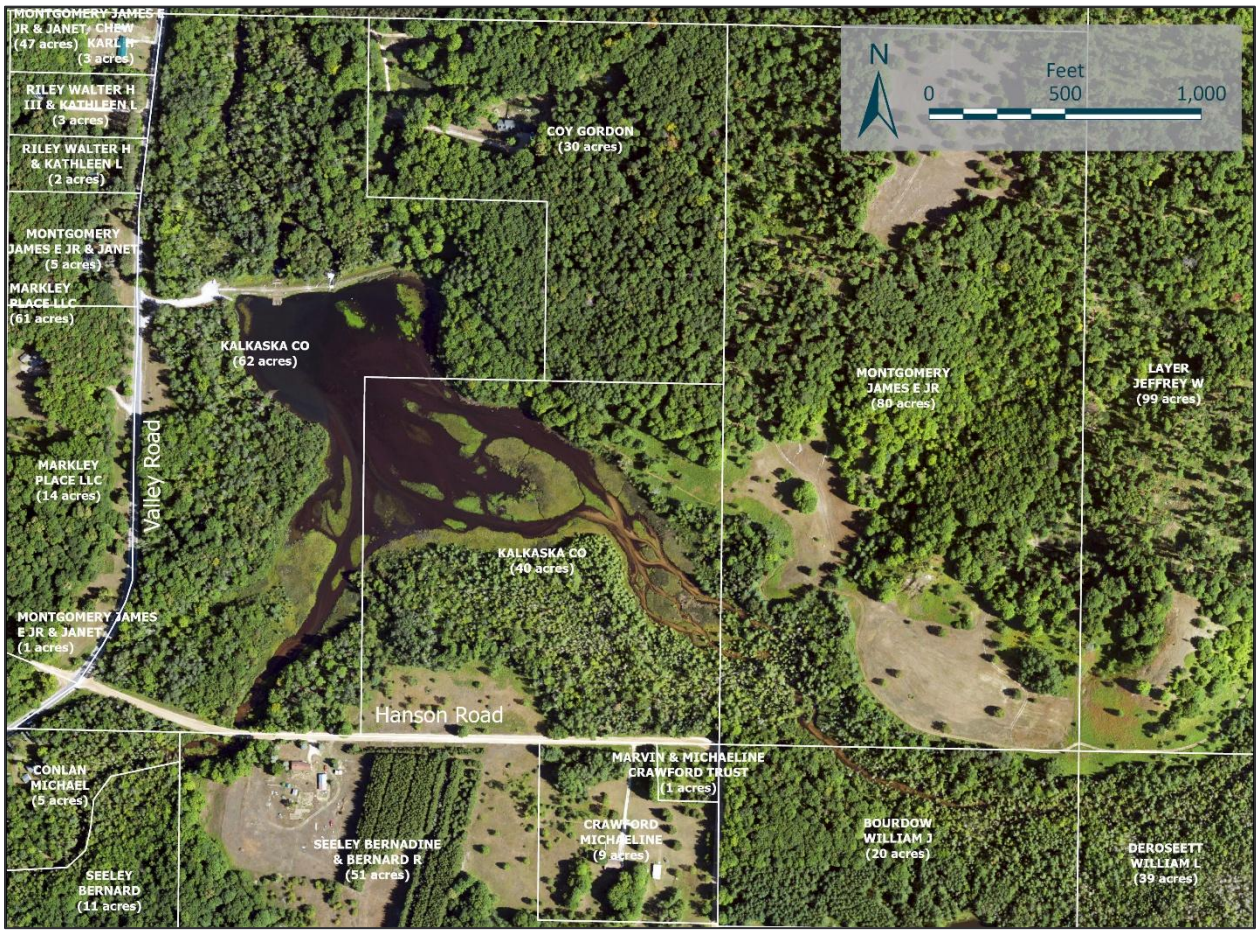


Figure 18. Property ownership in the vicinity of Rugg Pond Dam.

4. Geomorphic and Sediment Assessment

Inter-Fluve conducted a site survey and geomorphic assessment between May 11 and 14, 2026. The survey included topographic and bathymetric surveys, depth-of-refusal (DOR) surveys of accumulated sediments, geomorphic assessment of the Rapid River and Little Rapid River, and flow measurements. Elevation data were surveyed using both RTK GPS and Total Station equipment. In addition, survey data previously collected by Spicer Group (Spicer) under contract to Kalkaska County were made available to Inter-Fluve. Spicer's data includes topographic, bathymetric, and DOR survey data in the project area. Channel cross-sections and longitudinal profiles were developed using survey data collected by both Inter-Fluve and Spicer.

The horizontal coordinate system for this project is Michigan State Plane Coordinates, Central Zone, NAD 83. The vertical datum used in this project is the North American Vertical Datum of 1988 (NAVD88). Units of measure in the State of Michigan are International Feet.

4.1 DAM-INFLUENCED REACHES

Inter-Fluve assessed the dam-influenced reaches, which include the limits of impoundment upstream of the dam on the Rapid River and Little Rapid River and the east and west spillways of the Rapid River downstream of Rugg Pond Dam.

Sediment has deposited within the impoundment over time, resulting in a relatively uniform and shallow reach upstream of the deltas of the two tributaries (Figure 19). At the time of survey, the water surface elevation in the impoundment was approximately 831.2 feet. Extensive mud flats of deposited sediment covered approximately one-third of the impoundment. The northwest corner of the impoundment is deeper (about four to eight feet), likely due to the underspill gate in the west spillway, and past dredging upstream of the old powerhouse (see Stations 87+22 and 88+35 in Figure 19). Cross sections of surveyed sediment top and the depth of refusal indicate the sediment surface is uniformly +/- 828 feet in elevation. Surveyed DOR points reveal a valley in the Rapid River that has a width of 300-350 feet and relief on the valley bottom is typically 2-3 feet, except in locations near the western spillway structure where bed elevations are likely manipulated. The minimum valley elevations observed in DOR survey correspond with channel and valley elevations downstream of the eastern (concrete) spillway.

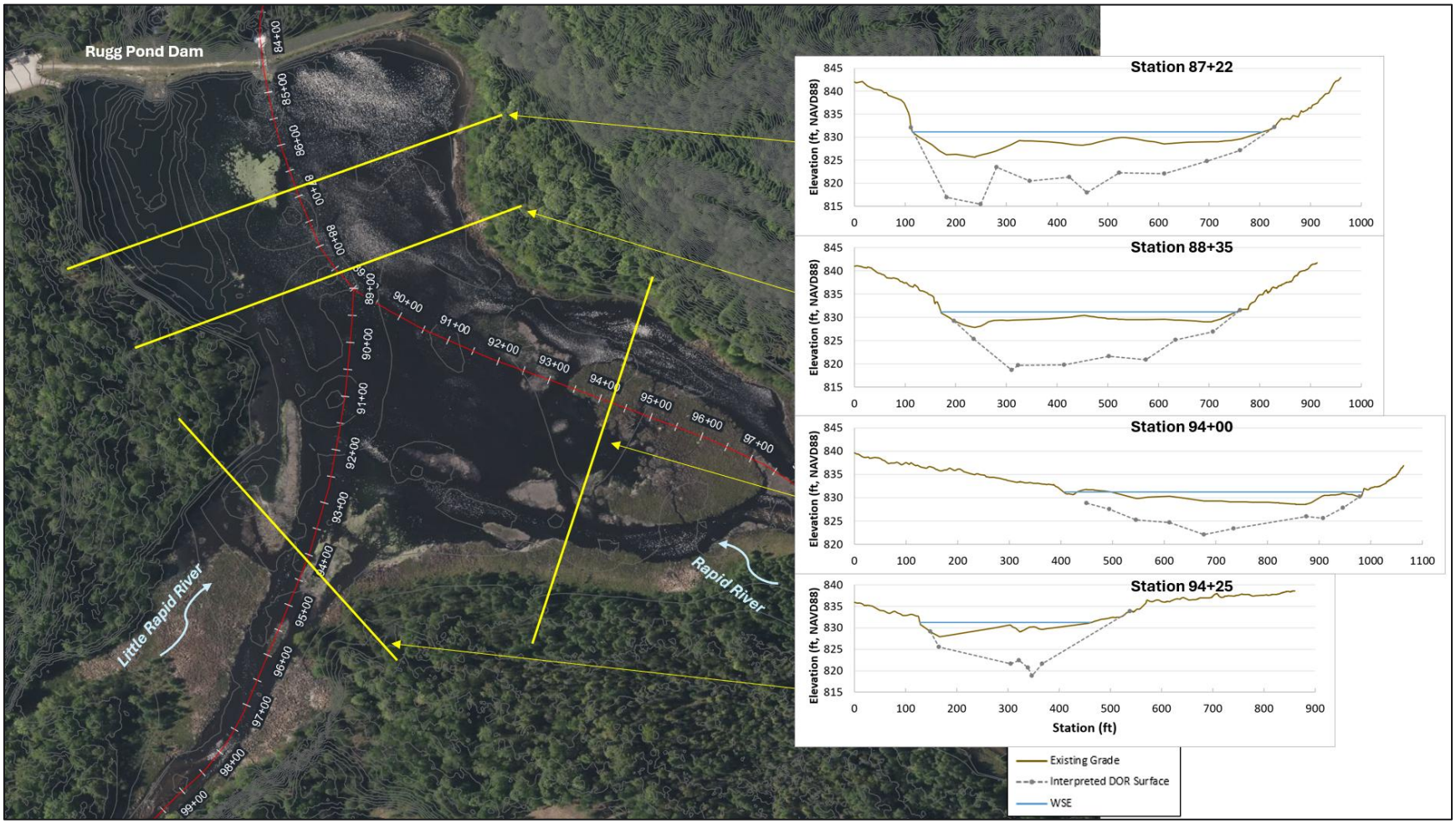


Figure 19. Select cross-sections in the Rugg Pond Dam impoundment, with water surface elevations depicted at the time of survey.

4.1.1 Impoundment Limits – Rapid River

Within the impoundment delta of the Rapid River, the existing wetted with is 160 feet, on average, less than 3 feet deep, and multithreaded (Figure 20). Cross-sections surveyed in the Rapid River and its delta are shown in Figure 21. Sediment thickness ranges from five to eight feet thick at the foreset bed of the delta, to about one foot thick at the upstream end of the depositional area, 200 feet downstream of the old crossing. No discernable sediment deposit thickness was measured within 80 feet downstream of the upstream stream crossing. A single, discrete relic channel is not discernable based on the DOR data collected in this reach, suggesting that this area may have historically been multithreaded and complex, similar to conditions observed in upstream reaches and recorded in GLO surveys. Cattails were widespread on banks and midchannel bars.



Figure 20. Rapid River delta, looking downstream. Photo taken 5/12/2026.

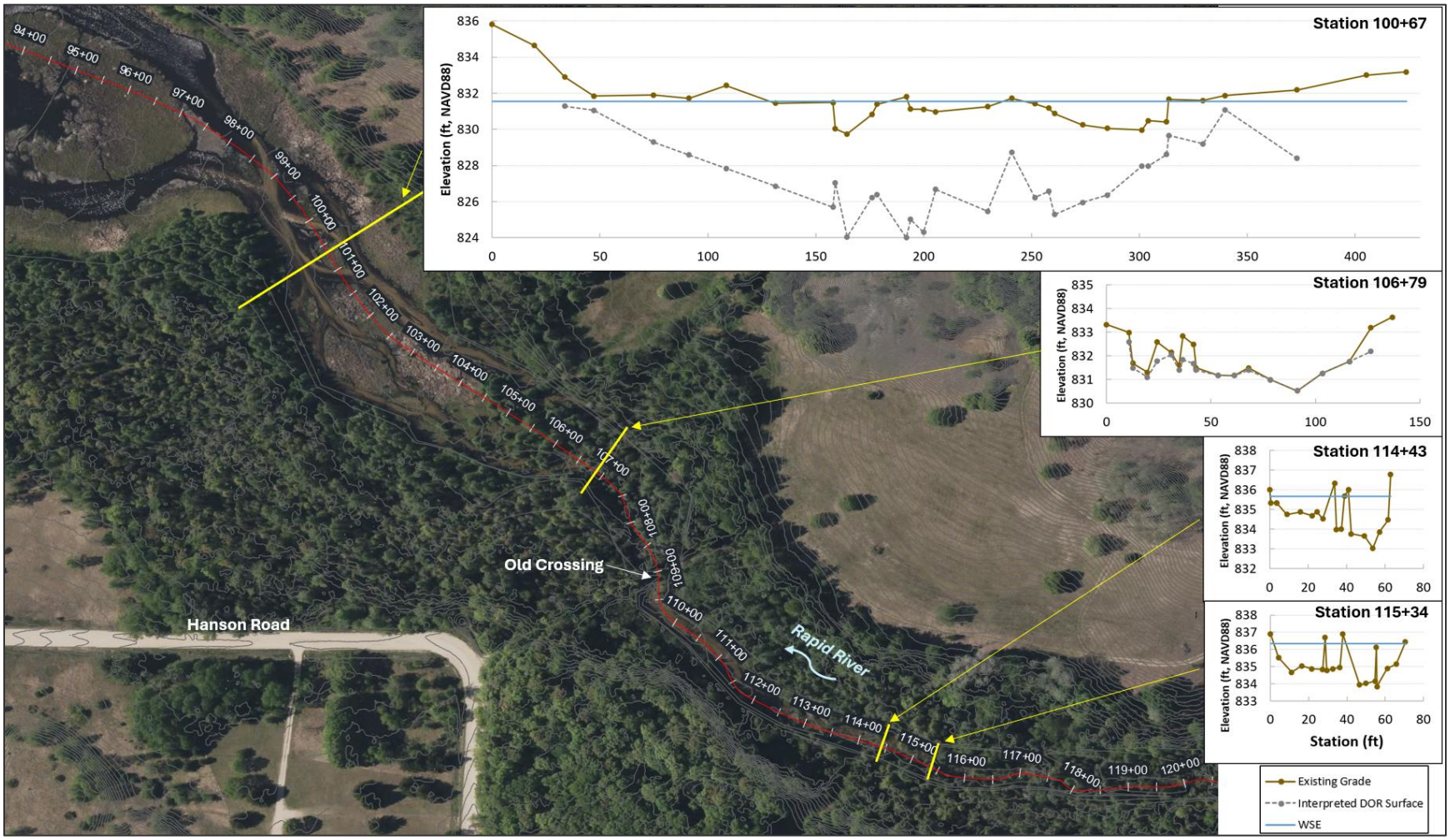


Figure 21. Cross-sections in the upstream Rapid River based on Inter-Fluve survey data, with water surface elevations depicted where available at the time of survey.

4.1.2 Impoundment Limits – Little Rapid River

The Little Rapid River forms a delta between Hanson Road and the impoundment, which ranges from 70 to about 350 feet wide and contains extensive mud-flat-like areas of fine, impounded sediment (Figure 22). Cross-sections surveyed in the Little Rapid River and its delta are shown in Figure 23. Several mid-channel bars exist in the upper reaches of the delta. Vegetation along the banks was dominated by cattails. Water depths are less than three feet deep on average, though this reach contains more bed heterogeneity than the Rapid River delta, with pockets of deeper water adjacent to wide, flat, shallow areas. Sediment thickness varies widely, from 12 feet at the foreset of the delta to four feet just downstream of Hanson Road. The DOR cross-sections, along with visible tree stumps, indicate potential relic channel positions, though also suggest complexity and perhaps a multithreaded system (see Section 4.2).



Figure 22. Little Rapid River delta, looking downstream. Photo taken 5/11/2026.

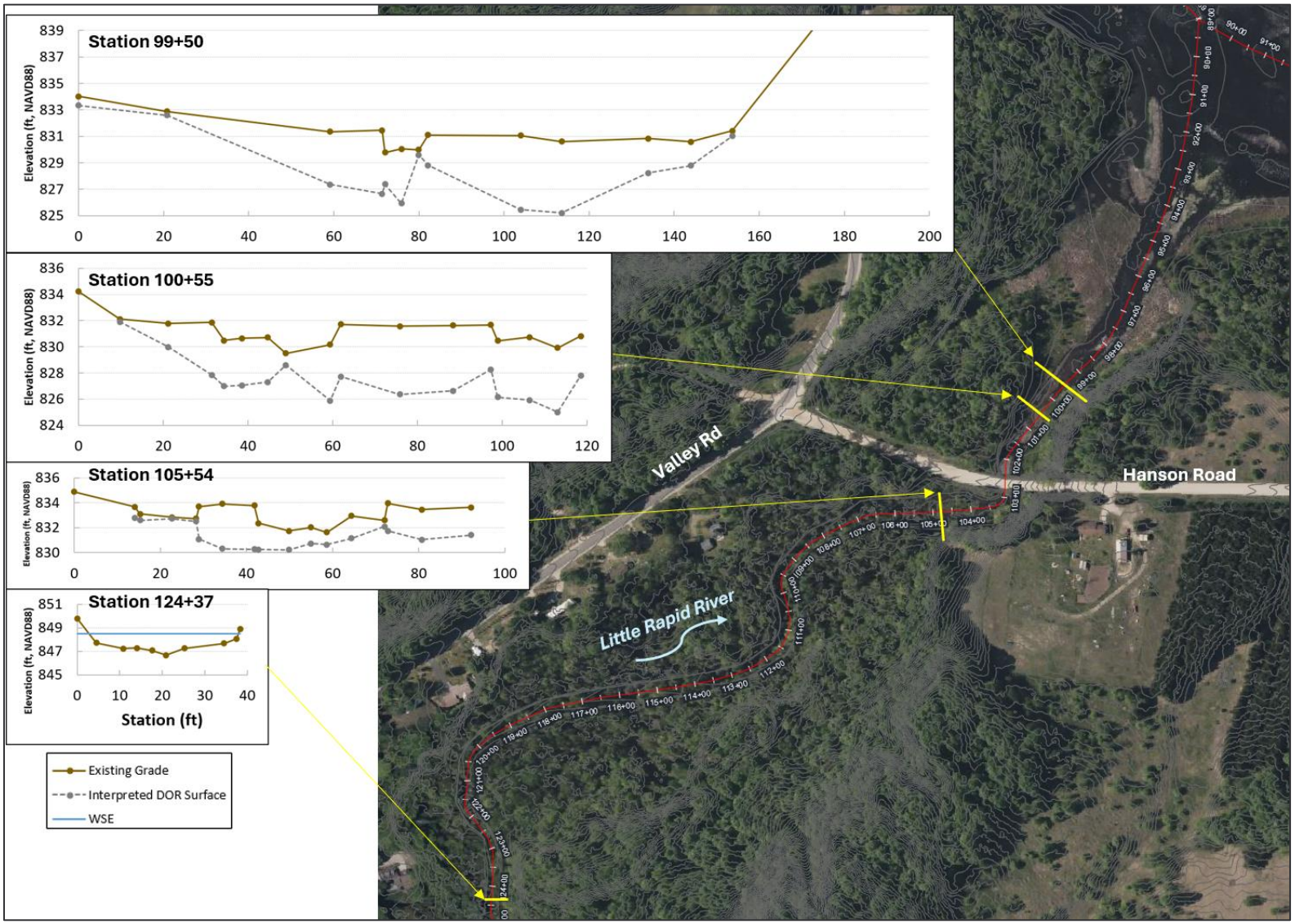


Figure 23. Cross-sections in the Little Rapid River based on Inter-Fluve survey data, with water surface elevations depicted where available at the time of survey.

4.1.3 Downstream of Dam

Flow passes through the dam through two spillways (see Section 3.1), creating two channels which join 250 feet downstream of the dam (Figure 24). The east channel is approximately 30 feet wide with 2.5-feet-tall banks, and the west channel is approximately 20 feet wide with banks that are 5 feet tall. The riffle downstream of the eastern spillway has a crest elevation of 814.7 feet and the west channel has a thalweg elevation of approximately 809.8 feet. The west channel has clearly been excavated, as indicated by the absence of coarse material on the bed, the straightened channel backwatered by a downstream mainstem riffle, spoils piles on banks, and channel bed elevations substantially lower than those of surrounding reaches.

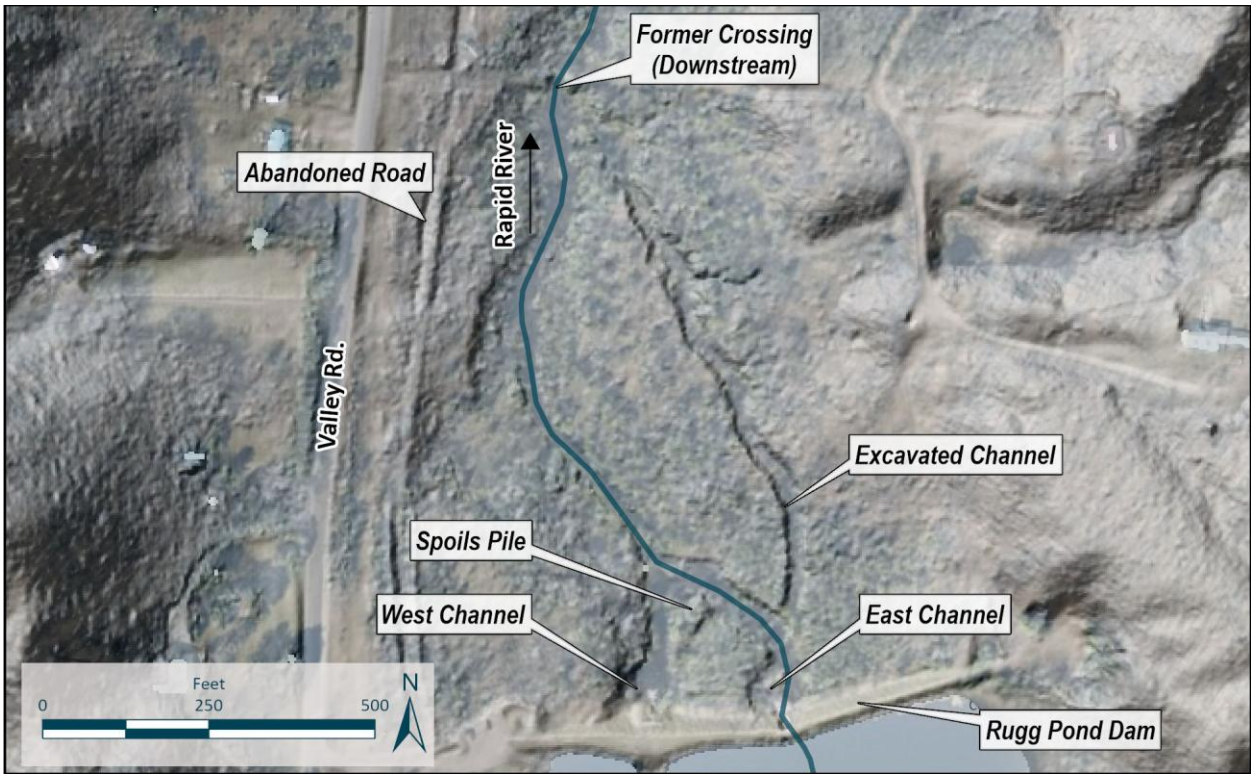


Figure 24. Features downstream of Rugg Pond Dam overlayed on FEMA DEM (2019) and Michigan Imagery (2017) by Michigan Statewide Authoritative Imagery & LiDAR (MiSAIL).

Downstream of the confluence of the east and west channels, the river widens to approximately 40 feet, with banks heights of approximately 4 feet and plane-bed conditions. This portion of the river appears to have been straightened during dam construction, with spoils placed along the banks. Channel cross-sections surveyed in the east spillway channel and downstream Rapid River are shown in Figure 25.

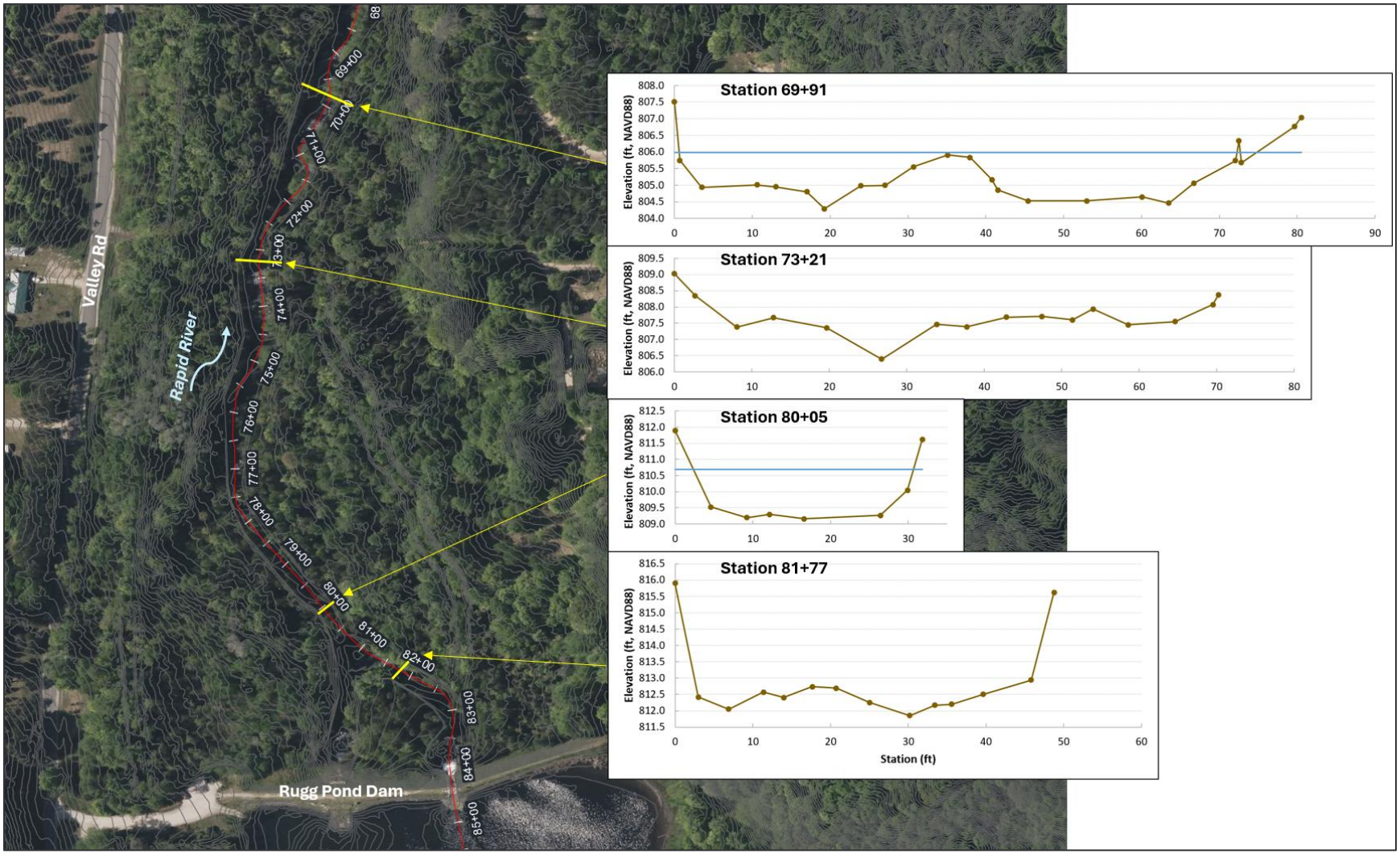


Figure 25. Cross-sections in the downstream Rapid River & east spillway channel based on Inter-Fluve survey data, with water surface elevations depicted where available at the time of survey.

An excavated channel approximately 800 feet long connects the east spillway channel to the Rapid River at the location of a former crossing (Figure 24). This channel was likely excavated during dam construction and shows no signs that it conveys river flows, even during floods. However, this channel originally conveyed the entire flow out of the east spillway after dam construction. The east channel assumed its present alignment sometime between 1954 and 1983, when flow was directed into what is now the main channel (Figure 26). It is not known whether this change was due to channel avulsion or intentional realignment.

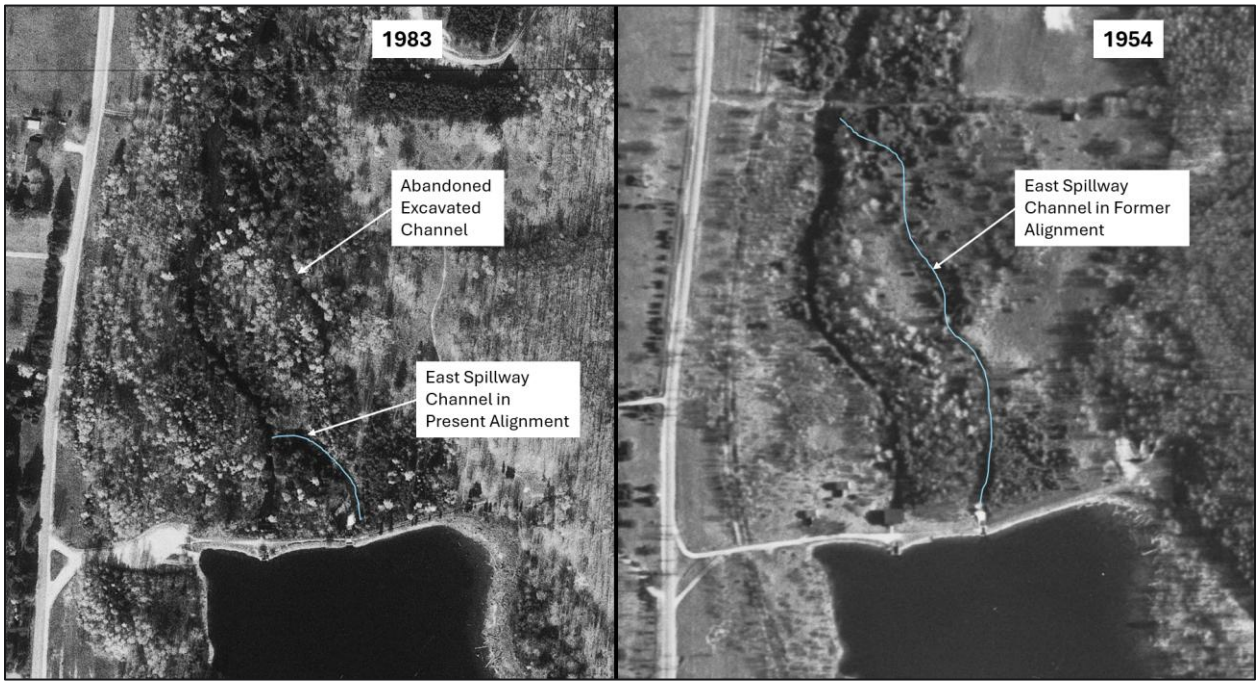


Figure 26. Historical aerial imagery of Rugg Pond Dam and the spillway channels from 1954 and 1983. (Source: USGS).

4.2 SEDIMENT ASSESSMENT

Inter-Fluve conducted bathymetric and DOR surveys of the impoundment. Bathymetric survey data were collected using a single beam echosounder attached to a canoe, synced with RTK GPS. Additional bathymetry and bank shots were collected using conventional RTK GPS surveying techniques and augmented by survey collected by Spicer. DOR probing consists of advancing a rigid, graduated rod through relatively softer impounded sediment deposits until encountering a more resistant stratum. Resistant strata may be sand, gravel, cobble, or floodplain soils and are interpreted as the pre-dam channel or floodplain surfaces, depending on their material and elevation relative to adjacent features. DOR methods are approximate only; it is possible that what is interpreted as the refusal surface may be shallower or deeper than the actual pre-dam features, and the types of materials are only characterized by sound and feel. Figure 27 shows the interpreted resistant material and depth found at each DOR survey point, where available. DOR data collected by others did not include material descriptions.

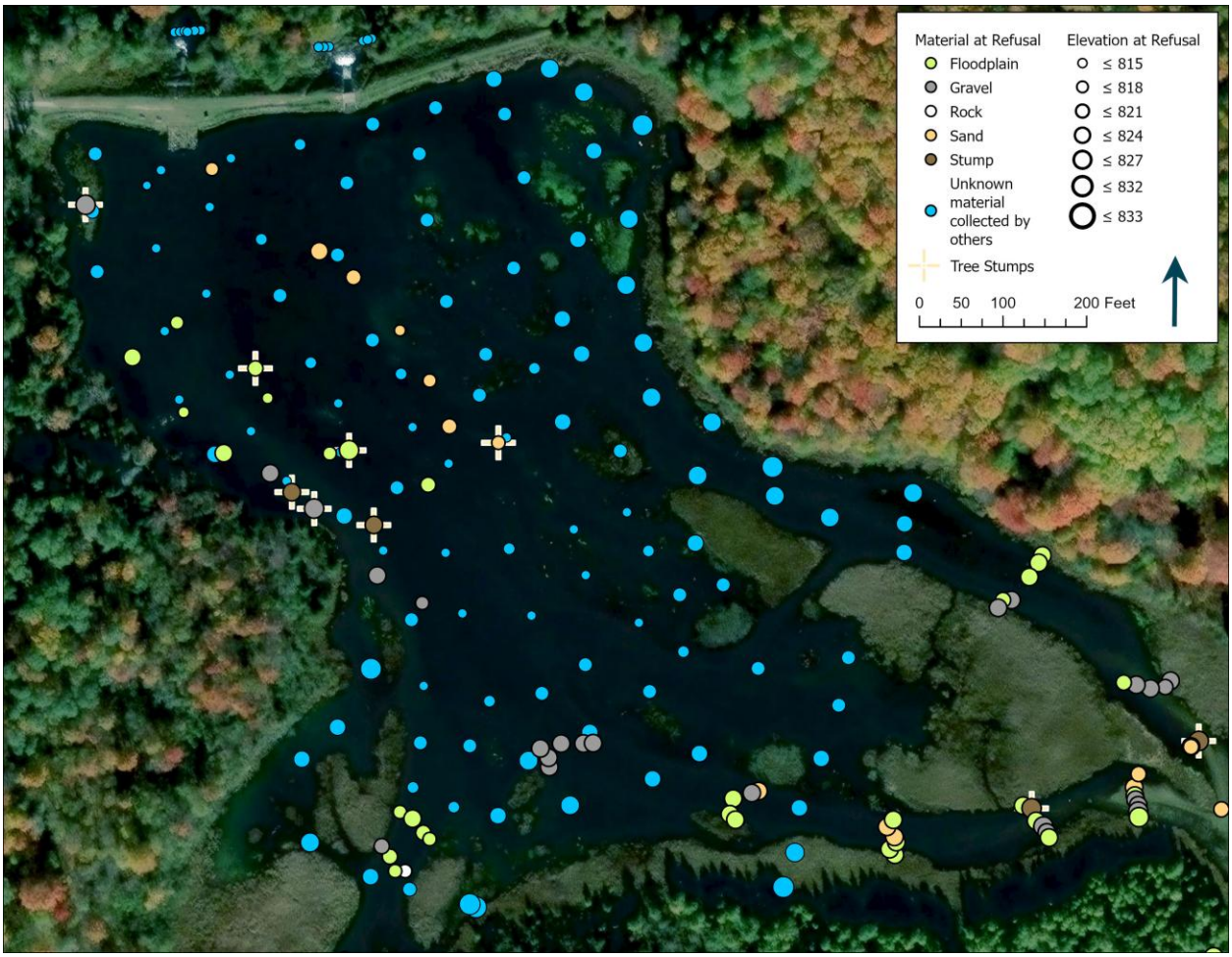


Figure 27. Depth of refusal (DOR) survey points. The color of the point indicates the material found at refusal, and the size of the point indicates the depth at which refusal was encountered. Smaller dots indicate lower elevations.

Terrain surfaces were developed in AutoCAD Civil3D for bathymetry, DOR, and sediment thickness and are provided in Appendix B. The bathymetric and DOR surfaces were developed using both Inter-Fluve and Spicer survey data, though Inter-Fluve data was prioritized in areas where data overlapped spatially. In general, elevations from the two surveys are similar. The exception is in the north/northwest portion of the impoundment, where bathymetry elevations from Inter-Fluve are two to eight feet higher than Spicer's. Inter-Fluve used an Echosounder mounted to a canoe to measure the top of sediment elevation, whereas Spicer used a survey rod to probe down to the top of sediment. Accumulated sediments in this area were noticeably loose and unconsolidated. The Echosounder likely picked up the top of these sediments better and represents a higher, more conservative (more accumulated sediment) top of sediment elevation. It is also possible that additional sediment has deposited in the impoundment in the four years between the two surveys.

4.2.1 Sediment Quantity

The bathymetric and DOR surfaces were used to create a sediment volume surface for the Rugg Pond Dam impoundment, extending into both rivers, 450 feet upstream of Hanson Road in the Little Rapid River and 80 feet upstream of the old crossing on the Rapid River (see Appendix B, Sheet 3). The estimated total volume of sediment is 214,000 cubic yards (CY). Much of the impoundment contains deposits six to twelve feet thick. Approximately 1,400 CY of accumulated sediment is present upstream of Hanson Road.

4.2.2 Sediment Quality

Sediment samples were collected in the Rugg Pond Dam impoundment by Great Lakes Environmental Center, Inc. (GLEC) in July, 2020 under contract to Kalkaska Conservation District. The report completed by GLEC is included in Appendix C. GLEC collected 11 samples with core lengths that ranged between 6.6 and 12 feet and composited depths from three to ten feet for laboratory analysis (Figure 28). Results of the grain size distribution indicate that accumulated sediments consist primarily of organic-rich, fine-to-medium grained sand and silt (no gravel was present). On average, the samples were comprised of 42% sand (27% medium-grained, 15% fine) and 58% fines (51% silt, 7% clay). The average organic carbon fraction was 25.3%, ranging from 21.4% to 30.7%.

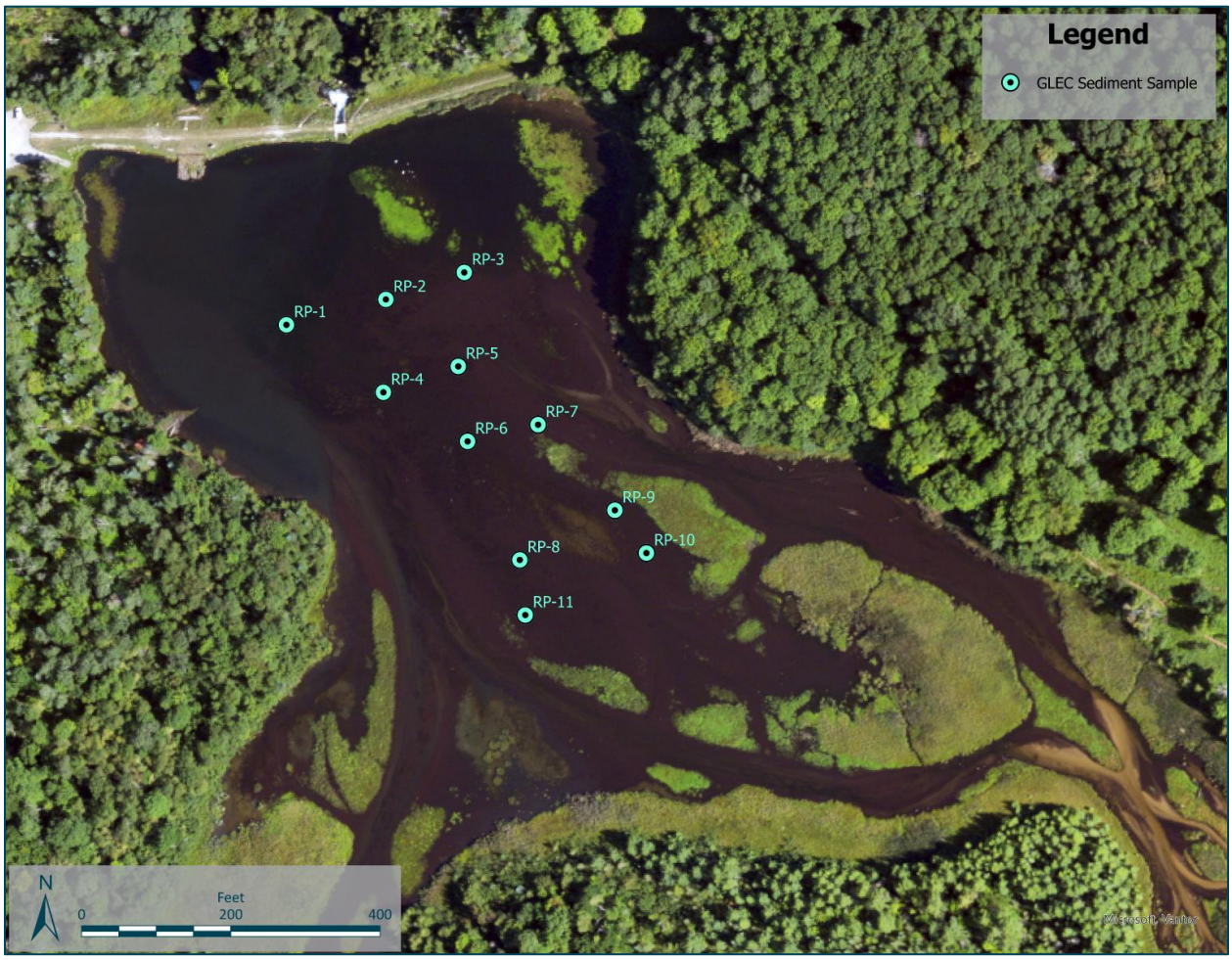


Figure 28. GLEC sediment core sample locations collected in 2020.

The eleven collected cores were analyzed in a lab for contaminants per EGLE's Water Resources Division Policy and Procedure WRD-048, Sediment Testing for Dredging Projects (EGLE, 2018). Laboratory analysis tested for common contaminants including heavy metals and polycyclic aromatic hydrocarbons (PAHs). Five constituents were measured in concentrations exceeding WRD-048 sediment screening levels across multiple samples:

- Selenium screening level (1.9 mg/kg) was exceeded in all 11 samples (3.5 – 5.4 mg/kg)
- Arsenic screening level (33 mg/kg) was exceeded in two samples (34.3 mg/kg in RP-1 and 90.1 mg/kg in RP-9)
- Fluorene screening level (536 ug/kg) was exceeded in one sample (1,040 ug/kg in RP-5)
- Naphthalene screening level (561 ug/kg) was exceeded in four samples (1,740 ug/kg in RP-1, 9,990 ug/kg in RP-5, 4,830 ug/kg in RP-7, and 1,480 ug/kg in RP-9)
- Phenanthrene screening level (1,170 ug/kg) was exceeded in two samples (2,850 ug/kg in RP-5 and 1,200 ug/kg in RP-7)

Concentrations of both heavy metals exceed the statewide soil background levels published by EGLE of 2.8 mg/kg for arsenic and 0.44 mg/kg for selenium, as well as the sand background levels published for the Michigan glacial lobe of 0.86 mg/kg for arsenic and 0.40 mg/kg for selenium (EGLE, 2023).

In addition to the EGLE WRD-048 sediment screening levels, the results of the chemical analysis were compared to the United States Environmental Protection Agency (EPA) threshold and probable effect concentrations (EPA, 2002) and ecological screening levels (EPA, 2003). In general, the EPA probable effect concentrations equal the EGLE WRD-048 levels, and the EPA threshold effect concentrations equal the ecological screening levels. The WRD-048 levels are higher than the ecological screening levels for all analytes; therefore, the same five constituents with exceedances listed above also exceed ecological screening levels. In addition, arsenic levels exceeded the ecological screening levels in all 11 samples, and two samples (RP-5 and RP-7) recorded ecological screening level exceedances for ten PAHs.

The EGLE WRD-048 requires that sediment dredging projects collect six samples for the first 10,000 CY of sediment to be dredged, plus one sample for every additional 10,000 CY of sediment that will be managed. If all 214,000 CY of sediment were to be managed, 27 cores total would be required to properly characterize the site sediment conditions. Additional samples may need to be extracted from cores to define vertical sediment texture variations. The number and location of cores to be collected will be determined in subsequent project phases in consultation with Michigan EGLE staff.

4.3 RIPARIAN VEGETATION

Existing riparian vegetation consists of wetland and upland communities. Plant communities are typical of riverine corridors, impounded water, and forested uplands. Vegetation communities vary throughout the site, with wetland and transitional communities being dominated by cedar swamp, alder thicket, and sedge meadow, while the uplands were dominated by hemlock-northern hardwood forest. In the impounded portions of the study area, a typical vegetation change occurs from the water's edge to a sedge meadow, followed by alder thicket, and ultimately to the upland community. Within the riverine sections, vegetation transitions are more variable but generally follow one of two patterns. From water's edge directly into a cedar swamp before transitioning into uplands, or from water's edge through a sedge meadow and alder ticket, then into a cedar swamp before transitioning to the upland community.

The cedar swamp community is dominant in stream reaches outside of the influence of the impoundment, as presented in Section 4.4, primarily consisting of northern white cedar (*T. occidentalis*) and accompanied by yellow birch (*B. alleghaniensis*) and tamarack/eastern larch (*L. laricina*). Transitional areas between the impoundment and free-flowing reaches are more dominated by tamarack and speckled alder (*A. incana*), with understories dominated by marsh marigold (*C. palustris*) and *Carex* species. Curly-leaf pondweed (*P. crispus*) has been observed in the Torch River near the confluence with the Rapid River and has been documented upstream on the Rapid River at Rugg Pond Dam (ERCOL-WPIT, 2022).

4.4 REACH ASSESSMENTS

Inter-Fluve geomorphologists and ecologists performed a geomorphic assessment of adjacent reaches of the Rapid River and the Little Rapid River. Potential analog reaches were identified in river reaches upstream of the impoundment in the Little Rapid River and both upstream and downstream of the impoundment in the Rapid River (Figure 29). These reaches are located in relatively un-impacted reaches not affected by the dam or other direct human influences.

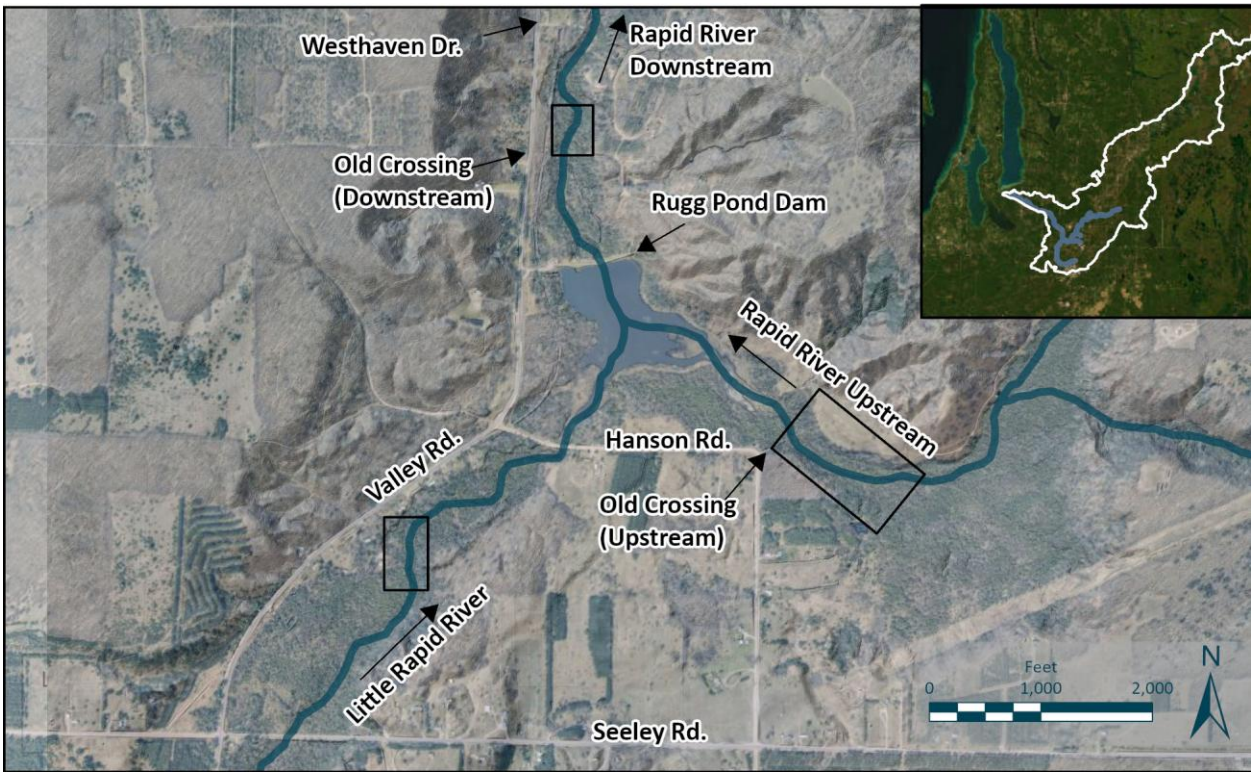


Figure 29. Analog reach locations relative to the project area.

4.4.1 Little Rapid River

The Little Rapid River flows through a terraced alluvial valley north-northeast to its confluence with the Rapid River within the Rugg Pond Dam impoundment. Cross-sections collected at multiple locations show the change in the channel upstream in comparison with the channel at the impoundment (Figure 23 in Section 4.1.3). At its maximum, the active valley width between terraces is 500 feet and at the narrowest, upstream of Hanson Road, it is 150 feet. The average stream gradient between Seely Road and Hanson Road is 0.75%, with steeper local gradients in upstream sub-reaches and lower stream gradients near Hanson Road. The impoundment created by the dam and Hanson Road extends to a location approximately 500 feet upstream of Hanson Road. Immediately upstream of the Hanson Road culvert, the impounded wetted width is approximately 100 feet. Bed substrates are fine-grained and organic rich and overlie gravels at depths of 0.5 to 4.0 feet. In this area, the stream has a braided pattern around vegetated bars composed of fine sand and silt (Figure 30). Banks in this reach are approximately one foot tall. Riparian vegetation consists of

obligate wetland herbaceous vegetation, shrubs, and mature tamarack and cedar trees. While walking the river, Inter-Fluve and CRA encountered submerged logs that showed evidence of being cut and placed in a row, indicating an old crossing approximately 200 feet upstream of Hanson Road.



Figure 30. Little Rapid River looking upstream from Hanson Road. Photo taken 05/11/2026.

Upstream of the impounded reach, the channel narrows to approximately 50 feet wide and has a bed composed of mobile sand and gravel. The wetted perimeter at baseflow occupies the entirety of the valley bottom, and banks are approximately one foot high. Large wood is abundant in the channel, and form channel-spanning complex networks that are densely vegetated with newer growth trees including tamarack and alder (Figure 31). Root networks form a layer both on the bed surface and above the water surface, stabilizing bed materials in place locally. The large wood splits and constricts flow in complex ways that forces pools, creates trailing bars, and results in near-equilibrium conditions of the sand bed.



Figure 31. Typical channel conditions in the Little Rapid River upstream of Hanson Road. Photo taken 05/11/2026 at Station 109+50.

In reaches farther upstream, approximately 0.5 miles upstream of Hanson Road, the riparian vegetation community shifts to a mature cedar swamp forest that extends into the channel (Figure 32). Large wood and racked coarse wood are abundant and many stable channel-spanning log jams are present (Figure 33). Vegetated bars commonly form behind jams, creating an anastomosing channel. Channel widths in this reach range from 30 to 70 feet, with an average of 50 feet. The widest and most complex sections of the channel occur in locations where large wood splits flow into three or four side channels that cover most of the valley bottom. Single-thread segments are typically narrower (see Station 124+37 in Figure 23 in Section 4.1.3). This reach is steeper than downstream, with a slope of 1.15%. Large wood pieces are typically covered by moss, well established, and appear to have been stable for long periods of time. This is common in groundwater-dominated systems where moderate flood flows are not powerful enough to mobilize wood. Boulders are scarce, but where present they force local scour and deposition.



Figure 32. Little Rapid River analog reach. Photo taken 05/13/2026.



Figure 33. Log jam in the Little Rapid River. Photo taken 05/13/2026.

4.4.2 Rapid River – Upstream

The Rapid River generally flows southwest before turning to the northwest just upstream of the Rugg Pond Dam impoundment. An old crossing is located about 100 feet upstream of the limit of the impoundment. The crossing includes a berm, a 48-inch corrugated metal pipe culvert, and a 24-feet-wide span over which a wooden footbridge has been placed (Figure 34). The crossing impounds water upstream for approximately 200 feet. In this sub-reach, the channel has a single thread and is approximately 100 feet wide (see Station 106+79 in Figure 21 in Section 4.1.1). Bed sediments are primarily silt and sand that have accumulated behind the crossing to depths of up to two feet. Large wood is present along the margins of the channel and absent within the channel.



Figure 34. Footbridge crossing the Rapid River upstream of the impoundment. Photo taken 5/13/2026.

Upstream of the sub-reach impounded by the old crossing, large wood begins to dominate channel forms and increases in density with distance upstream. Channel widths range from 70 to 90 feet with an average width of 74 feet. Bank heights are typically low, and the average bankfull depth is 3.2 feet (see Stations 114+43 and 115+34 in Figure 21 in Section 4.1.1). The valley bottom is approximately 350 feet wide and features prominent terraces on river left. Large wood jams frequently span the channel, split flow, create local scour and deposition, and act as nursery logs for new growth. This reach has an average gradient of 0.62%. Bed materials are primarily composed of sand with sparse gravel and cobble. The channel is stable, and mature cedar, tamarack, and birch trees line the banks and grow on downed nurse logs in the channel (Figure 35).



Figure 35. Typical channel conditions in the Rapid River upstream of the impoundment. Note the nursery log in the foreground supporting new growth. Photo taken 05/13/2026.

4.4.3 Rapid River – Downstream

In the reach downstream of the dam, the Rapid River channel ranges from 30 to 80 feet wide and has an average gradient of 0.57%. The average bankfull depth is 3.4 feet (See Station 81+77 in Figure 25 in Section 4.1.3). The active valley bottom is approximately 100 feet wide. The channel is primarily single-threaded but forms multiple channels in areas more than 1,100 feet downstream of the dam where log jams split flow and create stable bars. Bed materials are primarily composed of medium to coarse gravel. Banks are up to five feet high in areas where past channel excavation or floodplain fill have occurred, and these areas typically have plane-bed conditions with no large wood within the channel. Areas further downstream that have not been subjected to direct anthropogenic manipulation typically have riffle-pool morphology, large wood along the channel margins, and banks approximately two feet tall.

Downstream of a former road crossing at the downstream limit of county-owned land, near Westhaven Drive, large wood is more abundant and strongly influences channel forms (Figure 36). In this reach, alternating large wood jams force the channel thalweg to meander within a relatively straight valley bottom, force pools, and create bars (Figure 37). These wood jams typically consist of one or two key pieces that rack mobile and coarse wood. This pattern repeats over a stable reach approximately 400 feet long. Flow velocities are higher and bed materials are coarser in this reach than in reaches upstream of the impoundment.



Figure 36. Wood jam observed in the Rapid River downstream of Westhaven Drive. Photo taken 05/12/2026.



Figure 37. Representative photo of channel conditions in the Rapid River downstream of Westhaven Drive. Photo taken 05/12/2026.

4.5 LONGITUDINAL PROFILES

Channel profiles were developed using longitudinal and cross-sectional survey data collected by Inter-Fluve and select survey data from Spicer. The average gradient over the length of the full Rapid River profile (Figure 38) is 0.64%, with reach slopes of 0.62% upstream of the impoundment, 1.96% in the east spillway channel, and 0.57% downstream of the impoundment. The average grade of the interpreted DOR surface through the Rugg Pond Dam impoundment is also 0.62%, which is consistent with the overall river system slope. The profile for the Little Rapid River is shown in Figure 39. The slope of the reach upstream of the impoundment (0.75%) and that of the interpreted DOR surface (0.84%) are similar.

The DOR profile indicates a potential relic channel bed through the impoundment. Bed elevations near the upstream limit of the impoundment are at approximately 829 feet. The lowest bed elevations in the impoundment are approximately 816 feet and suggest continuity with elevations in the east spillway channel. The profile also exhibits several potential steeper grade breaks, including at, or just below, the location of the dam (station 83+00, about four feet of drop) and two potential grade breaks within the impoundment at stations 88+00 and 93+00.

The Hanson Road culvert is slightly perched above the river bed downstream of the road; the culvert invert is at elevation 830.3 feet while the bed elevation is around 829.4 feet. The upstream invert of the culvert (elevation 831.2 feet) is 4.1 feet higher than the interpreted pre-dam river bed elevation of 827.3.

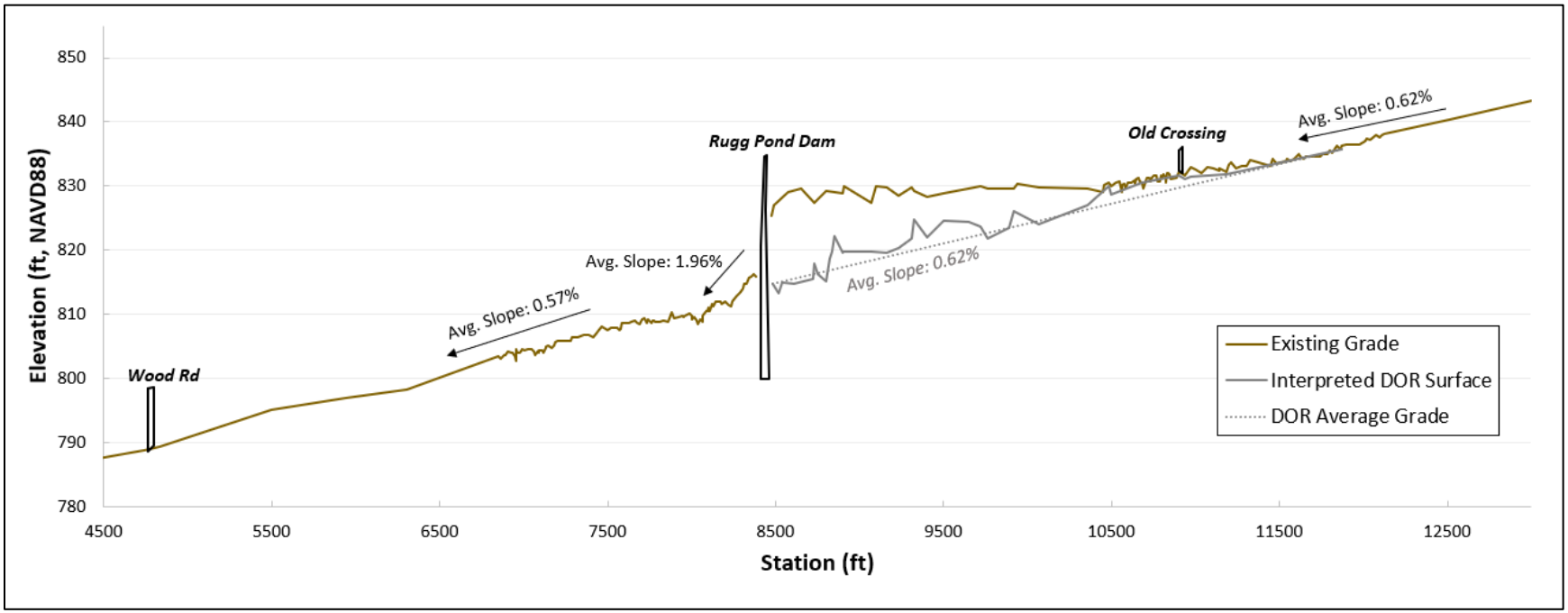


Figure 38. Longitudinal profile of the Rapid River from upstream of the old crossing off Hanson Road to downstream of Wood Road.

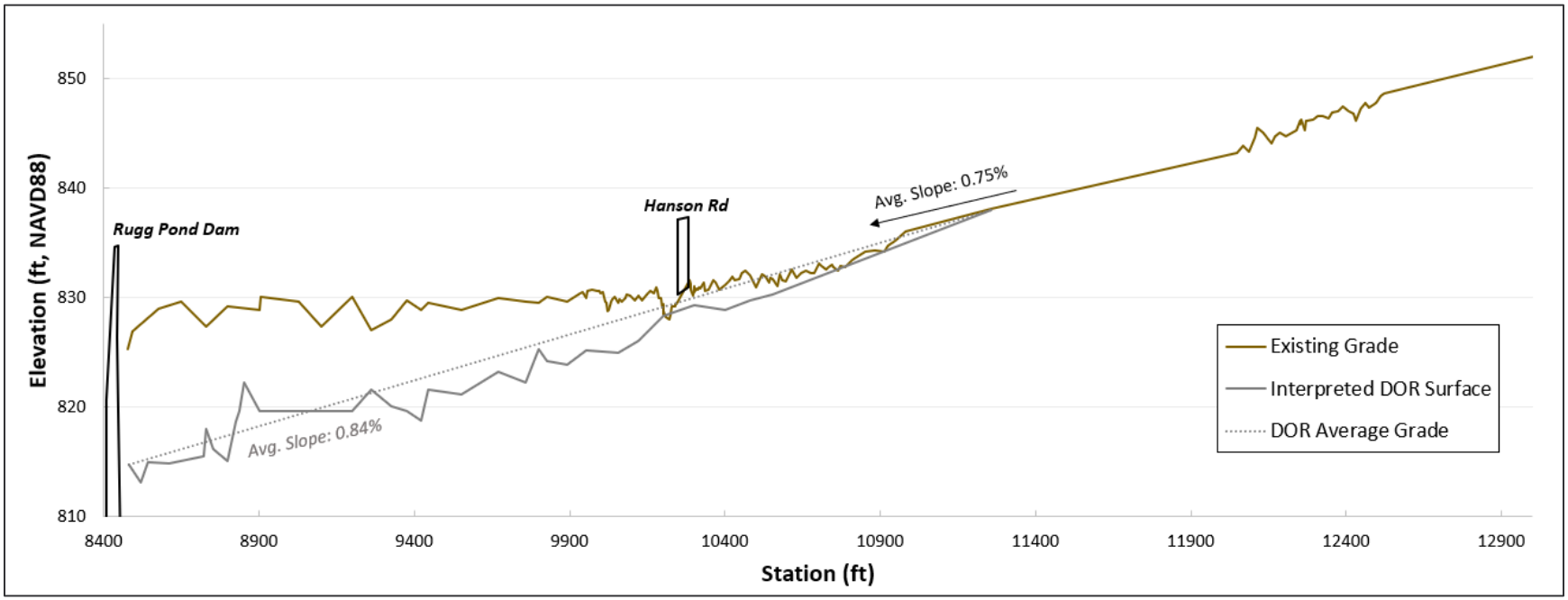


Figure 39. Longitudinal profile of the Little Rapid River from upstream of Hanson Road to Rugg Pond Dam.

5. Supporting Investigations

5.1 GEOTECHNICAL INVESTIGATION

Materials Testing Consultants (MTC) was retained to collect soil borings along the dam structure and at Hanson Road. The full Summary of Soil Borings Report prepared by MTC is included in Appendix D. MTC collected four soil borings to depths of 50 feet and one offset soil boring to a depth of 25 feet. At the Rugg Pond Dam embankment, the borings encountered very loose to loose granular fill and very soft to medium stiff cohesive fill at the ground surface to depths ranging from 13 to 18 feet. Medium dense to very dense granular subgrade was encountered under the fill material. Groundwater was encountered during drilling at depths from 3 to 5.5 feet (elevations 829.5 to 831.7 feet). At the Hanson Road crossing, very loose to medium dense granular fill was encountered at the surface to depths ranging from 5.5 to 8 feet. Very loose to very dense granular fill was encountered under the fill material. Groundwater was encountered at 5.5 to 6 feet deep (elevations 832.7 to 834.2 feet).

5.2 WETLAND ASSESSMENT

Inter-Fluve completed a wetland delineation for the project area on May 27th and 28th, 2026. The full Wetland Delineation Report is included in Appendix E. The delineation was conducted according to the Routine Onsite method described in the 1987 Corps of Engineers Wetlands Delineation Manual (United States Army Corps of Engineers, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (United States Army Corps of Engineers, 2012). The full wetland delineation report is provided in Appendix E. Six wetland units were identified within the study area, totaling 19.09 acres (Table 2 and Figure 40).

Table 2. Summary of wetlands found in the study area.

Wetland Unit	Cowardin Classification	Area (Acres)
A	Persistent, Emergent, Palustrine (PEM1)	0.12
B	Broad-Leaved Deciduous, Scrub-Shrub, Palustrine (PSS1)	2.27
C	Persistent, Emergent, Palustrine (PEM1)	0.09
D	Needle-Leaved Evergreen, Forested Palustrine (PFO4)	6.74
E	Diked/Impounded, Persistent, Emergent, Palustrine (PEM1h)	8.05
F	Needle-Leaved Deciduous, Forested, Palustrine (PFO2)	1.82

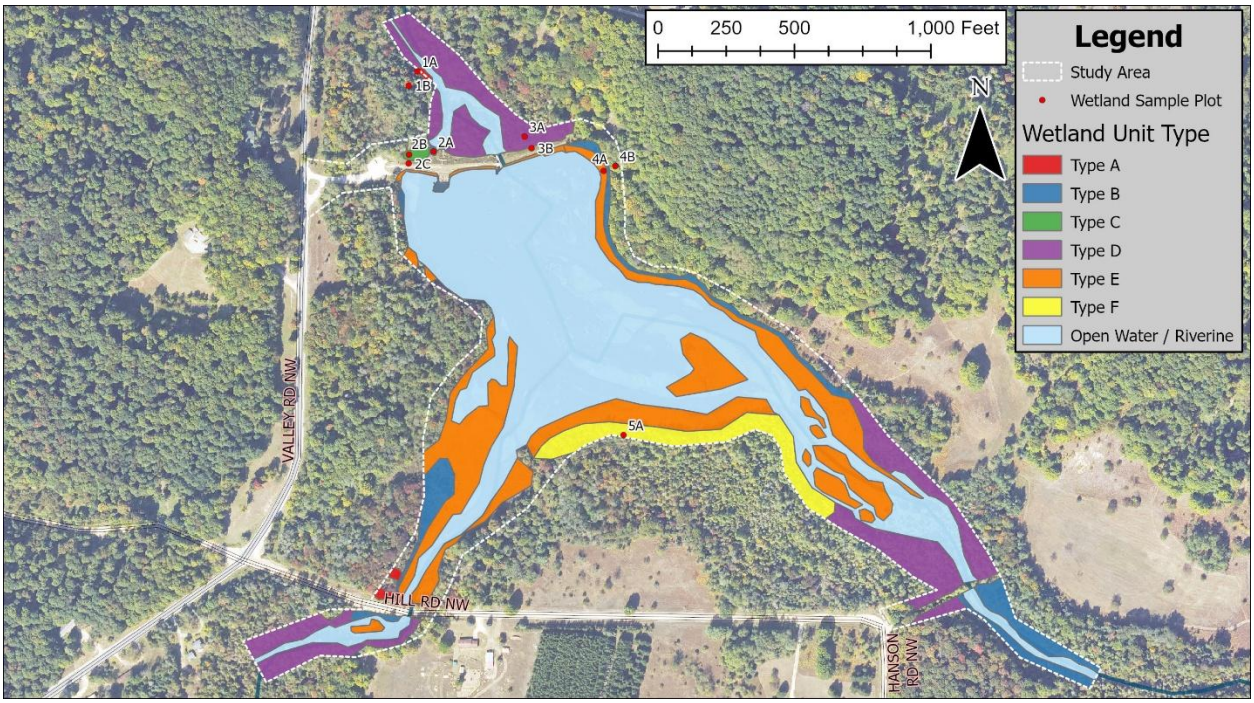


Figure 40. Wetland Unit Types and locations delineated in Inter-Fluve's on-site wetland delineation May 27 – 28, 2026.

Overall, the wetlands in the study area appeared to be driven in some part by groundwater, including from low-lying depressional positions, seeps created from modified landscapes, and shallowly inundated conditions. Each wetland unit had a distinct plant community. Emergent and herbaceous-dominated units were commonly characterized by sedges, horsetail, marsh marigold, and other hydrophytic herbaceous species. Other wetland units consisted more of shrub/forest communities including alder, willow, white cedar, and tamarack. Some wetland units consisted of a mix of herbaceous and forested vegetation. Soils across the wetland units were typically characterized by dark, mucky surface horizons. Redox was common in many sample plots of wetland units. In wetland sample plots, a restrictive layer such as cobble, wood, or rock was encountered, which may contribute to the shallow groundwater conditions. Overall, the soil profiles observed in the wetland sample plots were generally consistent with hydric soil characteristics in saturated soil settings.

5.3 THREATENED AND ENDANGERED SPECIES

The project team completed a U.S. Fish & Wildlife Service IPaC analysis (Information for Planning and Consulting) for the project site. The IPaC analysis identifies federally listed endangered, threatened, and candidate species that may be present in the project area and highlights designated critical habitats of these identified species, if applicable. The project site is in possible ranges of the federally threatened Eastern Massasauga (*Sistrurus catenatus*) and the federally proposed threatened Monarch butterfly (*Danaus plexippus*). No critical habitat for either species overlaps with the project area. This analysis will be revisited once a limit of disturbance is identified to review potential anticipated construction impacts and avoidance measures.

Michigan Natural Features Inventory (MNFI) rates the Rugg Pond Dam area as 'high' under its Biological Rarity (Biorarity) Index model (MNFI, 2006). This index score represents the biological richness and rarity of an area and combines information on species presence, rarity, and, in some cases, habitat quality, to give an overall measure of conservation value. A 'high' Biorarity score indicates that Rugg Pond Dam area is biologically rich and important for conservation.

5.4 HISTORICAL AND ARCHAEOLOGICAL ASSESSMENT

Heimlich Consulting was retained to document the cultural resources and any regulatory review regarding Section 106 documentation for the removal of Rugg Pond Dam. The Initial Archaeological Documentation and Phase I Archaeological Field Reconnaissance report prepared by Heimlich Consulting is provided to Kalkaska County and CRA under a separate cover. The USACE and Michigan State Historic Preservation Office (MSHPO) would require archaeological documentation of Rugg Pond Dam prior to removal. Rugg Pond Dam does have historical significance and retains its integrity as a National Register eligible structure. As a mitigating factor for removal, it is recommended that the minimum architectural documentation and archaeological monitoring occur during the entirety of the removal of the dam. The Phase I Archaeological Reconnaissance did not observe any buried cultural resources.

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Appendix A| Dam Repair Drawings

1983 engineering drawings and 1985 as-built drawings from Gosling Czubak for dam repairs.

Appendix B| Survey Surface Maps

Bathymetric, Refusal, and Sediment Thickness surfaces developed by Inter-Fluve.

Appendix C| GLEC Sediment Quality Assessment

Great Lakes Environmental Center sediment quality assessment report and laboratory results form 2020.

Appendix D| MTC Summary of Soil Borings Report

Summary of soil borings report developed by MTC under contract to Inter-Fluve.

Appendix E| Wetland Delineation Report

Wetland delineation report developed by Inter-Fluve.