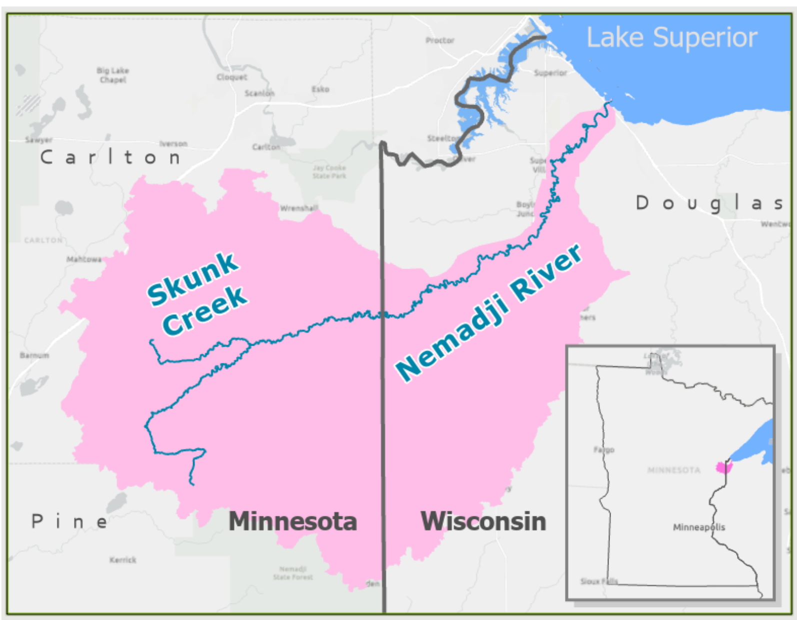
Skunk Creek Watershed

Minnesota's Lake Superior Basin

Project objectives

Effectiveness monitoring is essential in evaluating the efficacy of stream restorations and other watershed implementation projects. A main goal of such efforts is to then apply learned knowledge to improve future projects. The Minnesota Pollution Control Agency (MPCA) in partnership with local watershed partners has reviewed and selected 35 Section 319 project watersheds encompassing 114 Hydrologic Unit Code (HUC)-12 subwatersheds across the state to monitor and assess the effectiveness of watershed improvement projects.

Figure 1. Skunk Creek, in the Nemadji River Watershed



In June 2024, the U.S. Environmental Protection Agency (EPA) awarded the first of such four-year grants to Carlton Soil and Water Conservation District (SWCD) in partnership with the MPCA and Minnesota Department of Natural Resources (DNR) in the Skunk Creek Watershed (Figure 1). Monitoring within the grant aims to assess effectiveness of past projects including those administered under the Nine Key Element Plan, which was awarded in 2020 with EPA Clean Water Act Section 319 funding. Monitoring activities were designed to address each of the five components of watershed health: hydrology, geomorphology, connectivity, water quality, and biology; and other components such as landowner participation and roadway stability for an all-encompassing assessment of the benefits and limitations of projects.

This report summarizes the first year (July 1, 2024, through June 30, 2025) of effectiveness monitoring efforts in the watershed and presents initial data results.

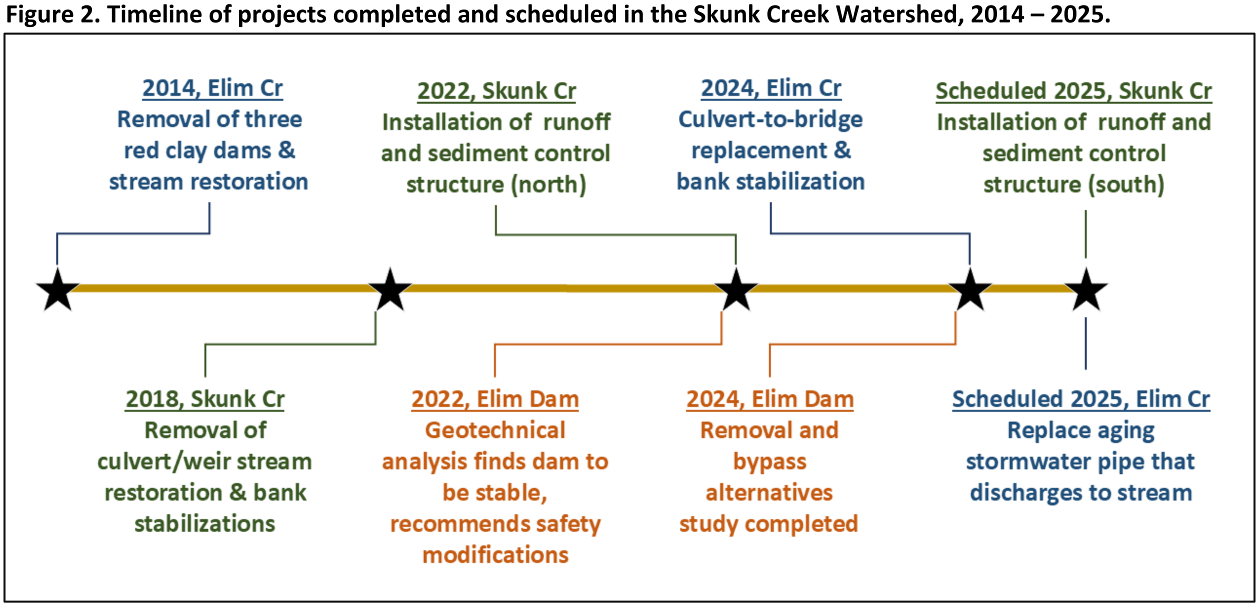
Watershed projects overview

Over the past decade, the Carlton SWCD and Carlton County Transportation Department (CCTD) initiated and managed various watershed improvement projects in the Skunk Creek Watershed to address water quality, stream stability, erosion, and fish habitat issues. Implementation focused on Skunk Creek and its tributary Elim Creek with projects ranging from roadway runoff containment to full-scale stream restorations. A timeline of completed and scheduled projects is shown below in Figure 2. The earliest projects were funded by the Minnesota Clean Water Fund and the U.S. Fish and Wildlife Service's Fish Passage Program. These projects included barrier removals and stream restorations on Skunk Creek and Elim Creek. In 2020, EPA Clean Water Act Section 319 funding supported the development of a nine key element (NKE) plan to implement projects and fund engineering designs and studies to address remaining issues in the watershed.

In addition to the construction projects listed in Figure 2, several smaller best management practices (BMPs) projects are scheduled for completion in 2025. They include a 16-acre pasture and hay planting adjacent to Elim Creek intended to reduce soil erosion and enhance water quality through increased species diversity, a 25-acre multi-species cover crop planting near the headwaters of Skunk Creek to correct bare soil conditions created by winter bale grazing, and 13.2-acre pasture and hay planting near the headwaters of Skunk Creek in a field that has been in annual crops for several seasons intended to reduce runoff, erosion, and nutrient loss.

Lastly, a degrading and perched culvert and related stream bank stability issue were identified on Elim Creek at the state Soo Line Recreational Trail crossing during the 2024 monitoring season. The soil material around the pipe culvert outlet is beginning to "unravel" causing sink holes in the landscape. The eroding sediment is being depositing into the downstream channel, which is incised, and several streambanks are undercut and eroding. Since this discovery, Carlton SWCD is working with other County and State partners to secure funding with the intent to replace the failing culvert within the next five years.

Figure 2. Timeline of projects completed and scheduled in the Skunk Creek Watershed, 2014 – 2025.



Year 1: 2024 Monitoring progress and results

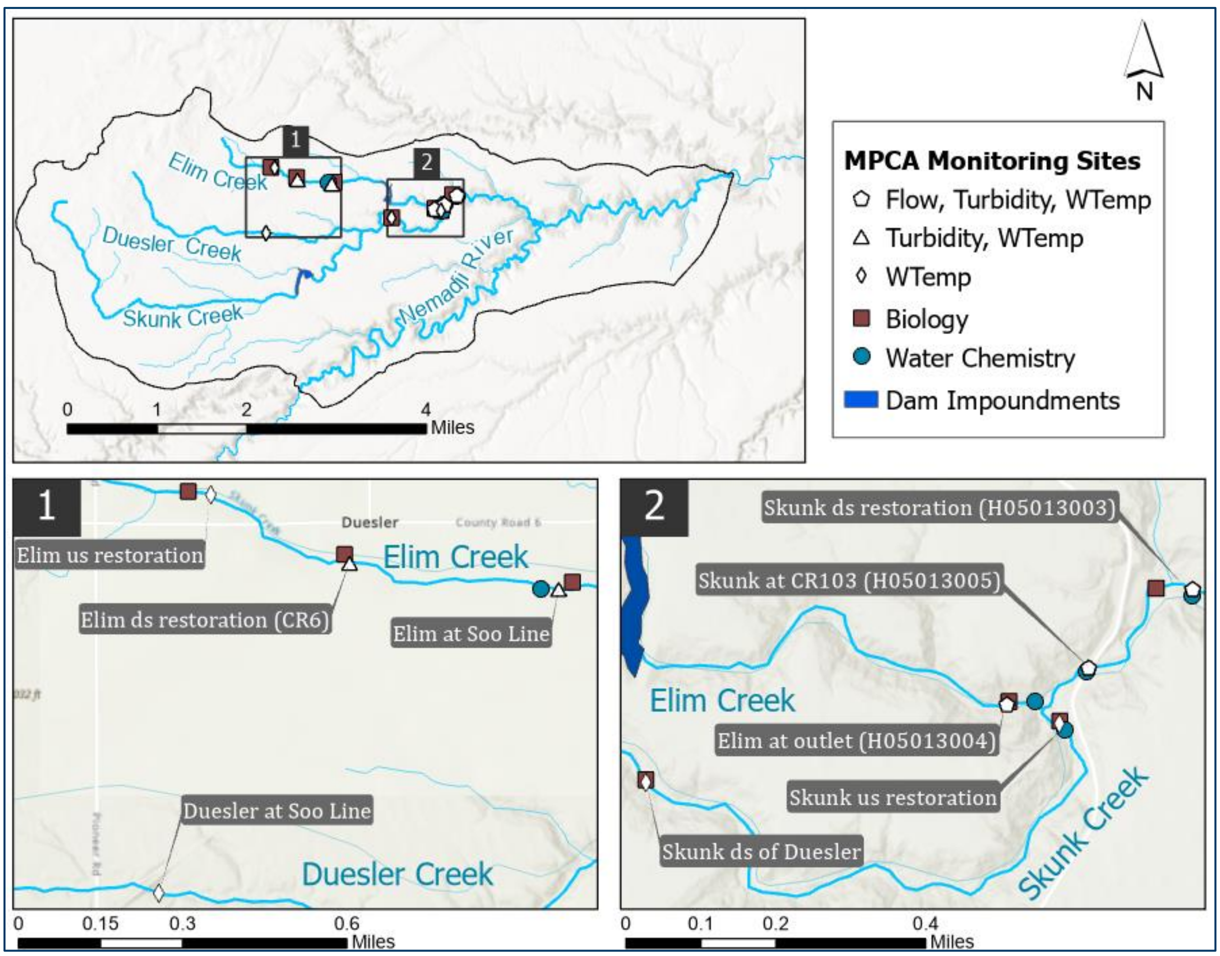
Monitoring for this effort officially began in June 2024 focusing on hydrology, geomorphology, connectivity, water quality, and biology at select locations (Figure 3).

In 2024, discrete water chemistry samples were collected and continuous measurements using deployed sensors were recorded to evaluate water quality across the watershed. Continuous water level was collected and associated streamflow was calculated at two stations (Figure 3, Flow). Discrete water chemistry data stored is stored in the Environmental Quality Information System (EQuiS) database. All continuous data including hydrological (water level/flow) and water quality data (water temperature and turbidity) are stored in the Water management information system by KISTERS (WISKI) database. Site identification numbers for each database are reported in Table 5 of the Appendix of this report.

Initial data results from 2024 monitoring efforts combined with available data collected prior to the issuance of this 319 Effectiveness Monitoring contract were combined to assess and report results.

Biology was not sampled in 2024 but is planned for the late-summer and fall of 2025.

Figure 3. Monitoring sites (past/present) for streamflow, continuous turbidity and water temperature (WTemp), and water chemistry sampling.



Hydrology

Skunk Creek gage H05013005

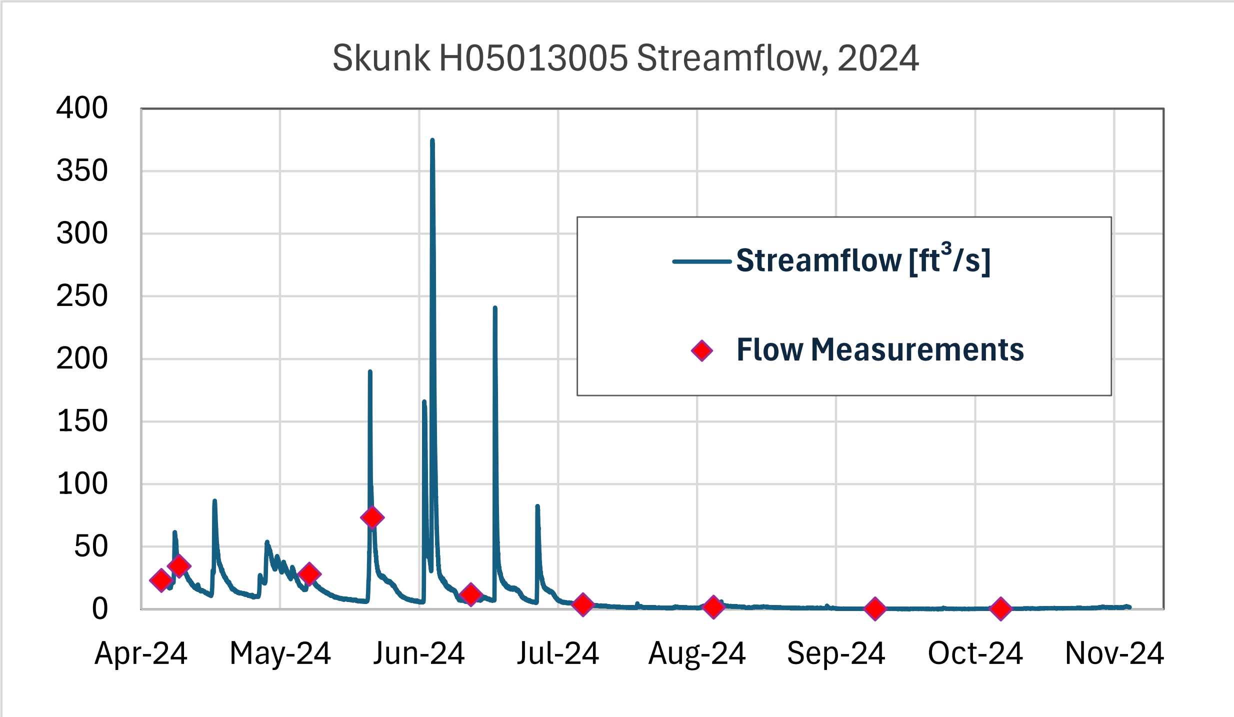
Since 2020, MPCA has been collecting 15-minute water level data using a radar sensor and calculating streamflow for Skunk Creek at the Carlton County Highway 103 bridge (Figure 4). This location is referred to as the *Skunk at CR103* site throughout this report. The WISKI identification number is H05013005. Water level and streamflow data collection continued during the 2024 open water season from April 8 to November 7.

Figure 4. Skunk Creek streamflow site, *Skunk at CR103* (H05013005).

Oscillations in water levels caused by sensor placement over a wavy and sometimes turbulent stream riffle created some level of uncertainty in the 2024 field measured stage readings. To alleviate these errors, a second sensor was placed on the upstream side of the bridge in April 2025. Water level data will be recorded at both upstream and downstream sensors for the 2025 season. The sensor with the best data quality (i.e. less oscillations in water level data) will record water levels after 2025.

Discrete flow measurements were collected nine times throughout the 2024 season to validate and build a level-streamflow rating curve. Seven of those measurements were waded using a FlowTracker2 acoustic doppler velocimeter and two were collected by a moving boat method using a Sontek RS5 acoustic doppler current profiler. Discrete flow measurements captured all flow conditions (very low, low, moderate, high, and very high) in 2024 (Figure 5 and Table 1). Flow measurements from past years were also considered in the development of the rating curve. Daily streamflow values were quality coded fair to poor based on the number and quality of flow measurements used to develop respective sections of the curve. Flow measurements collected after the 2024 season will be used to further improve the rating curve for this gage. Four measurements were collected between April and June of 2025 covering low, moderate, high, and very high flow conditions.

Figure 5: Continuous streamflow in units of cubic feet per second (cfs or ft^3/s at Skunk gage H05013005 and discrete flow measurements in the 2024 open water season.



In 2024, a DTS-12 turbidity and temperature sensor collected continuous data at this location and is discussed more in the continuous water quality section of this report.

Skunk Creek former gage H05013003

Pre-restoration flow data on Skunk Creek was gaged 250 meters downstream of the H05013005 location in years 2009 through 2013, at the downstream end of all restoration projects (Figure 3). This location is referred to as the *Skunk ds restoration* site throughout this report. The WISKI identification number is H05013003. During operational years, water levels were collected using a pressure transducer in a pool at the former culvert/weir outlet. These data are used in various analysis within this report as pre-restoration streamflow.

Elim Creek gage H05013004

The Elim Creek flow gage (Figure 6) was installed in August 2024. This location is referred to as the *Elim at outlet* site (Figure 3) throughout this report. The WISKI identification number is H05013004.

Figure 6. The MPCA measuring streamflow at *Elim at outlet* gage (H05013004).

The gage setup at this location consists of a pressure transducer to measure continuous water level, a staff gage to record field measured level, and a DTS-12 turbidity sensor to record continuous turbidity and water temperature. The pressure transducer and staff gage became unstable on August 31, days after installation, and resulted in erroneous water level values through September 11, 2024, when the problem was identified. The equipment was remounted, and the gage collected good data through November 7, 2024, when the pressure transducer was removed for the winter season.

The pressure transducer was reinstalled April 2025, prior to spring season peak flows, as was a trail camera focused on the staff gage and stream channel.

Discrete flow measurements were collected by wading method with a FlowTracker2 four times between August and November 2024, capturing low and very low streamflow conditions. The daily streamflow record will be calculated in two to three years when adequate flow measurements are available to establish a water level-streamflow rating curve. Flow measurements collected after the 2024 season will be used to further improve the level-discharge rating curve for this gage. Three measurements between 0.5 cfs and 6 cfs were collected between April and June of 2025.

Hydrology data storage and analysis

Flow data for the 2024 season (Skunk H05013005 and Elim H05013004) and all historical flow records (Skunk gages H05013003 and H05013005) are stored in the WISKI database and are summarized in Figure 7.

Monthly flow volumes at the Skunk Creek gage H05013005 in 2024 align with DNR Climatology reports that March through June finished as the seventh wettest on record for the area with a 4.85-inch precipitation surplus; and that normal precipitation in July and August was followed by the driest September on record and below normal precipitation in September and October. Results for the 2025 season will be reported in next year's annual summary.

A flow duration curve was completed for Skunk Creek using all flow data (2009 through 2024) from Skunk gages H05013003 and H05013005 to define five flow regimes (very low, low, mid-range, high, and very high) based on percent flows exceeded for the period of record (Table 1). The flow regimes are also displayed in the water quality duration curve analysis in the *discrete (sampled) water quality* section of this report to evaluate if water quality targets for total suspended solids (TSS) are being met under various flow conditions.

Annual peak flows for Skunk Creek, considering both the past and current gage locations, range from 65 cfs to 907 cfs (maximum recorded in 2012 during a 500-year flood) and have a median value of 183 cfs for years 2010 through 2024. The "very high flow" range (highest 10% of the flow record) is extensive and ranges from 19 cfs (Table 1) to 907cfs. This is a result of a highly flashy stream system, one that experiences significantly increased flows following the onset of a precipitation and a rapid return to pre-rain conditions shortly after the end of the precipitation.

Flood frequency analysis was outlined in the monitoring plan but was decidedly not completed. A review of the discharge dataset identified multiple factors that would affect the reliability of such analysis 1) a small overall flow dataset, 2) missing data from snowmelt through early May of year 2009; and all November data for years 2020 through 2023, and 3) uncertainty in very high discharge values. The MPCA will aim to compute missing November flow data for respective years and measure more high flows over the course of this project to improve the reliability and quality of flood frequency analysis. New data will also be included in updating monthly flow volumes reported in Figure 7.

Figure 7. Flow records for years 2009-2013 (pre-restoration on Skunk Creek, gage H05013003) and 2020-2024 (post-restoration, gage H05013005) averaged and compared to the 2024 flow record (gage H05013005).

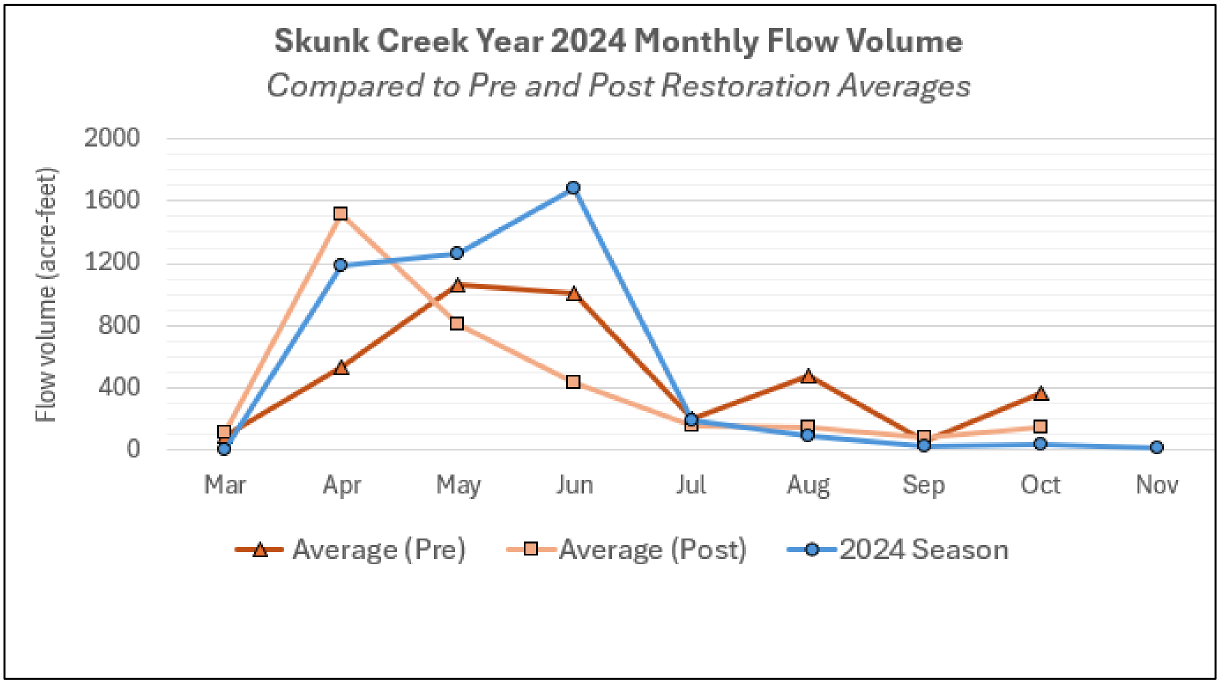


Table 1. Flow regimes for Skunk Creek using 2009-2024 data from gages H05013003 and H05013005

Flow regime	Flow range (cfs)	Range for % flow is exceeded
Very Low	< 0.45	> 90
Low	0.45 - 1.38	60 - 90
Mid-range	1.38 - 3.10	40 - 60
High	3.10 - 19.15	10 - 40
Very High	> 19.15	< 10

Geomorphology

Two main goals of the effectiveness monitoring effort were to 1) evaluate the success of stream restoration work and BMP implementation and 2) learn from each project to improve future efforts. Fluvial geomorphology is a useful tool in that evaluation process.

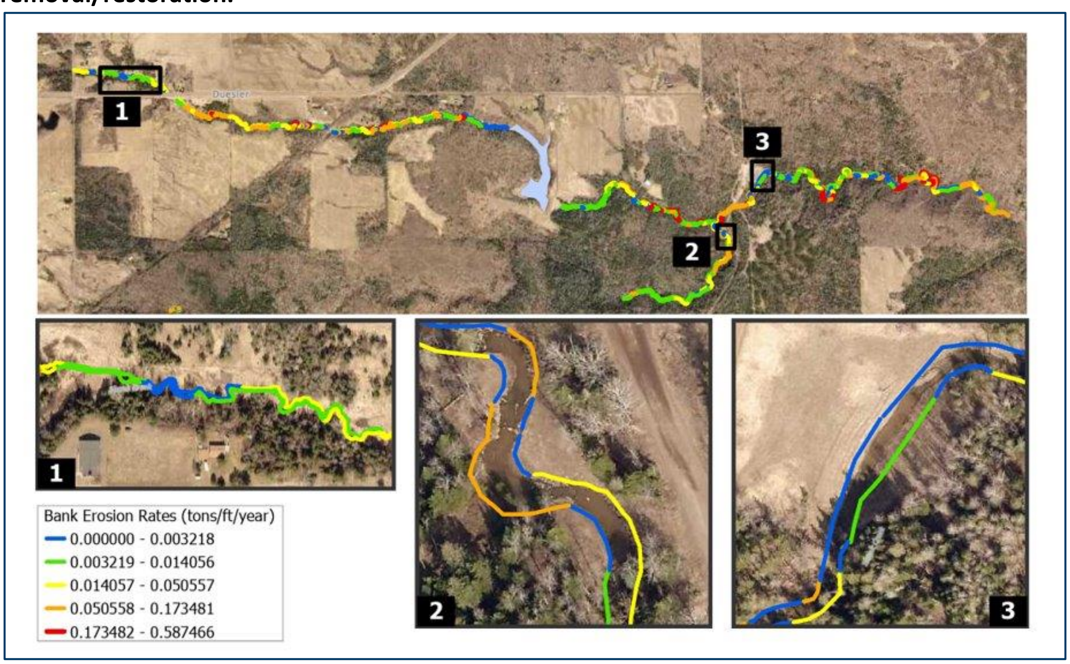
Fluvial geomorphology is defined by the DNR as the study of river processes and form that focuses on the hydrodynamic forces that shape rivers; the result of the interplay between the force of moving water and the materials forming the streambed.

Geomorphology surveys were completed by DNR in 2024 on Skunk Creek, Elim Creek, and Duesler Creek. Surveys included the collection of longitudinal and cross-sectional data and the completion of stability worksheets and pebble counts. Some surveys occurred at completed restoration sites, while others were on unrestored reaches and those expected to undergo future restoration efforts. Nine surveys were completed throughout the watershed. Five of the surveys included the placement of monuments at the cross-sections so that the future surveys can be compared to 2024 surveys.

The DNR staff used desktop analysis and field data collection to begin the Watershed Assessment of River Stability and Sediment Supply (WARSSS). The WARSSS is a three-phase methodology developed by Dave Rosgen of Wildland hydrology. The methodology identifies locations and processes adversely affected by land uses, provides a quantitative analysis of sediment supply and channel stability, predicts factors contributing to sediment yield, and establishes a process for mitigation. WARSSS will continue in the watershed throughout 2025 with a goal to finalize a report in 2026.

Rapid Bank Assessment for Nonpoint source Consequences of Sediment (BANCS) is a model that predicts annual erosion rates by incorporating field observations of bank erosion hazards (based on attributes such as bank height, root density, bank material, etc.) and near bank stress (rates the energy exerted by the stream against the bank). Rapid BANCS data was collected in the watershed (Figure 8) by DNR in the spring through fall seasons of 2024. These data were used to determine erosion rates, which ranged from low (blue) to high (red) across the Skunk Creek Watershed.

Figure 8. Bank erosion rates are shown across the watershed and within restorations in subset maps: 1. Elim Creek dam removal restoration, 2. Skunk Creek bank stabilization/restoration and 3. Skunk Creek culvert-weir removal/restoration.



Generally, erosion rates were low to moderate in the restored reaches; however, moderately high erosion rates were documented within the upstream Skunk Creek restoration (Figure 8, Inset map 2) and with less severity in the downstream Skunk restoration (Figure 8, Inset map 3). To further explain areas of higher erosion and stream function within restoration reaches, the Minnesota Stream Quantification Tool (MNSQT) was applied.

MNSQT, a spreadsheet tool funded by EPA that quantifies the functional lift of stream restoration and mitigation projects, was applied to specific restorations and reaches. The MNSQT is designed to produce objective, verifiable, and repeatable results by consolidating well-defined procedures for objective and quantitative measures of defined stream variables. Four geomorphic categories (*riffle percentage, pool depth ratio, pool spacing ratio, and dominant BEHI/NBS combinations*) collected by DNR in 2024 were applied. MNSQT outputs both a score and categorization (functioning, functioning at risk, not functioning) for a given reach. A summary of project reaches, geomorphology observations, and MNSQT results from the DNR are below:

Elim Creek clay dam removal project (site: *Elim us restoration*. Figure 8, inset map 1)

Restoration work to remove three clay dams and restore the stream to a natural channel occurred on two stream segments within this reach, an upstream segment downstream of Pioneer Road and a downstream segment just upstream of CR6.

In general, the upstream segment looks stable, and the restoration appears to have met objectives. MNSQT results conclude *riffle percentage* is "functioning at risk" while the other categories are "functioning." Although the *riffle percentages* fall into the "at risk" category, they are very close to the "functioning" category. Survey results found that the cross-sections surveyed in 2024 are slightly wider and deeper than the initial design. However, there is little apparent incision, which is supported by bank measurements that verify the river is connected to its floodplain.

The farther downstream segment of the project does not score as well as the upstream as both *riffle percentage* and *pool spacing ratio* are "functioning at risk". This may be due, in part, to impacts from a downstream culvert which was recently replaced in fall of 2024 to alleviate stream stability and fish passage issues. Like the upstream project, deviation from design on channel dimension is found on surveyed cross-sections in this reach. Similarly, it does not seem to be a detriment to the project. This segment has very deep pools, which are critical trout habitat, and overall, displays very little erosion.

Skunk Creek bank stabilization project (site: *Skunk us restoration.* Figure 8, inset map 2)

The primary goal of this restoration was to stabilize a slump area along County Road 103 by regrading, stabilizing, and protecting the stream bank.

The MNSQT *riffle percentage* scored within the "not functioning" category and *BEHI/NBS combination* scored within "functioning at risk." The geomorphology survey and MNSQT results uncovered several design issues of concern with the highest being that the design cross-sectional area is double the area projected by regional curves (channel dimension relationships defined for Northeast Minnesota). This presumably over time will lead to 1) future erosional downcutting, vertical erosion that deepens the channel by removing stream bed material, at the project site and 2) aggradation, sediment deposition that fills the channel resulting in a shallower depth, in the downstream culvert/weir removal project site.

Other technical aspects of the design (e.g. bankfull benches at incorrect elevations, no toe-wood in the middle meander, and misplaced J-hooks) are cause for concern and are reducing the stability and functionality of the reach. Additionally, the end of the restoration is not adequately tied into the existing downstream channel. These results suggest that overtime this reach will be prone to additional erosion. Current elevated bank erosion rates are documented in Figure 8, inset map 2.

Skunk Creek culvert removal project (site: *Skunk ds restoration.* Figure 8, inset map 3)

The primary goal of this restoration, to remove a pipe culvert and reduce very high erosion at the pipe outlet while also allowing passage of brook trout to upstream coldwater habitat, was achieved.

MNSQT *riffle percentage* and *pool depth ratio* scored within "functioning at risk." While clearly an improvement from the pre-restoration channel, there are questions about the project's design/construction and longevity of function. Specific concerns are the bankfull to floodplain width ratio, a wide variation in riffle cross sectional area, and the atypical positioning of a J-hook at the beginning of the restoration. The J-hook likely led to a blowout of the right bank at the start of the restoration, which is the only area with a higher BEHI/NBS (Low/High) combination in this restored reach. Despite the concerns, currently (seven years post-project) there is little evidence of active incision other than the erosion at the J-hook.

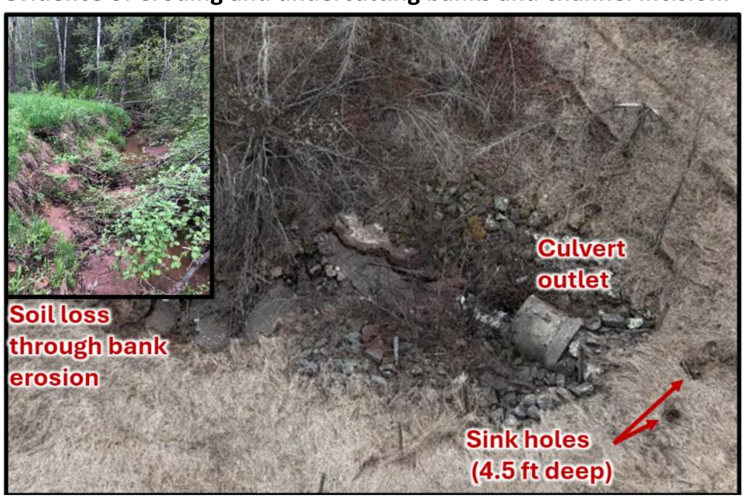
Lastly, there is little difference between the riffle and pool cross-sectional areas, which indicates that sediment is filling pools over time and reducing available habitat. The sediment likely is coming from the upstream project site and/or an unrestored and incised reach located between the two project sites. The unrestored section is "not functioning" for both *pool spacing ratio* and *BEHI/NBS combination*.

Elim Creek proposed culvert removal project on state trail (site: *Elim Soo Line*)

This reach of Elim is impacted by a perched culvert under the Soo Line Recreational Trail. The replacement of the culvert is being proposed as a future project due to sediment loss and the forming of sink holes around the pipe outlet (Figure 9).

MNSQT pool spacing ratio scores as "not functioning" and BEHI/NBS combination scores within "functioning at risk". There is evidence of undercutting banks and incision in the cross sections, both related to erosion. The pool spacing ratio also indicates instability. The dominant BEHI/NBS combination within the surveyed segment is Moderate/Moderate (moderate erosion on both right and left banks) and shortly downstream shifts to High/Moderate (high on one bank, moderate on the other) or High/High (high erosion on both banks).

Figure 9. Soo Line Trail culvert outlet at Elim Creek. Two sink holes have formed near the outlet and there is evidence of eroding and undercutting banks and channel incision.



Elim Creek, between Elim dam and Skunk Creek confluence (site: *Elim at outlet*)

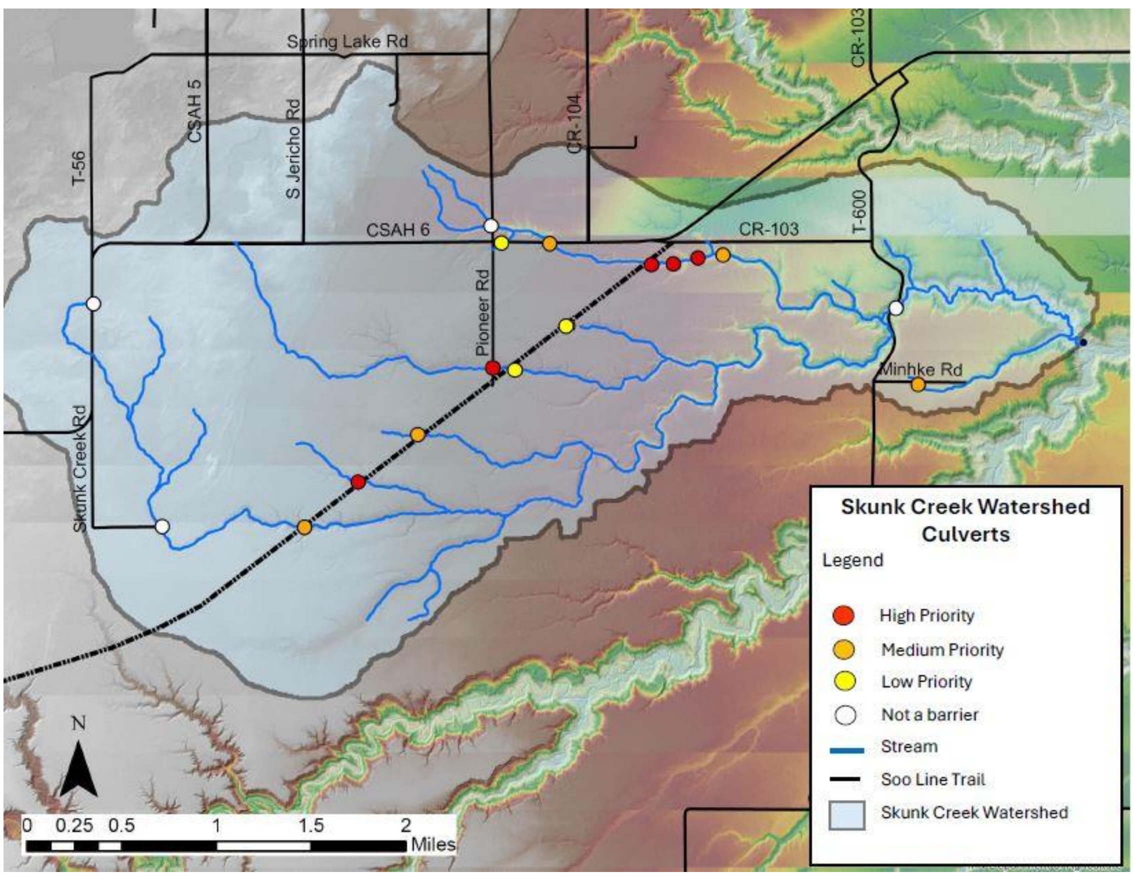
No restoration work was completed on this reach, but it is a primary monitoring location and is impacted by other streams and barriers in the watershed. This includes upstream Elim dam and the down-cutting of Skunk Creek downstream. The riffles in this reach are incised and the riffle percentage scores in the "not functioning" category. Channel incision likely stems from concentrated flows at Elim dam's outlet pipe. While this is more pronounced upstream, the effects can still be seen in this area. The downstream end of the survey has an increase in slope, which is likely due to the downcutting of Skunk Creek, which is creating a head cut moving up Elim Creek. In short, this area is being negatively impacted on both ends.

Connectivity

In summer of 2024, DNR completed a culvert survey in the Skunk Creek, Elim Creek, and Duesler Creek (tributary to Skunk Creek) subwatersheds. The DNR Stream Crossing Basic Assessment form was used to collect data for each road crossing. The crossings were then evaluated using a Stream Crossing Prioritization Matrix (SCPM) to identify those that are barriers to sediment transport and aquatic organism passage, and prioritize crossings (low, medium, high) based on the severity of impact on stream function based on conditions observed upstream and downstream of the crossing.

The survey and SCPM located 17 crossings within the Skunk Creek Watershed (Figure 10), that includes 7 in the Elim Creek Watershed, 3 in the Duesler Creek Watershed, and 7 in the main Skunk Creek Watershed. Of these crossings, 13 (76%) were identified as barriers. There are 1.4 crossings per stream mile and 1.8 barriers per stream mile. This density of crossings and barriers per stream mile is comparable to that of watersheds within the city of Duluth (Mission Creek = 1.3 crossings per stream mile, and 1.2 barriers per stream mile). The density is increased by the Soo Line Recreational Trail and private crossings. Priority crossings for removal, replacement, or repair within the Skunk Creek Watershed are spread throughout the watershed and include five high priority and five medium priority crossings. The highest priority crossings for removal, replacement, or repair are concentrated in the Elim Creek Watershed. An additional high priority crossing is located on Duesler Creek.

Figure 10. Stream Crossing Prioritization map in Skunk Creek Watershed. Identifies crossings that are barriers to sediment transport and aquatic organism passage.



Continuous water quality

Water temperature

One of five main goals listed in the NKE plan is to maintain water temperature for Skunk Creek (and its tributaries) to stay within Class 2A coldwater expectations and support coldwater species such as brook trout. Water temperature sensors were deployed in 2024 at all nine locations displayed in Figure 3. Data were recorded at 15-minute intervals at 8 of the sites. The sensor at location *Skunk Creek ds of Duesler* was lost during deployment in summer of 2024. Continuous water temperature was measured using a combination of sensors including DTS-12s and Onset hobo V2 dataloggers.

For each of the three stream systems, sites are ordered from upstream to downstream in Table 2, illustrating the percent of time (Growth %) June through August that temperatures are in an optimal range to support brook trout (Salvelinus fontinalis), or in ranges that cause stress or become lethal to brook trout under prolonged periods. Additionally, each site is assigned a thermal class based on its growth temperature range and average summer temperature.

Thermal classes explained below, do not change within stream reaches irrelevant of restoration work. The *Elim us restoration* site has the coldest summer temperatures and is most suitable to support brook trout in higher relative densities. Cold temperatures there are likely due to close connectivity to groundwater springs within the sandier geology and past stream restoration efforts that removed three clay dams. Temperatures downstream of the impoundment (*Elim at outlet* site) are two degrees warmer than the three Elim Creek locations upstream of the dam. While *Elim at outlet* site temperature can support brook trout, it is more suitable to support a mix of cold, cool, and warmwater species. All three Skunk Creek sites are located downstream of a major Skunk Creek impoundment and likewise are most suitable to support a mix of cold, cool, and warmwater species.

Table 2. 2024 temperature metrics, color-coded by MPCA's Northeast Minnesota thermal classification for Skunk, Duesler and Elim Creeks.

Site	Growth %	Stress %	Lethal %	Avg Temp (Celcius)	Thermal Class (Northeast MN)
Skunk ds of Duesler	---	---	---	---	---
Skunk us restoration	66%	34%	1%	19.2	2
Skunk at CR103	70%	29%	0%	18.8	2
Skunk ds restoration	69%	30%	1%	18.9	2
Duesler at Soo Line	83%	17%	0%	17.8	3
Elim us restoration	100%	0%	0%	15.3	4
Elim ds restoration (CR6)	95%	5%	0%	16.7	4
Elim at Soo Line Trail	97%	3%	0%	16.7	4
Elim at outlet	68%	32%	0%	18.5	2

Thermal Class 2: Can support Brook Trout/other coldwater species, often a mix of cold, cool, and warmwater taxa
Thermal Class 3: Frequently supports Brook Trout and other coldwater species, lower relative densities
Thermal Class 4: Frequently supports Brook Trout and other coldwater species, higher relative densities

Pre-and-post restoration temperature data was available for two stream segments: 1) *Elim Creek outlet* site and 2) the combination of two sites (*Skunk at CR103* and *Skunk ds restoration*) that are located 250 meters apart.

Comparing to historical data, the percent of summer water temperatures within the optimal growth range for brook trout has decreased over time at both Elim at outlet site (Figure 11) and the reach that includes both Skunk at CR103 and Skunk ds restoration sites (Figure 12) with a moderately strong correlation (r2 =0.49) for the Elim at outlet site and a weak correlation (r2 = 0.17) for the combined Skunk Creek sites. Further analysis of thermal density plots (Figure 11 and Figure 12, right) show more specifically the reduction of the proportion of measurements in the low temperature range and an increase in measurements in the higher temperature range in the water column for those same locations.

DNR Climatology summaries for 2024 report that April through August air temperatures averaged about 1.0°F above the 1991 through 2020 normal (30-year arithmetic mean) for the region. September through October surged to 6.2°F above normal, and September finished 1.2°F warmer than any other September in 130 years of record. Continued monitoring of air and water temperature is important in expanding the dataset to better monitor temperature trends and understand the influences on water temperatures in this watershed. Sensors were deployed at all Skunk and Elim sites again in 2025.

Figure 11. Elim Creek thermal stats (% Growth and % Stress) for data years between 2006 and 2024 (Left) and density plot (Right) for the same period at *Elim at outlet* site H05013004.

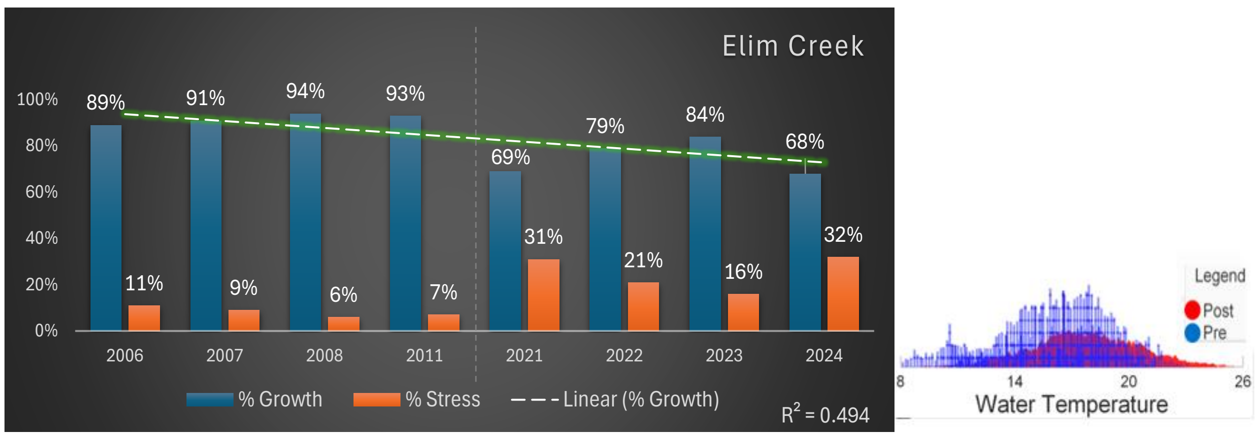


Figure 12. Skunk Creek thermal stats (% Growth and %Stress) for data years between 2006 and 2024 (Left) and density plot (Right) for the same period in the stream reach that extends from *Skunk at CR103* site H05013005 downstream to *Skunk ds restoration* site H05013003.

Stream turbidity

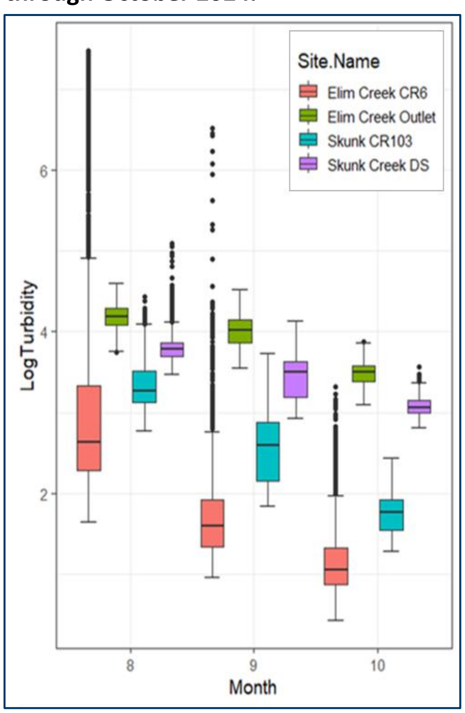
Continuous turbidity sensors (model DTS-12) recording at 15-minute intervals were deployed at four locations: 1) *Elim ds restoration CR6*, 2) *Elim at outlet*, 3) *Skunk at CR103*, and 4) *Skunk ds restoration* (Figure 13) in 2024. The sensor for *Skunk at CR103* was installed in late-May 2024 and the remaining three sensors were installed in August. All sensors collected data through October.

An adjustment was made to the continuous turbidity monitoring design in 2025. Three sensors were redeployed in the same locations as the 2024 placement, and the fourth sensor was moved to a new location (Figure 13). The sensor for site *Skunk at CR103* was moved downstream of the Soo Line Recreational Trail crossing on Elim Creek where a project to replace a failing culvert is currently being considered. The intent is to collect pre-project data for future effectiveness analysis. Continuous data for the 2025 season will be reported in the 2026 annual report.

Figure 13. Continuous turbidity locations, 2024 and 2025. Black squares = sensors placed in the same location both years, while circle symbols show the movement of a 2024 sensor (white) to a new location (black) in 2025.

Turbidity at all four 2024 sites (Figure 14) generally decrease over the August to September period. Elim Creek at CR6 (pink) has the lowest interquartile values of the four sites, which can be explained by its small drainage area and sandier geology. Higher outliers at that site were potentially caused by construction activity immediately upstream at the culvert-to-bridge removal site and will be re-evaluated again at the end of the 2025 data year.

Figure 14. Continuous turbidity whisker plots show spatial variability within Skunk and Elim Creeks August through October 2024.

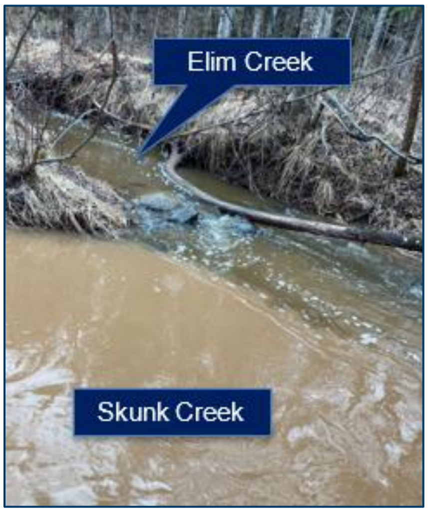


Downstream of the Elim dam at *Elim at outlet* site (green), the interquartile range increases from the upstream site, likely due to both the clayey geology and contributing sediment from stream downcutting and areas of high bank erosion (displayed in Figure 8).

Turbidity levels noticeably decrease downstream of the Elim-Skunk confluence at *Skunk at CR103* (blue) and then slightly increase at *Skunk ds restoration* (purple) within the 2018 culvert removal restoration reach. Erosion from an incised and unrestored stream section between the two Skunk Creek restorations is a potential cause of the increase.

Continued geomorphology surveys and data collection over the next 10 or more years will help in causal analysis and is scheduled to occur every 2 years.

Figure 15. Elim Creek flowing into a more turbid Skunk Creek.



More detailed analysis of turbidity (i.e. over various seasons, flow regimes, and/or rain event size) is presumably needed based on conflicting results of secchi data at the stations. For example, in April 2025, photographs (Figure 15) and secchi readings (Elim = 35cm, Skunk = 9cm) for a half-inch rain event show clearer water at the Elim Creek outlet than Skunk Creek, suggesting that turbidity in the system is more complex than the whisker plot displayed in Figure 14 and turbidity dynamics may vary based on flow regimes and/or specific events or conditions.

TSS-turbidity regressions were not evaluated due to lack of data points for most locations. These will be evaluated in future annual reports, starting with the completion of the 2025 data collection season.

Discrete (sampled) water quality

In 2024, the MPCA and SWCD collaboratively collected 18 water quality samples and secchi readings at each of the two primary water quality sampling sites (*Skunk ds restoration* and *Elim at outlet*) which are co-located near the flow gages. Samples were analyzed for TSS, total phosphorus (TP), chloride (Cl), total Kjeldahl nitrogen (TKN), and Nitrate-Nitrite. Additional TSS and TP samples were collected five times, capturing varying flow regimes and seasonality, at three additional monitoring locations (Figure 3, Water Chemistry sites) and will be used to create turbidity-TSS regression curves and/or assess spatial changes in sediment and phosphorus water chemistry. The MPCA collected samples April through June of 2024, using Clean Water funding and the SWCD collected samples July through November 6, 2024, using 319 Effectiveness Monitoring contract funds.

In 2025, samples were collected at primary sites 11 times through June 23 with 8 corresponding secchi collected during that period. Secondary site samples were collected three times. Sampling will continue throughout the 2025 ice-free season.

Water quality results

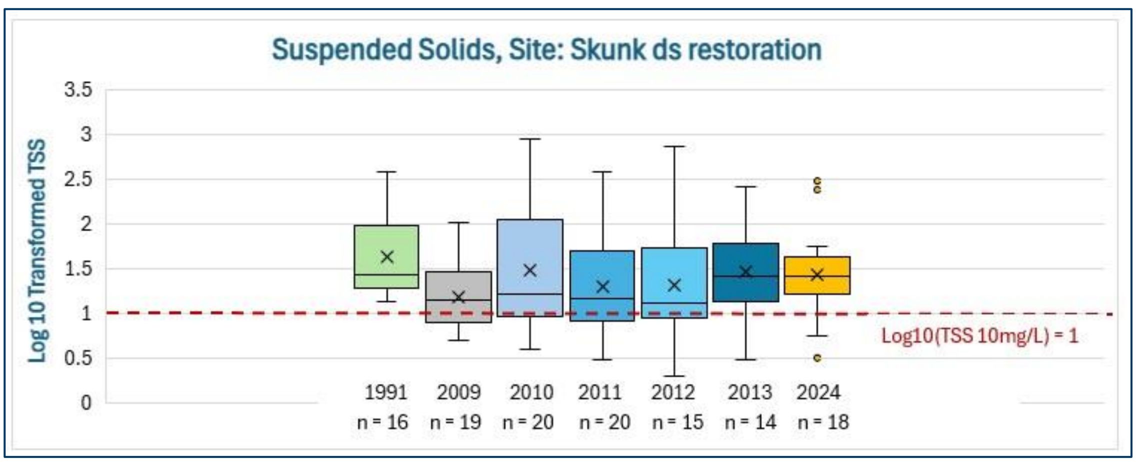
Past studies conclude that the nature of the soil in this area has made it difficult for this stream to meet the TSS and TP water quality standards simply because of the high erodibility of the landscape and because the fine sediments suspend easily upon disturbance and then slowly settle. Water quality data (TSS and volatile solids) from years 2010 to 2013 confirms that inorganics or soil material account for most of the TSS at the Skunk Creek site. Furthermore, soil bound phosphorus is believed to be the main source of TP in the stream based on a strong TSS-TP relationship ($r^2 > 0.8$) suggesting that TP remains high due to elevated TSS.

Water quality sample results for the 2024 open water season are summarized in Table 3 and show that Cl and nitrate-nitrate levels were well below the water quality target (criteria) by one to two orders of magnitude in both Skunk and Elim Creeks. TKN values were also low. TP and TSS exceeded the respective water quality standards for most samples. Maximum annual values for the two parameters were at least one order of magnitude greater than state water quality criteria. The percent exceedance of water quality criteria for TSS and TP in the 2024 dataset (Table 3) and the greater post-restoration dataset (TSS = 82%, TP = 80%) was equal or greater than reach exceedances (TSS = 66%, TP = 80%) sampled in pre-restoration years. However, evaluation of such changes is limited by the lack of post-restoration data as shown in TSS whisker plots (Figure 16) and water quality duration curves (Figure 17).

Table 3. Water quality sample results for 2024 season at the primary sites. Median and maximum values as well as the percent of samples exceeding the Minnesota water Quality Standards (criteria) are shown.

Stream Site	Analyte	Sample Count	Median (mg/l)	Maximum (mg/L)	Exceeding %	Criteria (mg/L)
Skunk Cr	Chloride	18	2.4	7.9	0	230
downstream of	Nitrate + Nitrite	17	0.06	0.15	0	10
restoration	TKN	17	0.9	2.0	---	---
	Total Phosphorus	21	0.09	0.28	86	0.05
	Suspended solids	18	26	300	83	10
Elim Cr	Chloride	18	4.9	8.3	0	230
outlet	Nitrate + Nitrite	17	0.07	0.23	0	10
	TKN	17	1.2	1.9	---	---
	Total Phosphorus	21	0.10	0.28	86	0.05
	Suspended solids	18	32	280	94	10

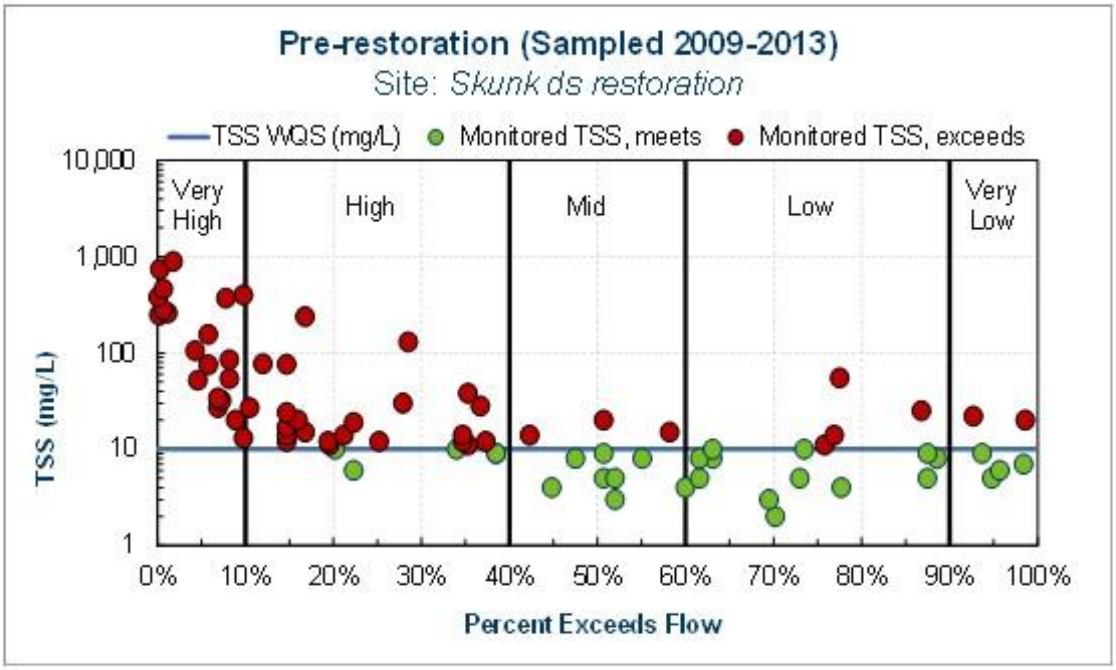
Figure 16. Whisker plot of log transformed TSS for Pre (1991-2013) and Post (2024) project years at site *Skunk ds restoration (ID: S005-617)*. Only years with 14 samples or more were graphed. Red dashed line = Log transformed WQ standard (10mg/L)

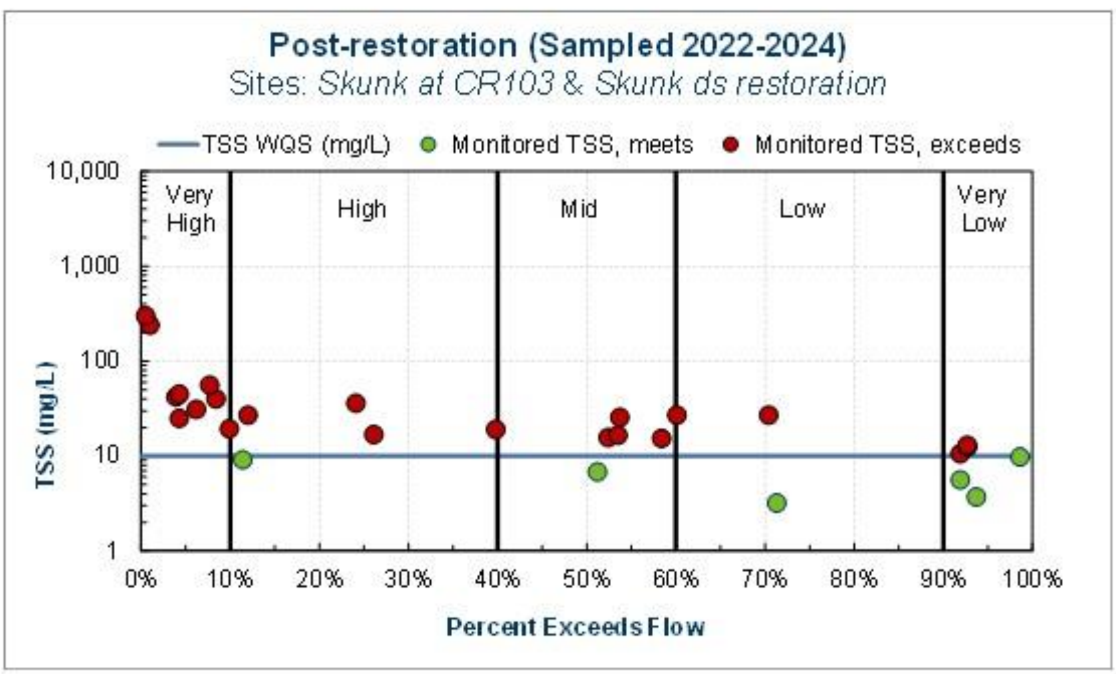


While 2024 post-restoration median values (Figure 16) are comparable to pre-restoration median values, both Figure 16 and Figure 17 display a decrease in maximum TSS concentrations in 2024 compared to pre-restoration years. Reduced concentrations of samples collected within high and very high flow regimes (Figure 17) further infer potential success of stream restorations and other watershed projects in reducing extreme erosion and associated TSS concentrations.

More post-restoration samples are needed to evaluate trends and/or the presence of statistically significant changes in water quality over time and within different flow regimes. Flow duration and water quality duration curves and tables will be evaluated annually as more data is collected. These analyses will be completed on Elim Creek in the future but presently are limited by lack of both pre- and post-restoration data.

Figure 17. TSS water quality duration curves pre- and post-restoration for Skunk Creek sites *Skunk ds restoration* (ID: S005-617) and *Skunk at CR103* (ID: S002-600) which are located 250 meters apart. Graphs show the number of samples that meet and exceed water quality target (10 mg/L) for five flow regimes.





Pollutant loads and flow weighted mean concentrations

This project intends to further evaluate changes within the water quality dataset by evaluating annual loads and flow weighted mean concentrations (FWMC; concentration weighted proportional to a corresponding flow rate) for TSS and TP over time.

For this first year, annual mass loads and FWMC were calculated at site *Skunk ds restoration* using FLUX32 method 8 for all five analytes samples (Table 4) for the period of record when samples were collected, April 6 through November 6, 2024. The MPCA aims to complete by the end of the next fiscal year the same analysis for 2025 samples, and TSS and TP load calculations and FWMC for past years given there is sufficient data. Historical data will then be used to evaluate change in annual loads and FWMC on Skunk Creek over the full data record including pre- and post-restoration years.

Table 4. Pollutant Load concentrations and FWMC for Skunk Creek site *Skunk ds restoration* (S005-617) at the downstream end of the restored reach, calculated with FLUX32. Data range is from April 6 through Nov 6, 2024.

	Mass (kg) Load	FWMC (mg/L) Load/Volume	Sample Count	Daily Flow Duration (Days)	Daily Mean Flow Rate (cfs)	Daily Total Flow Volume (Acre Feet)
Suspended Solids	464,821	84.0	18	215	10.5	4,486
Total Phosphorus	760	0.14	18	"	"	"
Total Kjeldahl Nitrogen	6,863	1.24	17	"	"	"
Nitrate + Nitrite	361	0.07	17	"	"	"
Chloride	10,268	1.86	18	"	"	"

Biology and habitat

Fish and macroinvertebrate sampling (that will include an observational scan for mussels), and quantitative habitat assessments will begin in field season 2025 at seven locations (Figure 3). The MPCA staff and the SWCD met four times between October 2024 and March 2025 to finalize locations for biological sampling, identify equipment and training needs, delegate responsibilities, and set goals and timelines. Field reconnaissance, quantitative habitat surveys, and fish and macroinvertebrate sampling will occur June through September 2025. Field training for quantitative habitat assessments was completed in early June 2025.

The DNR Fisheries stocked brook trout (identified by fin clips) in the watershed at four locations in October 2024, including within restoration reaches on both Elim Creek and Skunk Creek. Biologists will document the number of clipped and unclipped brook trout in the sample to assess resident verses stocked trout.

Outreach and education

In 2024 and early 2025, several outreach efforts were conducted in the watershed ranging from educational workshops to targeted mailings and phone contact with landowners. In 2024 and the start of 2025, 11 letters were sent to landowners regarding geomorphic surveys and monitoring and restoration efforts taking place in the watershed. Responses were received from five of the landowners.

An invitation (Figure 18) for an educational workshop focused on agricultural BMPs was sent to landowners throughout the Nemadji River Watershed in early 2025. Four landowners in the Skunk Creek Watershed registered for the event.

Lastly, both phone calls and in-person meetings were conducted in 2024 and 2025 with a specific landowner in the Skunk Creek Watershed regarding the Elim Dam removal and bypass alternatives study outlined in Figure 2. This outreach is planned to be continued throughout 2025 to inform next steps and goals for Elim Dam.

Figure 18. Agricultural BMP workshop mailing to landowners.

Road stability

Roadway Materials Tracking

During fall of 2024 and winter of 2025, Carlton SWCD and the CCTD partnered to develop an add-on to a staff timecard and created an application (developed by the Carlton County GIS team) to document and inventory materials used in road maintenance projects in the Skunk Creek Watershed. This application will record the volume of gravel used during grading, shoulder repair and maintenance, flood repairs, ditch washouts, culvert washouts, and general washout repair. This tool will be utilized throughout the 2025 season and beyond to record gravel usage for grading and maintenance of gravel roads and other storm-related repairs.

Roadway Runoff Secchi Tube Sampling

Secchi tube measurements and photographs were collected in roadside ditches and/or tributaries near roadway runoff and sediment control project sites four times in 2024 and five times in 2025, targeting periods when ditches were flowing. Frequently secchi measurements coincided with water quality sample collection. Photographs of a 1.25" rainfall event on May 2, 2025, are shown in Figure 19. Secchi readings in flowing ditches will continue throughout April 2028, at which time, the value and need for such data will be re-evaluated.

Figure 19. Observed clarity at Right: north ditch to Skunk Creek at CR103 crossing, Middle: Skunk Creek upstream of the CR103 crossing, and Left: south ditch to Skunk Creek at CR103 crossing.

Future reporting

The current contract period for effectiveness monitoring in the Skunk Creek Watershed extends through April 2028. An annual report will be submitted in July of each year to document monitoring and data analysis progress. This report covered monitoring and analysis through the fiscal year (July 1, 2025) as stations were being established and adjustments were made to the plan through spring 2025. Future reports will cover monitoring and analysis over the open water season of each calendar year.

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CLEAN WATER LAND & LEGACY AMENDMENT

Appendix

Table 5. Monitoring site identification numbers for water quality discrete samples (EQuIS) and continuous hydrology/water quality data (WISKI). Continuous data sites with H prefix indicate hydrology (water level/flow) and water quality data were collected. Continuous data sites with W prefix only have continuous water quality data.

Monitoring Site Name	Water Quality Sample ID (EQuIS* data system)	Continuous Data ID (WISKI** data system)
Skunk ds restoration	S005-617	H05013003
Skunk at CR103	S002-600	H05013005
Skunk us restoration	S011-857	W05013009
Skunk ds of Duesler	-	W05013010
Duesler at Soo Line	-	W05013008
Elim at outlet	S007-453	H05013004
Elim at Soo Line	S002-601	W05013006
Elim ds restoration (CR6)	S017-299	W05013007
Elim us restoration	-	W05013011

*EQuIS = Environmental quality information system

** WISKI = Water management information system by KISTERS

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