Trott Brook
Water Quality
Restoration Assessment

Prepared by:

Anoka Conservation District

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Primary author:

Jamie Schurbon	Anoka Conservation District, Watershed Projects Manager

Review and comment by:

Brian Clark	Anoka Conservation District, Natural Resource Technician
Rebecca Haug	Anoka County Transportation Division
Ryan Sandhoefner	City of Elk River, Engineering Project Manager
Mark Riverblood	City of Ramsey, Parks & Assistant Public Works Director
Bruce Westby	City of Ramsey, Public Works Director/City Engineer
Joe Feriancek	City of Ramsey, Assistant City Engineer
Becky Wozney	Lower Rum River Watershed Mgmt Org., Watershed Coordinator
Chuck Johnson	Minnesota Pollution Control Agency, Watershed Hydrologist
Bonnie Goshey	Minnesota Pollution Control Agency, Project Manager
Reid Northwick	Minnesota DNR, Watershed Specialist
Dan Cibulka	Sherburne Soil and Water Conservation District

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Cover Photo:

Trott Brook at Nowthen Blvd in the City of Ramsey

Disclaimer

At the time of printing, this report identifies and ranks potential BMPs in or near Trott Brook. This list of practices is not all-inclusive and does not preclude adding additional priority BMPs in the future. An updated copy of the report shall be housed at the Anoka Conservation District.

Contents

Brief Summary

- **Oxygen and biotic impairments** – Trott Brook from Ditch 51 to the Rum River is listed by the MN Pollution Control Agency (MPCA) as impaired (not meeting state water quality standards) for low oxygen and impaired biota (depleted invertebrate & fish communities). Previous studies identified elevated phosphorus as an underlying cause of low oxygen, and low oxygen as an underlying cause of biotic impairments. Those designations and findings utilized monitoring data from only the Nowthen Blvd stream crossing. This study collected data from seven sites along the stream length to assess conditions, diagnose the problems, and recommend solutions.

- **Low oxygen throughout stream** – We found low dissolved oxygen (DO) throughout the length of Trott Brook. DO was notably higher (better than) than observed during 2013-2015; the impairment does not appear as severe as previously thought.
- **Phosphorus slightly below impairment level** – Trott Brook is close to, but slightly better than, state phosphorus standards. Phosphorus levels across all sites the last 10 years average 94.6 µg/L with a standard deviation of 10.7 µg/L, compared to the state standard of 100 µg/L.
- **Stream corridor wetlands consume oxygen** – While previous studies pointed to phosphorus as the cause of low oxygen, in this study we deduced that a large contributing factor is the wide peatland floodplains through which the stream flows. This is exacerbated by lateral ditches within these wetlands that drain to Trott Brook.
- **Large oxygen demand reductions needed, likely unachievable** - Oxygen demand reductions needed to meet state water quality standards were estimated at 40% in the 2017 total maximum daily load (TMDL) study. Modelling every possible practice on the landscape with no limit on cost results in a 36.3% TP reduction & 15% DO reduction – falling well short of the goal at an estimated cost of >$36M. The model does not incorporate new data that found somewhat improved oxygen levels, but the reductions needed are still large.
- **5% phosphorus reductions recommended as an interim goal** - Phosphorus reductions large enough to achieve dissolved oxygen standards are not feasible nor cost effective. A modest 5% phosphorus reduction is feasible at reasonable costs as a starting point. This level of reduction is recommended to prevent a new impairment for phosphorus, would be consistent with watershed-level goals of 5% phosphorus reductions to the Rum River from all areas, and would help reduce dissolved oxygen and biotic impairments. Additional phosphorus reductions may be sought after this interim goal is achieved.
- **Top projects are wetland restorations and ag practices** - The three most cost effective practices for water quality are a) wetland restorations within the stream corridor by plugging peatland lateral ditches, b) agricultural conservation practices such as conservation tillage and cover crops, and c) robust stormwater standards for new development. Other possible practices are detailed in this report.
- **Wetland restorations by lateral ditch blocks may outperform model predictions** – The HSPF (Hydrological Simulation Program – Fortran) model is not strong at estimating nutrients or oxygen demand from drained floodplain wetlands. Nor does it represent well the practice of floodplain wetland restorations by lateral ditch blocks. These projects should be pursued for multiple benefits to dissolved oxygen, nutrients, habitat, and hydrology. They may make reaching goals more achievable.

- **Avoid ditch cleanout** – Maintenance cleaning of lateral ditches could have a negative impact on Trott Brook water quality. Most ditches have been neglected and filled over time, which is desirable from a stream water quality standpoint.
- **Urban stormwater pollutant reductions aren't the primary solution** - While the 2017 TMDL study calls for 82% of oxygen demand reductions from MS4 regulated communities' stormwater, only 19% of oxygen demand is estimated from that source. Most reductions need to come from voluntary actions on non-permitted, non-point pollutant sources.
- **Impairment designation needs to be revisited** - A re-evaluation of the stream's impairment status is warranted based on new data, and planned by MPCA in 2026. Low oxygen is not as severe as previously observed. It appears that the low oxygen meets conditions for a 4D natural background designation due to the influence of surrounding wetlands. Data supporting the biotic impairment as of 2024 is mixed, and it may be appropriate to consider this stream for Tiered for Aquatic Life Use (TALU) standards that set reduced expectations for ditched or modified waterways.

Executive Summary

Purpose

The purpose of this study was to identify causes of low oxygen and biotic impairments in the Trott Brook corridor, and identify projects to address them. The report further estimates the magnitude of pollutant reductions needed to achieve water quality goals. Practices to achieve those reductions are ranked by cost-effectiveness. It is intended that local watershed managers will use this document to prioritize their work. It is further intended that the Minnesota Pollution Control Agency will use the new findings to update their assessment of Trott Brook's condition, including whether it meets state water quality standards and which standards should apply.

About Trott Brook

Trott Brook is a small stream that drains to the Rum River. It originates in Sherburne County, Minnesota near the City of Elk River and flows through the City of Ramsey in Anoka County. The 23,069 acre watershed (excludes Ford Brook subwatershed) is a mixture of residential, agricultural, and undeveloped lands that is developing as part of the Twin Cities suburbs. The watershed is dominated by sandy soils. The stream is approximately 10-20 feet wide and 1-4 ft deep. In most areas it flows through a broad peatland floodplain that is 300-1,300 feet wide. It is a low-gradient stream with a drop of 2-6 feet per mile. The stream is not actively used for recreation (fishing, boating, swimming, etc) due to limited access and its small size.

Nearly all of the stream is ditched or straightened, except the final 2 miles before discharge to the Rum River. The entire main channel and all tributaries are part of the state's "altered waterways" inventory. Many lateral ditches were dug in the early 1900's, and 20 currently exist. Most of these are short, with the purpose of draining floodplain wetland adjacent to the stream. Today, lateral ditches have more total length than the channel of Trott Brook and its natural tributaries.

Impairment Status

Trott Brook is currently listed as "impaired" for not meeting four Minnesota water quality standards. It has a low oxygen impairment for which a TMDL report was completed in 2017. Elevated phosphorus was identified as a primary contributing factor. Impairments for benthic macroinvertebrates and fish were the subject of a 2016 stressor identification study that listed low oxygen and high phosphorus as primary stressors, while recognizing the altered channel as a contributing factor. Finally, a high sulfate impairment was added in 2020, as it would relate to wild rice production. All of these impairment designations were based on data at only the Nowthen Blvd stream crossing and apply to the reach from Ditch 51 to the Rum River.

Study Components

This study included:

- **Water quality monitoring**. In 2023, we monitored seven sites along the length of Trott Brook. This included 8 grab samples at all sites before 9:00 a.m. to document daily low oxygen levels. Deployable dissolved oxygen sondes were placed at four sites for eight simultaneous days. Additionally, eight grab samples were taken in 2024 at Nowthen Blvd only.
- **Stream health assessment**. The Minnesota Stream Health Assessment protocol was performed at each of seven sites. This protocol rates surrounding land uses, riparian zone conditions, in-stream habitat, morphology, and aquatic vegetation.
- **Stream stability assessment**. A level III Pfankuch stream reach inventory and channel stability evaluation was performed at each of seven sites, including Rogen stream type categorization.
- **Restoration goal recommendations**. An HSPF SAM model aided in estimating pollutant reductions needed to achieve goals. Unfortunately, the model could not be updated from 2015 to current land

uses, nor calibrated with post-2015 so it is the same model used by MN Pollution Control Agency (MPCA) in the 2017 TMDL study.

- **Pollutant source assessment**. An HSPF SAM model aided in determining pollutant sources. We further deduced the relative importance of various sources from monitoring data, stormwater discharge maps, and other methods.
- **Practice identification**. Practices reasonable to implement in the subwatershed, possible benefits, and approximate costs were identified by HSPF SAM modeling & professional judgement.

Water Monitoring Findings

The entire stream length had moderately low oxygen, but not as low as observed by pre-2016 monitoring. It is important to note that the MPCA's minimum data requirements for assessing the water as impaired were met only for the Nowthen Blvd site over the last 10 years. With that said, the four of six sites with lesser data were on track to exceed the dissolved oxygen impairment criteria (>10% of samples <5mg/L) if more data were collected.

The Ditch 27 tributary is model-estimated to not have low oxygen problems, but this has not been field-verified. Reviewing aerial photos, we find that this ditch, like Trott Brook, flows though large and nearly continuous wetlands and has similar land uses. The channel is poorly defined or indiscernible in many of these wetlands. If wetlands are a significant source of oxygen demand, Ditch 27 may have low dissolved oxygen.

Sondes observed oxygen fluctuations at four sites along Trott Brook, with moderately low to low oxygen at each. Minimum oxygen was around 5 mg/L at two sites and 4 mg/L at two sites. Diel oxygen fluctuations were 3.98 to 7.96 mg/L compared to a desirable fluctuation of <3.5 mg/L. There was no upstream-to-downstream improvement or deterioration of dissolved oxygen levels.

Trott Brook is close to, but slightly below, the total phosphorus state standard of 100 µg/L. Average total phosphorus in the last 10 years was above that standard at four of seven sites, but the highest was only 105 µg/L. The average across all sites was 94.6 µg/L with a standard deviation of 10.7 µg/L. There was no upstream-to-downstream improvement or deterioration of conditions.

Causes of Low Oxygen and Phosphorus

We examined possible causes of low oxygen and sources of phosphorus. It's notable that observed levels of neither parameter correlate well with land uses. Both parameters are similar in the upstream rural reaches, middle agricultural reaches, and lower suburban reaches. HSPF SAM modeling estimated nearly equal (10-20%) oxygen demand from each major land use – grassland, forest, wetland, ag, and developed. We modeled best management practices (BMPs) in these land uses but were unable to reduce oxygen demand by more than 15%. This suggests a pollutant source not well accounted for in the model may be important.

We looked closer to the stream channel for possible sources. A 2016 MPCA stressor identification study suggests "channelization appears to be draining a wetland complex and may be contributing to the elevated nutrient concentrations along with the low DO concentrations observed." Our observations complimented the idea that the broad peatland wetlands through which Trott Brook flows are a cause of low oxygen and a likely source of phosphorus. These wetlands are 300-1,300 ft wide along most of the stream. Oxygen consumption by decomposition of organic material in these wetlands is likely high, and delivery of low oxygen water to the stream is accelerated by 20 man-made lateral ditches. The MPCA's guidance document for assessing water recognizes this scenario: "Some low-gradient, heavily wetland-influenced streams may never meet the current DO standard of 5 mg/L, even though pollutant sources and anthropogenic influences are insignificant or even non-existent. In such cases, the current DO standard is not a useful indicator of the health of the water (MPCA, 2024)."

Phosphorus concentrations in Trott Brook seem too low to be the primary or only causative factor for low oxygen or high diel oxygen fluctuation. Trott Brook's phosphorus concentrations are lower than the median for Anoka County streams. There are many other streams nearby with higher phosphorus but no low oxygen problem. This corroborates with the hypothesis that oxygen demand in wetlands adjacent to the stream, which might not be reflected in in-stream nutrient concentrations, is consuming oxygen. Reducing phosphorus levels is nonetheless recommended for other reasons and can only benefit the low oxygen condition.

Pollutant Reductions Needed and Feasibility

The best estimate is that a 40% (332 lbs/yr) oxygen demand reduction is needed to achieve water quality standards. That number is from the TMDL Study (MPCA, 2017_a), with correction of an apparent TMDL typographical error described in this report. Our modeling suggests this is unattainable. The most cost-effective modeled practices of agricultural conservation tillage and cover crops inexpensively achieve the first 9% of oxygen demand reductions and 22% of phosphorus reductions, but after that the return per dollar spent is poor. Maximizing BMPs (practices in every possible location with no budget limit) in the model yields only about a 15% oxygen demand reduction and 36% phosphorus reduction at a cost of >$36 million. The model does not do a good job of considering the practice of wetland restoration by plugging lateral ditches, and that practice may outperform others.

While achieving dissolved oxygen standards does not seem feasible, pursuing phosphorus reductions would benefit that goal and others. We suggest setting a modest interim reduction goal for phosphorus to make progress toward addressing low oxygen and biotic impairments, ensure Trott Brook does not become impaired for high phosphorus, and compliment efforts to keep the Rum River from becoming impaired for phosphorus. A 5% phosphorus reduction is the goal for the Rum River in the Lower Rum River Watershed Management Organization and Rum River Watershed Partnership plans. Once accomplished, additional reduction goals could be set.

Locations to Achieve Pollutant Reductions

Low oxygen and elevated phosphorus are present throughout the length of Trott Brook, and no one location is prioritized for practices. While not easily measured or modeled, we believe wide peatland wetlands alongside most of the length of Trott Brook are the primary source of oxygen demand and nutrients. Outside of this area, modeling estimates similar pollutant loading from a variety of land uses including urban, cropland, forested, grassland, and wetland. Therefore, there is no particular portion of the watershed or land use in greater need of pollutant reductions. Focusing on developed and agricultural lands with direct drainage into the stream should be prioritized, in addition to floodplain wetland restorations.

While the TMDL study (MPCA, 2017_a) attributes 82% of reductions needed to permitted MS4s (entities with stormwater system permits), pollutant reductions from developed landscapes won't sufficiently address the problem. The pollutant reductions needed are larger than all pollutant generation from developed lands. Moreover, <6% of the Trott Brook subwatershed is served by stormwater pipes and there are only five stormwater pipe outfalls directly into the stream. While stormwater treatment is an important strategy, it is not of greater importance than treating other land uses.

Practices to Achieve Pollutant Reductions

Top practices to reduce oxygen demand and phosphorus include:

1. **Restoration of wetlands** that are currently drained into Trott Brook. Likely method is ditch blocks in lateral ditches.
2. **Agricultural practices** including no till, reduced tillage, cover crops, water and sediment control basins, or others. Prioritize fields directly discharging to the stream. This practice will become less important as more agricultural lands are developed.
3. **Stormwater Treatment for New Development**. The communities in the watershed largely have robust stormwater treatment requirements. All communities except Elk River should consider adding

minimum impact development standards (MIDS). Elk River may consider adding a requirement of no increase in suspended solids or total phosphorus from pre-development conditions.

4. **An enhanced street sweeping schedule** (location, frequency) can increase pollutant removal from roads that drain to priority waters.
5. **Urban stormwater retrofits** - Add practices into existing development, where warranted. Practices include settling ponds, infiltration practices, iron-enhanced sand filters, or others. Cost:effective opportunities are limited because of the small amount of the subwatershed served by stormwater pipes, but where present in older (pre-1990's) development these projects would be worthwhile.
6. **Others detailed in this report**.

Recommendations

This report is intended to inform watershed managers on the nature of Trott Brook's impairment, practices to correct it, and likely costs. An iterative management approach is recommended. Recommended steps are:

1. **2024-2025 Monitoring** – The MN Pollution Control Agency (MPCA) has planned monitoring. New data will further inform stream condition and should result in an update to the HSPF model.
2. **2026 Re-Assess Impairment** – The MPCA will use the newest monitoring data to officially re-assess the stream. This is part of the agency's every-10-year monitoring and assessment program. This needs to include an update of the HSPF model to include current land uses and calibrate the model to new monitoring data. Data within this report and local comment should be considered.

   Natural background and the ditched nature of the stream needs to be considered in the updated stream assessment. For the low oxygen impairment, current data suggests that a 4D category designation of impairment is appropriate. This designation is for when impairment is due to natural background conditions "such as rivers influenced by wetlands which contribute to naturally low dissolved oxygen" (MPCA, 2024). For the biotic impairments, the ditched nature of the waterway upstream of Nowthen Blvd suggests Tiered Aquatic Life Use (TALU) standards are appropriate. These are reduced biological expectations for ditched waterways. Trott Brook has a benthic macroinvertebrate and fish bioassessment impairment based on conventional stream standards.

3. **Update local water plans** - Watershed managers will need to evaluate how Trott Brook improvement is to be prioritized relative to other watershed goals. This can be done during every-ten-year updates (or earlier amendments) to the Lower Rum River Watershed Management Organization Plan (next update in 2032) and the Rum River Watershed Comprehensive Watershed Mangement Plan (next update in 2033). Current plans have Rum River phosphorus reduction as a top priority. Practices for Trott Brook can advance that goal, thereby perhaps making Trott Brook phosphorus a higher priority than it would otherwise be. Trott Brook is not currently a priority in these plans.

4. **Pursue 5% phosphorus reductions** – We recommend this starting point to prevent a future nutrient impairment. It has benefits for oxygen levels and biota, without expectation of fully correcting those impairments. This interim goal is complementary to goals of reducing Rum River phosphorus by 5% in both the Lower Rum River and Rum River Watershed Partnership plans. Additional phosphorus reductions can be sought thereafter.

5. **Select project types** – We recommend that top projects to pursue are lateral ditch wetland restorations, agricultural BMPs near the stream corridor, and minor ordinance updates to ensure robust stormwater treatment in new development. These are amongst the most cost-effective and have multiple benefits to dissolved oxygen, nutrients, wildlife, and more.

6. **Effectiveness monitoring** – Continue periodic Trott Brook monitoring approximately every five years, or more frequently when major water quality projects in installed. All seven sites monitored in 2023 should be considered. If the number of sites must be reduced, prioritize Ermine Blvd, Armstrong Blvd and Nowthen Blvd to best capture conditions along the stream length.
7. **Consider dissolved oxygen practices** - Only after the above steps is it likely worthwhile to consider the pursuit of the large oxygen demand reductions. Presently, it appears the TMDL goal is unachievable. Efforts to get even a 15% oxygen demand reduction (toward the goal of 40% reduction) are model-estimated to cost well over $36M dollars. That magnitude of resources is not available. Available resources should be directed toward other watershed management priorities.

Study Scope

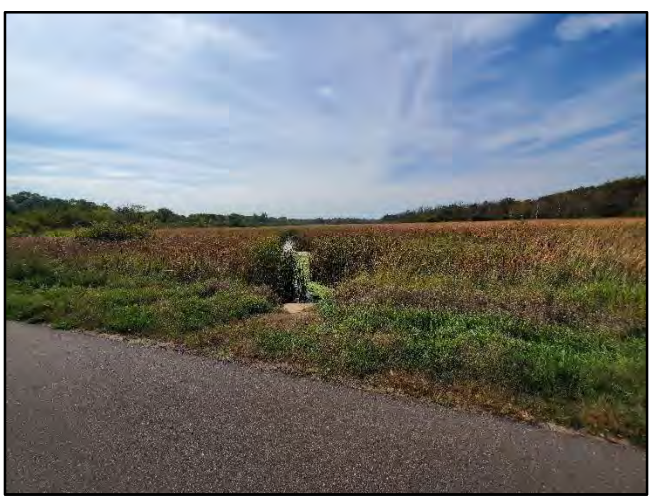
The scope of this study includes the entire length of Trott Brook. Water monitoring occurred along the stream length. Models used included the entire watershed to estimate pollutant generation and sources. The study identified some specific project locations within the stream corridor, but in the larger watershed only identified project types, not specific locations.

There are several subwatersheds draining to Trott Brook that are presented differently in this report. Ditches 27 and 51 were not monitored, but there are monitoring stations upstream and downstream of their outfalls into Trott Brook. Ditch 27 is included in the HSPF model as a separate subwatershed. Ditch 51 is part of the Trott Brook main stem HSPF model subwatershed. Ford Brook is a larger drainage similar to the size of Trott Brook which is excluded from this study entirely for two reasons. First, Ford Brook enters Trott Brook downstream of monitoring sites where impaired conditions had been found. It joins Trott Brook just 0.8 miles upstream of the Rum River confluence. Secondly, Ford Brook was the subject of a separate subwatershed study in 2024 by the Anoka Conservation District which identified and ranked practices for water quality impairment.

Figure 1 Photos of Trott Brook.

Trott Brook at Ermine St

Trott Brook at Armstrong Blvd

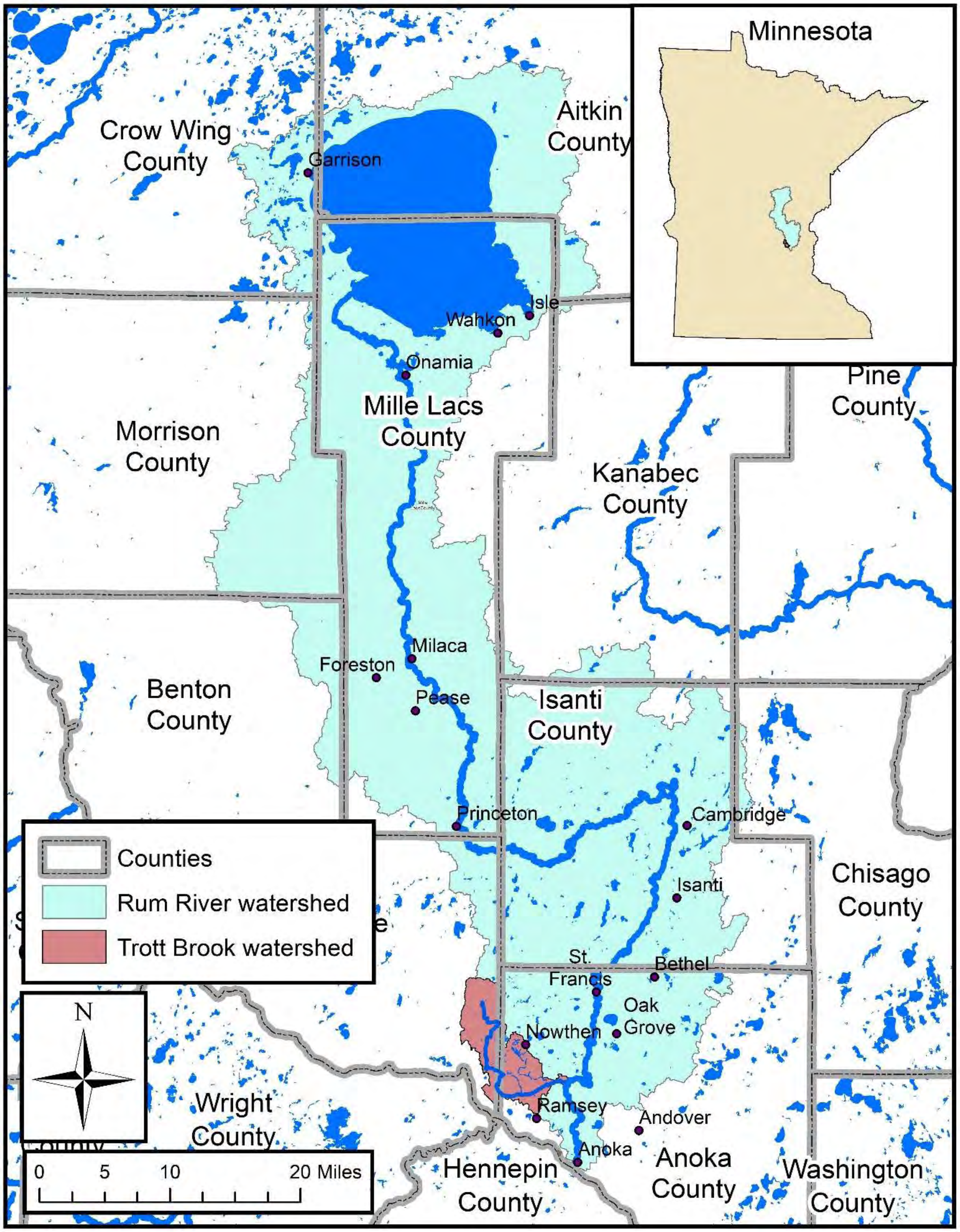


Trott Brook at Variolite St

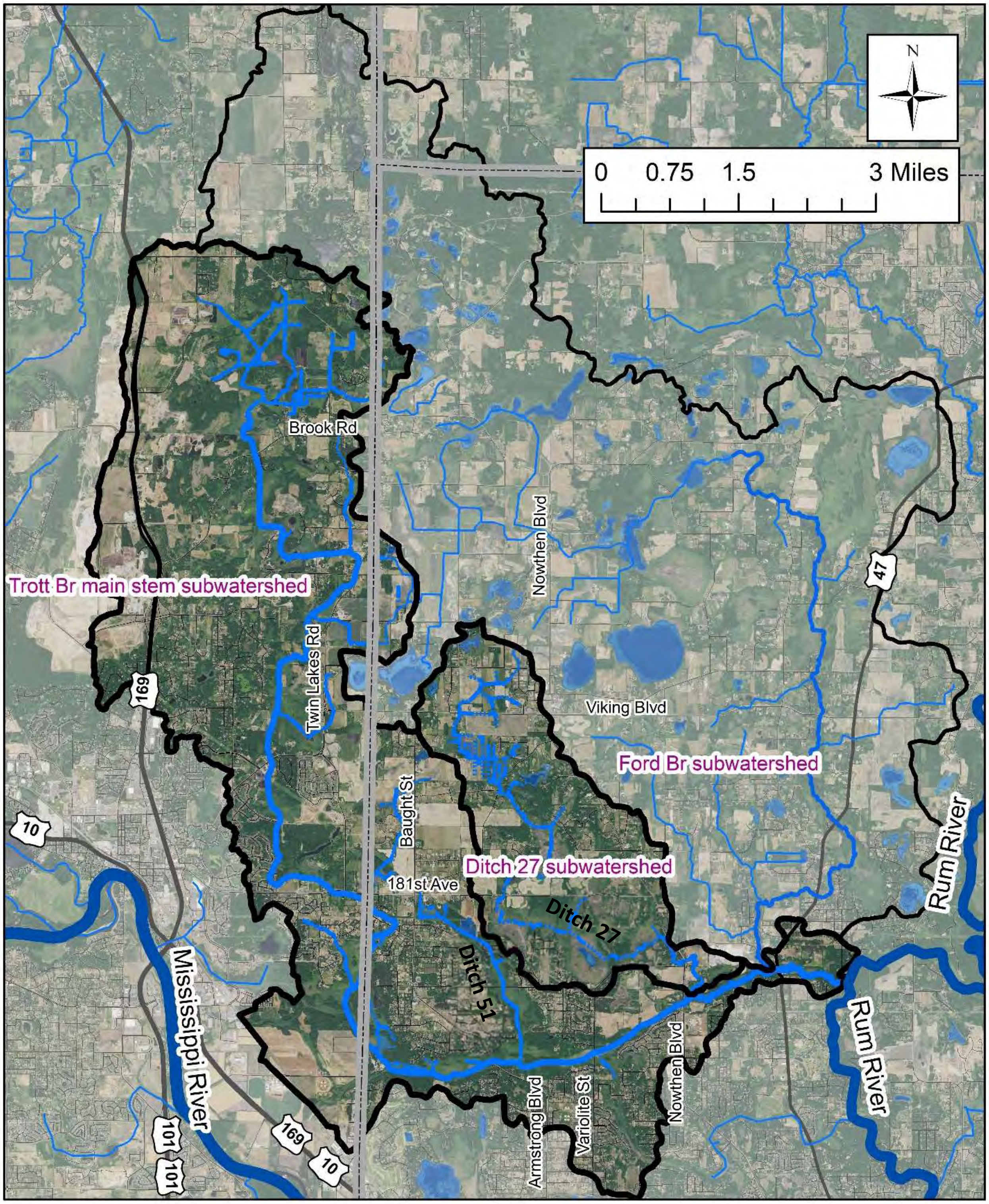
Trott Brook at Highway 47 (St. Francis Blvd)

Watershed Maps

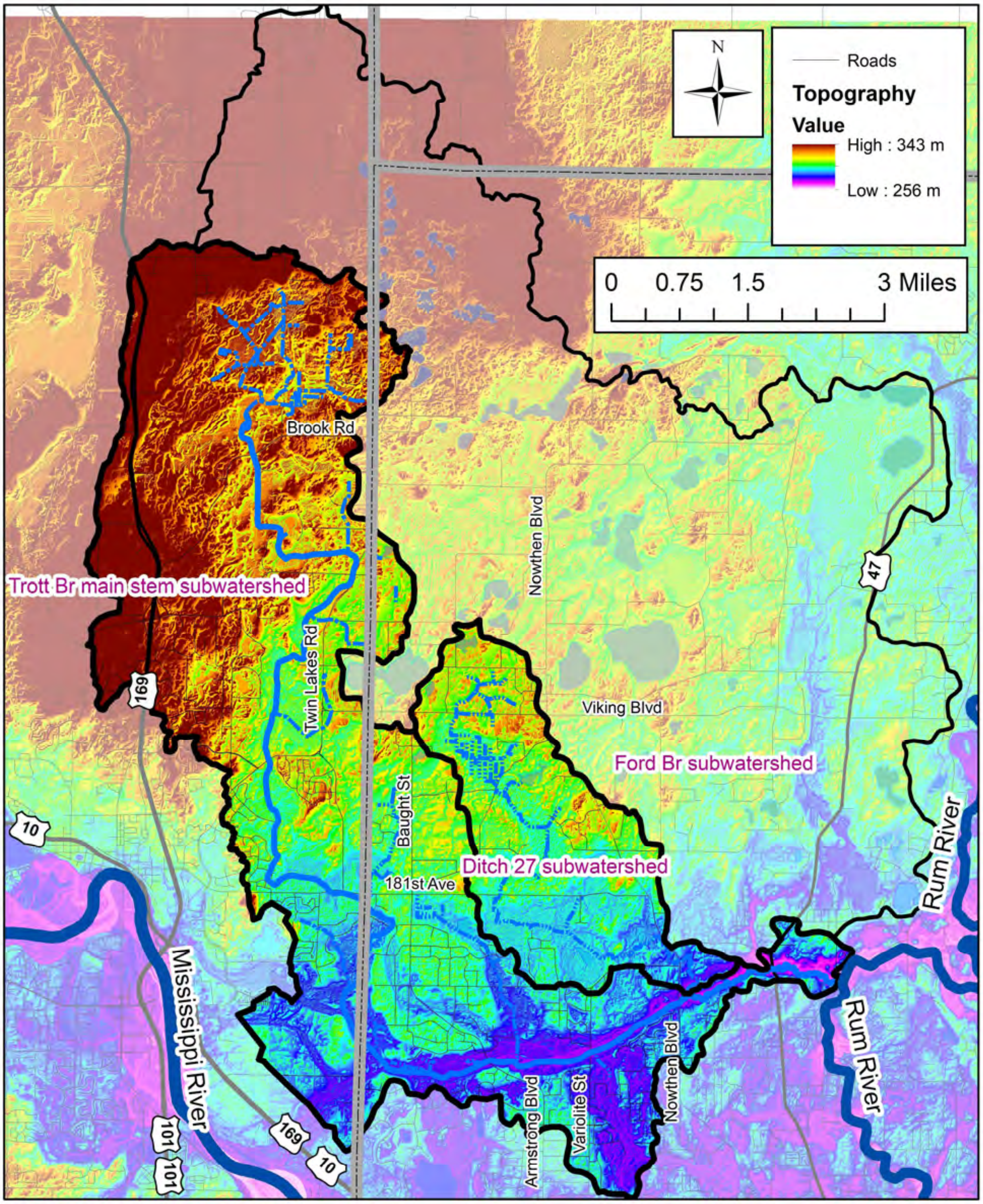
Map 1 Trott Brook waterhsed location.



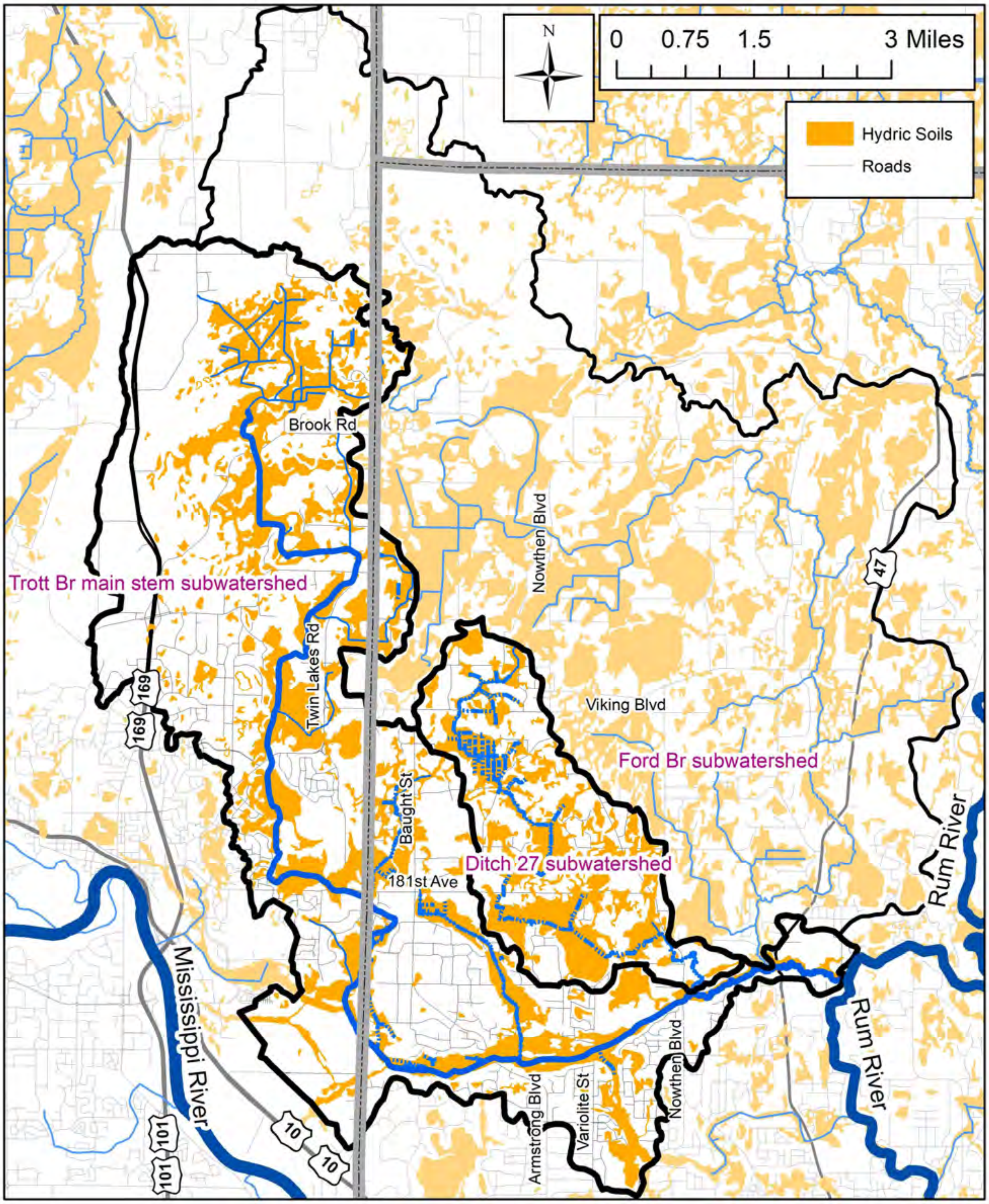
Map 2 - Trott Brook watershed.



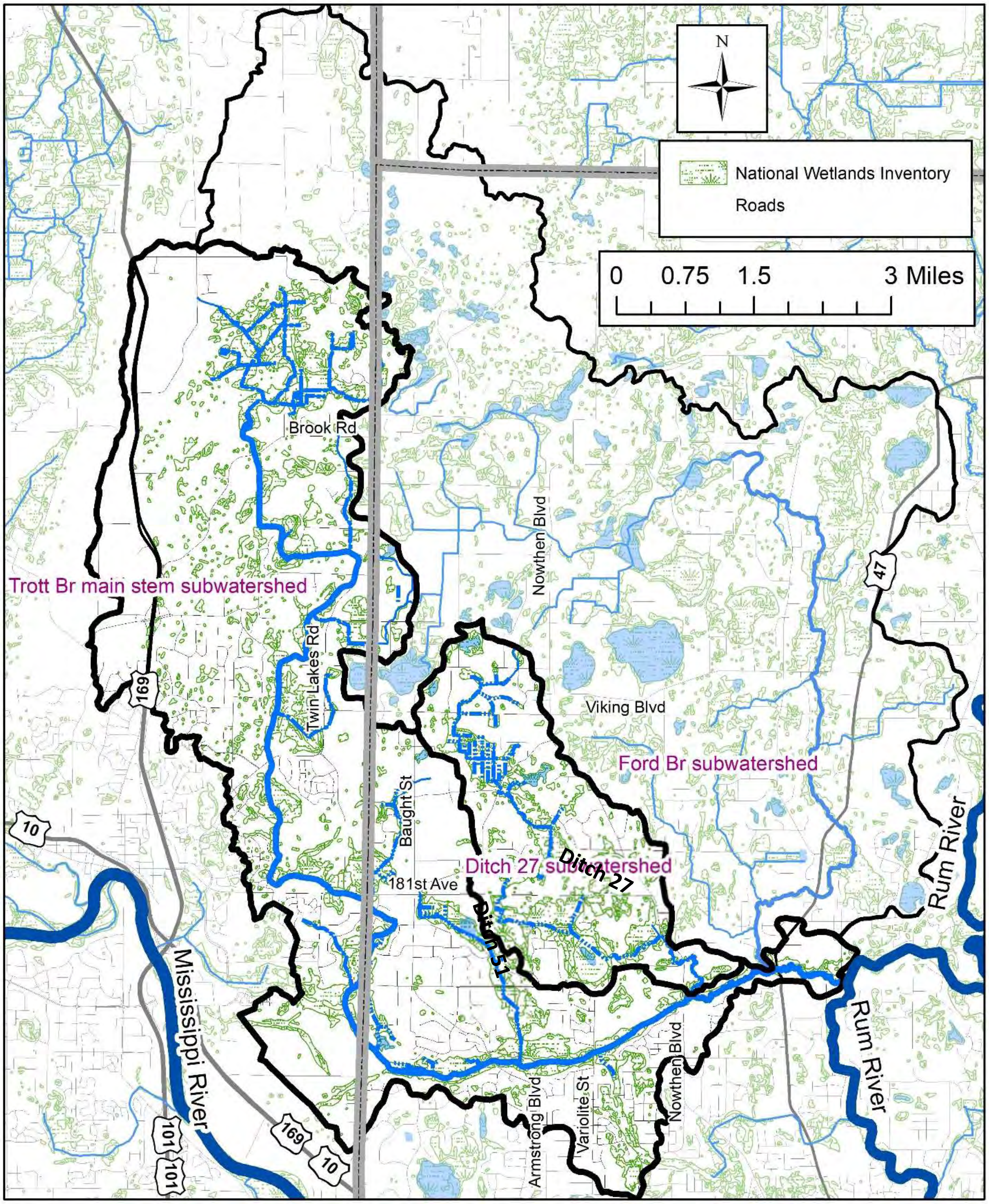
Map 3 - Topography.



Map 4 - Hydric soils.

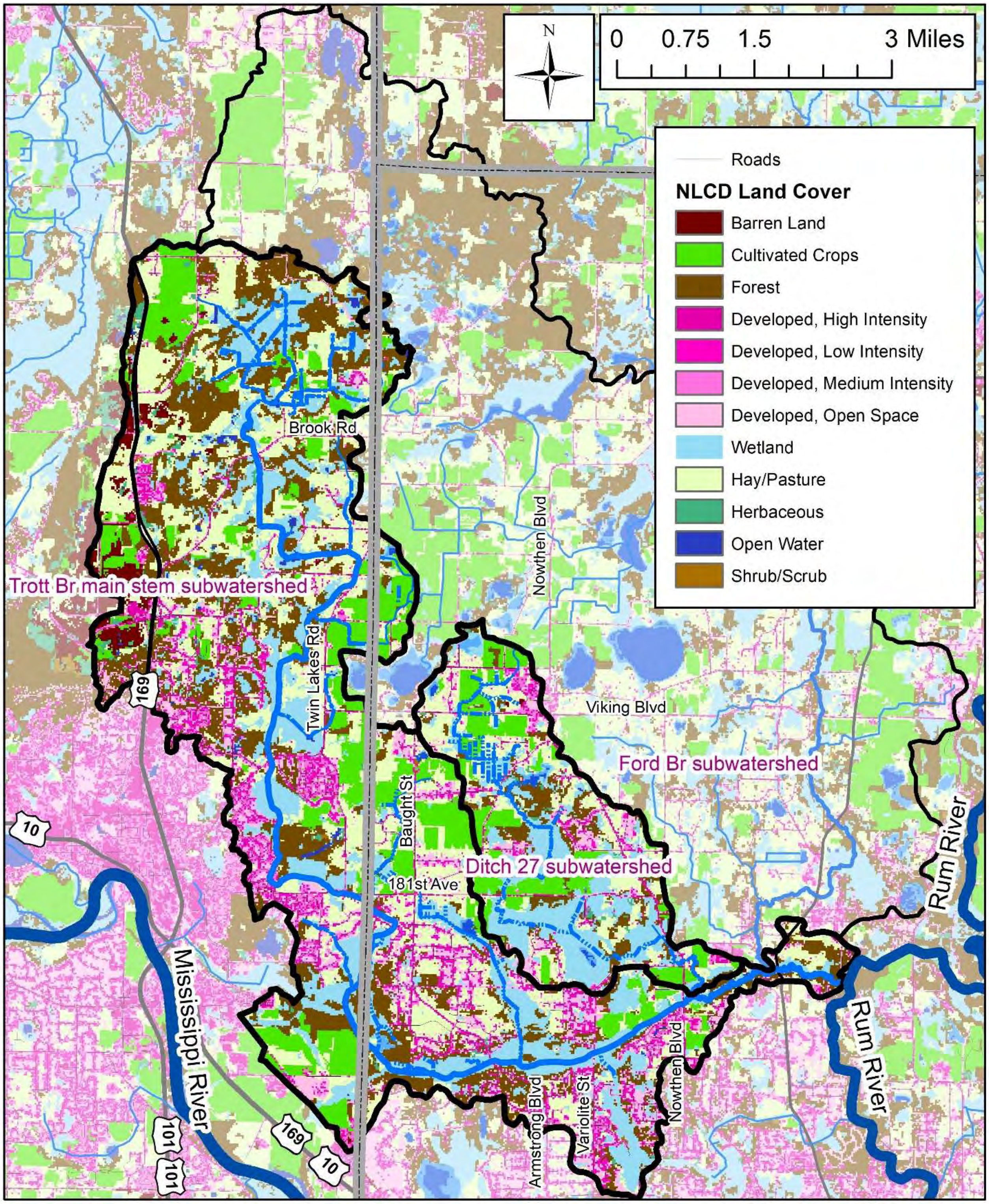


Map 5 - Wetlands (source National Wetlands Inventory)



Of 10,401 ac within 1,000 feet of Trott Brook and its tributaries, 3,927 (37.8%) are wetlands as identified in the National Wetlands Inventory.

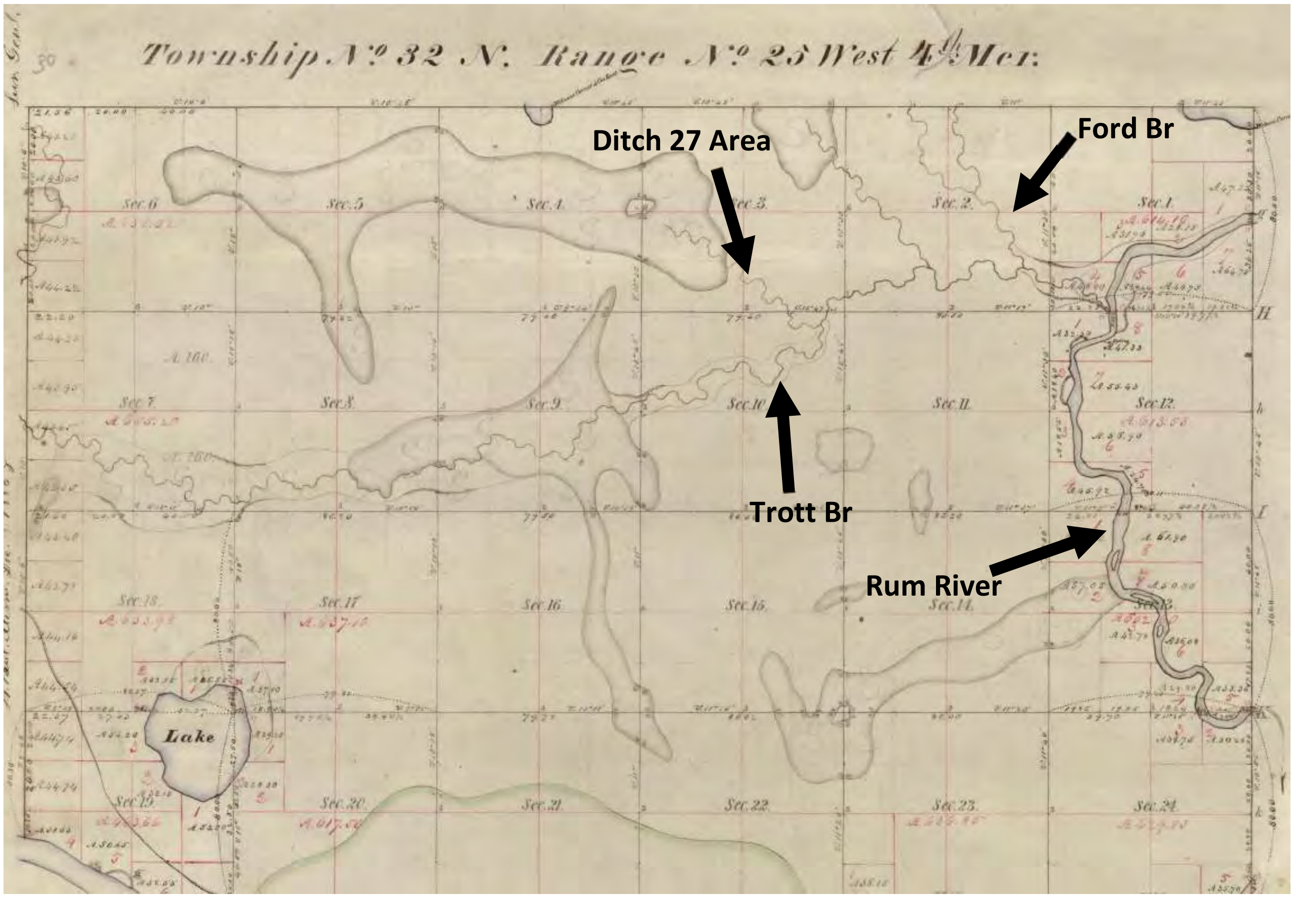
Map 6 - Land Use (source: USGS National Land Cover Database 2021)



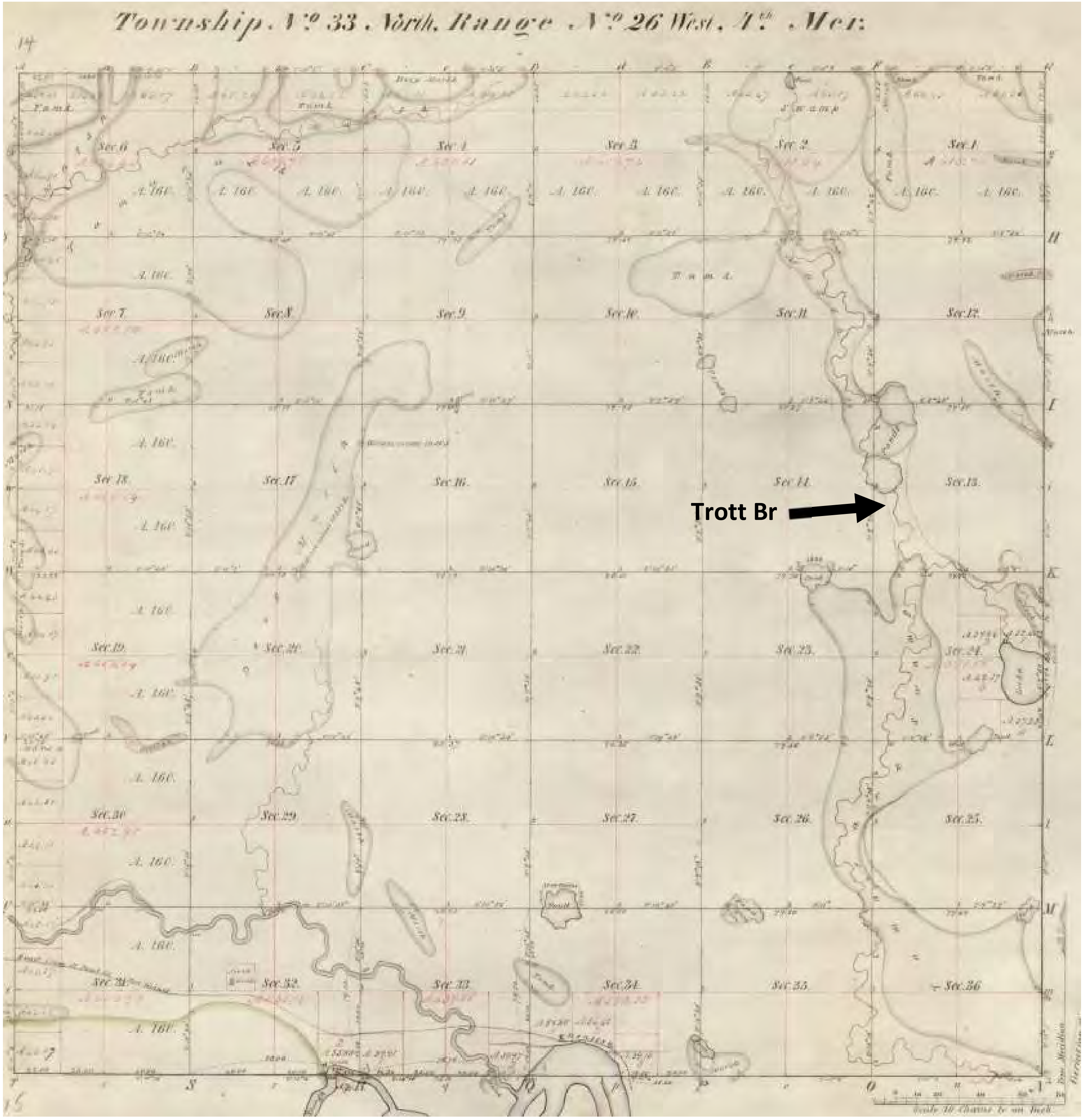
History

Trott Brook and the Ditch 27 tributary were a natural waterways prior to European settlement (Figure 2, Figure 3). The 1880's land surveys completed by the US Surveyor General's Office show sinuous waterways. Both flowed through wetland complexes for much of their length and were low gradient. Ditch 51 is now shown as a natural waterway.

<u>Figure 2</u> - 1883 Public Land Survey - Trott Brook in Anoka Co.



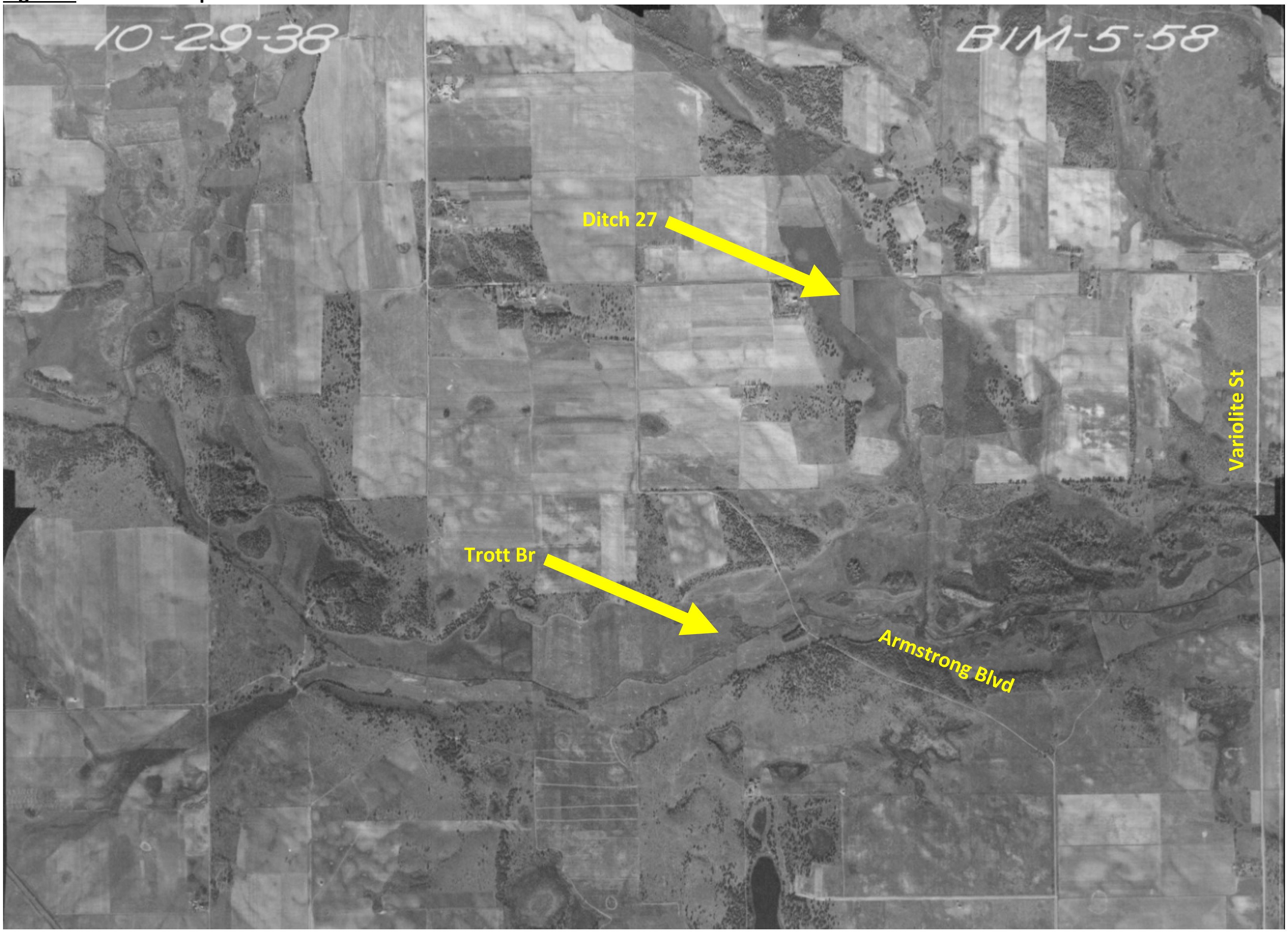
<u>Figure 3</u> - 1883 Public Land Survey – Trott Brook in Sherburne Co



Most channelization of the stream and construction of lateral ditches had occurred by the time of 1938 aerial photos (Figure 4). Ditching occurred within and lateral to Trott Brook, primarily in the late 1800's or early 1900's. This allowed certain agricultural land uses in the rich wetland soils near the stream. The 1938 aerial photos show haying in much of the riparian corridor (within 1,000 ft of the stream), with neat field lines and hay bales apparent in the photos. Row crop fields were present on much of the landscape outside of the riparian corridor. By the time of 1953 aerial photos, the riparian channel haying appears to have mostly come to an end, with succession to natural vegetation. Row crop agriculture continued to be the dominant land use outside of the riparian corridor.

We did not find historic feedlots or other likley hotspots of pollutants during historic photo reviews.

<u>Figure 4</u> - 1938 aerial photo of Trott Brook near Variolite St



<u>Figure 5</u> - 2024 aerial photo of Trott Brook near Variolite St

Current Stream Condition

Channelization, ditching, and creating lateral ditches have wholesale changed the Trott Brook waterway. The waterway is straight; clearly ditched from its sinuous natural path. The entirety of Trott Brook and most of its Ditch 27 tributary are part of the State of Minnesota's altered waterway inventory. That inventory was completed in 2013 by the Minnesota Geospatial Information Office for the MN Pollution Control Agency. It includes streams that have been channelized, ditched, or impounded.

Today, lateral ditches to Trott Brook have more total length than the historic natural channel of Trott Brook and its natural tributaries. Approximately 30.4 miles of tributary ditches currently exist. The Trott Brook main stem and Ditch 27 are 25.5 miles.

The extent of wetlands along Trott Brook was likely decreased by ditching, but most of those ditches have not been actively maintained. As a result, some lands along the stream may be wetter today than during the early or mid-1900's. Still, those lands more effectively drain into the waterway than prior to ditching.

Today, the Trott Brook watershed is suburbanizing. The riparian corridor has many ditched wetlands that prohibit development, but beyond the riparian corridor residential housing is common. Remaining agricultural fields are being converted to housing. The impact of this land use conversion on water quality is debated. While agricultural fields are subject to fertilizers and herbicides, and often have bare soils part of the year, the soils are sandy and landscape flat leading to less surface runoff. The new residential settings have more impervious surfaces but are subject to local regulations requiring treatment of that runoff to certain standards. Stormwater ponds, infiltration basins, and nonstructural practices like street sweeping are common.

Trott Brook has not re-meandered itself despite lack of ditch maintenance, and is unlikely to do so soon. The stream flows primarily through peatlands. Channel migration of peat streams is slow compared to alluvial streams that flow through sandy soils, and has been studied in nearby Cedar Creek which is similar to Trott Brook (Nittrouer, 2024). Shear stress is relatively low in low gradient streams such as these during in-channel flows, and cannot overcome the bank strength of the peat. During higher flows, these streams spill outward into broad peatland floodplains, further keeping in-channel shear stress lower than bank strength. If Trott Brook were re-meandered by digging new channels, the stream might contact more alluvial deposits on the outer fringes of its floodplain, but would still primarily flow through peatland.

Current Stream Status

Trott Brook is on the MN Pollution Control Agency's list of impaired waters (Table 1). In all cases, the designated impaired reach is from County Ditch 51 (just downstream of Armstrong Blvd) to the Rum River.

Table 1 - Impairments of Trott Brook & Applicable Studies

Impairment	Year Listed	Studies Complete	Notes
Low oxygen	2015	TMDL (MPCA, 2017_a) WRAPS (MPCA, 2017_b)	Strategies suggested: Wetland restoration, urban stormwater practices.
Benthic macroinvertebrates	2015	Stressor ID (MPCA, 2016_a)	Primary stressors: Low oxygen and high phosphorus. Habitat was examined but deemed not a stressor.
Fish bioassessment	2015	Stressor ID (MPCA, 2016_a)	Same as for macroinvertebrates.
Sulfate	2020		For wild rice production

Management Plans

Trott Brook management strategies could be identified in either of two local water plans (Table 2). Neither lists Trott Brook as a priority nor has specific actions for Trott Brook. This is partly because Trott Brook as limited recreational use and partly because of competing priorities.

Table 2 - Watershed Management Plans Covering Trott Brook.

Plan	Date	Summary
Lower Rum River Watershed Management Organization - Watershed Management Plan	2021	Trott Brook designated a "lower priority" water. Trott Brook has no water quality trend. Goal: Promote increased dissolved oxygen concentrations in Trott Brook (towards 75% of samples above 5 mg/L) over 10 years through education for riparian landowners, targeted pollution prevention practices (to reduce phosphorus and organics), and identification of shoreline restoration opportunities. Planned Action: Assessment of Trott Brook riparian restoration opportunities.
Rum River Comprehensive Watershed Management Plan	2022	Trott Brook is a tier 3 (lowest) priority for aquatic habitat and invasive species, but not on the priorities list for surface water protection or restoration. No actions are specifically planned for Trott Brook.

Comparison to Water Quality Standards

Low oxygen and moderate phosphorus are the primary concerns in Trott Brook. Low oxygen is both an impairment on its own, and is a stressor for biotic impairments. Elevated phosphorus can be a contributing factor to low oxygen, and Trott Brook is near the threshold for high phosphorus impairment. Achieving the State water quality standard for dissolved oxygen and preventing a phosphorus impairment designation are overarching goals for Trott Brook.

The state water quality standard (MPCA, 2024) is that dissolved oxygen be above 5 mg/L daily minimum. A stream is considered impaired if (a) >10% of all samples before 9am May through September violate the standard, (b) >10% of total May through September measurements violate the standard and there are at least three such violations, or (c) more than 10% of the total annual measurements violate the standard and there are at least three such violations. A minimum 20 measurements are required, of which 10 must be in the last 10 years. Trott Brook oxygen levels in comparison to the state standard are shown in Table 3. Sufficient data to assess exists only at Nowthen Blvd where it appears the state standard is exceeded.

<u>Table 3</u> - Stream dissolved oxygen standards applicable to Trott Brook. Data is 2015-2024

	Site	Average Dissolved Oxygen (mg/L)	# of Measurements/ # of years	% of Samples Below 5 mg/L Before 9am (# measurements of this type, # yrs)	Total measurements (# measurements of this type, # yrs)	Total annual measurements (# measurements of this type, # yrs)	Sufficient Data to Assess?
Upstream → Downstream	State Standard	5	At least 20	10% of any of these and at least 3 violations			
	Trott Brook at Twin Lakes Rd (S017-042)	5.56	10, 2 yrs	37.5% (8, 1 yr)	30% (10, 1 yr)	30% (10, 2 yrs)	No
	Trott Br at 181st Ave (S017-041)	6.22	8, 1 yr	14.2% (7, 1 yr)	12.5% (8, 1 yr)	12.5% (8, 1 yr)	No
	Trott Br at Ermine Blvd (S003-202)	7.24	10, 2 yrs	0% (7, 1 yr)	0% (10, 1 yr)	0% (10, 2 yrs)	No
	Trott Br at Armstrong Blvd (S008-652)	7.82	10, 2 yrs	0% (7, 1 yr)	0% (10, 1 yr)	0% (10, 2 yrs)	No
	Trott Br at Variolite St (S004-306)	6.13	8, 1 yr	28.6% (7, 1 yr)	25% (8, 1 yr)	25% (8, 1 yr)	No
	Trott Br at Nowthen Blvd (S003-176)	6.40	21, 3 yr	0% (7, 1 yr)	19.0% (21, 3 yrs)	19.0% (21, 3 yrs)	Yes
	Trott Br at Hwy 47 (S017-043)	6.94	8, 1 yr	0% (7, 1 yr)	12.5% (8, 1 yr)	12.5% (8, 1 yr)	No

To evaluate eutrophication, total phosphorus and response variables are considered together (MPCA, 2024). Total phosphorus and response variable standards are in Table 4. A stream is considered impaired if the phosphorus limit (100 µg/L) is exceeded along with at least one response variable. Minimum data required for phosphorus is 12 measurements in a minimum of two years over a 10 year period. Trott Brook sites vary, with some slightly above and some slightly below the phosphorus standard of 100 µg/L. On average Trott Brook sites were 94.6 µg/L.

At Trott Brook, limited response variable data is available for chlorophyll-a and diel dissolved oxygen flux. Chlorophyll-a is well below the state threshold but there is only data at one site. Diel dissolved oxygen flux is greater than the state standard at all four sites where that data is available. Minimum data required for dissolved oxygen flux is two sonde deployments for at least four days each. That quantity of data exists only at Nowthen Blvd. While sufficient data does not exist to assess Trott Brook for a phosphorus impairment, the data suggests the stream is close to but not exceeding state standards.

<u>Table 4</u> **- Stream eutrophication standards applicable and Trott Brook measurements.** Data are the averages over the last 10 years (2015-2024). Note that the data are insufficient for assessment at all sites except Nowthen Blvd (MPCA, 2024). 2013 diel dissolved oxygen flux is provided for context, although it is not within the assessment period (last 10 yrs).

		Causative	**Response (stress)**			
		Average Total Phosphorus µg/L (# measurements)	Chlorophyll-a (seston) µg/L (# measurements)	Diel dissolved oxygen flux (mg/L) (# sonde deployments)	Biological oxygen demand (mg/L) (# measurements)	Periphyton chlorophyll-a mg/m$^{2)}$ (# measurements)
	State Standard	100	18	3.5	2.0	150
Upstream → Downstream	Trott Brook at Twin Lakes Rd (S017-042)	102.8 (10)				
	Trott Br at 181st Ave (S017-041)	79.3 (8)		5.77 in 2023 (1)		
	Trott Br at Ermine Blvd (S003-202)	103.0 (8)				
	Trott Br at Armstrong Blvd (S008-652)	85.4 (10)		4.30 in 2023 (1)		
	Trott Br at Variolite St (S004-306)	105.0 (8)		7.96 in 2023 (1)		
	Trott Br at Nowthen Blvd (S003-176)	82.7 (17)	<1.78 (5)	3.98 in 2023 5.64 in 2013 (2)		
	Trott Br at Hwy 47 (S017-043)	104.3 (8)				

No new biota data were collected as part of this study. Comparison to stream biota standards is explored in the next section.

Summary of Pre-Study Data

2016 Rum River Watershed Monitoring and Assessment Report

The Monitoring and Assessment Report (MPCA, 2016_a) examines water quality and biological data collected during 2013-2015 to determine stream impairments, and generally considered data from the previous 10 years. During this time Trott Brook monitoring occurred only at Nowthen Blvd, in the lower portion of the watershed. The impairment designations apply only to the lower portion of Trott Brook from Ditch 51 (approximately Armstrong Blvd in the City of Ramsey) to the outlet into the Rum River.

The 2016 MPCA assessment resulted in an impairment designation for low oxygen. It found dissolved oxygen ranged 2.0-8.2 mg/L with a mean of 5.3 mg/L (n=19). The water quality standard is 5 mg/L. Authors speculated that high nutrients may be a cause based on diel dissolved oxygen fluctuation and observed aquatic plants. Phosphorus ranged 55-173 µg/L with a mean of 107.9 (n=15). The water quality standard is 100 µg/L. This report acknowledges that the stream's "close association with riparian wetlands…no doubt contributes to low dissolved oxygen." It points to Mike Drew Brook in rural Mille Lacs County as a "good example of how these types of streams can attain general use biocriteria in the absence of significant human disturbance."

Biological impairments were also designated based on inventories of the invertebrate and fish communities during 2013-2015. The fish index of biological integrity (IBI) was 35.04 in 2013 and 33.18 in 2015. The threshold is 42 (scores above this level are meeting healthy stream expectations). Previous fish assessment in 2000 found the fish community was better than the threshold (meeting healthy stream expectations) with a score of 49.

The invertebrate IBI was 46.47 (MPCA, 2016_a) in 2013 however another publication lists a score of 42.2 (MPCA, 2016b). This appears to be either a passing score above the threshold of 43, or slightly below. The report provides no discussion of this apparent discrepancy, but does conclude the stream is impaired for macroinvertebrate biota. The authors note that in a previous 2000 assessment the stream had a passing macroinvertebrate score of 64.6. They discuss that the stream flows through wetlands, and may of the invertebrates found in 2013 are commonly sampled in wetlands.

Channel condition and stream habitat were rapidly assessed during 2013-2015. Channel condition and stability assessment ranked Trott Brook as "fairly stable." The Minnesota Stream Habitat Assessment (MSHA) score was 54.87 (fair). These assessments were presumably done at Nowthen Blvd since that is where other sampling occurred.

2016 Rum River Watershed Stressor ID Report

This report determined stressors believed to be causing biotic impairments (MPCA, 2016_a). In Trott Brook the authors found low oxygen to be the primary stressor. Phosphorus was identified as a stressor causing low oxygen. Altered hydrology is a final stressor. Habitat was examined but deemed not a stressor.

Dissolved oxygen investigation included individual measurements as well as a sonde deployed in the streams to take readings around the clock. All data was from the Nowthen Blvd stream crossing. Individual measurements were above the dissolved oxygen threshold of 5 mg/L on 43 of 48 occasions (10.4%). The sonde found diurnal stream DO flux >3.5 mg/L which is indicative of eutrophication. Oxygen levels were commonly <4 mg/L at night.

Phosphorus levels were examined by grab samples. Phosphorus above the state standard of 100 µg/L was common in the 1998 to 2014 data record examined, averaging just over 100 µg/L. The authors note "channelization appears to be draining a wetland complex and may be contributing to the elevated nutrient concentrations along with the low DO concentrations observed."

No stream hydrology monitoring occurred, but altered hydrology was determined to be a stressor. This determination was based on the prevalent ditching of the stream.

2017 Total Maximum Daily Load (TMDL) Study

The TMDL report quantifies pollutant reductions needed to address water quality impairments (MPCA, 2017_a). The water quality target is to reach the State dissolved oxygen (DO) criteria of 5 mg/L daily minimum. A HSPF model was utilized to estimate oxygen demand. The model was re-run with incrementally lower oxygen demand rates until the stream reach was below the 5 mg/L standard less than 5% of the time during the open water months of April to November from 2006 through 2016. "The oxygen demand calculated by using the TMDL scenario was 332 lb/day, which represents a reduction of 50% from the current load of 661 lb/day" (MPCA, 2017_a).

In this 2024 study of Trott Brook we re-ran the HSPF models that were used for the TMDL. We found that the current oxygen demand load was 551 lb/day, not 661 lb/day as was reported in the TMDL. This seems to be a typographical error in the TMDL report. Presuming this is the case, a 332 lb/day reduction represents a 40% reduction needed, not 50%. Throughout this report we assume 332 lb/day or 40% is the correct needed reduction.

Table 5 - Trott Brook dissolved oxygen total maximum daily load. (MPCA, 2017_a)

TMDL Component		Oxygen Demand[a] (lb/day)
Total Daily Loading Capacity		332
Margin of Safety		33
Wasteload Allocations	Permitted Wastewater Dischargers	–
	MS4s	272
	Construction and Industrial Stormwater	3
Load Allocation		24
Current Load		661
Required Reduction		50%

(a) Oxygen demand accounts for the combination of SOD, NOD, and BOD.

Low oxygen, and oxygen demand, were not flow dependent. Low oxygen occurred in high, medium, and low stream flows. TMDL authors created flow duration curves that compare oxygen and oxygen-consuming pollutants to flow and the frequencies of those flows (Figure 6 & Figure 7). Biological oxygen demand (BOD_5), total phosphorus, and chlorophyll-a did not seem to be dependent upon flow. Peak ammonia was observed in high and very high flows on average, but that is driven by a small minority of measurements with very high ammonia.

An HSPF model was used to develop the TMDL. It utilizes land use data and estimates contributions of oxygen-demanding substances from the watershed. It also estimates factors that can re-aerate the water (phytoplankton, benthic algae, and re-aeration). It assigns an estimated percentage of oxygen demanding pollutants coming from each land use.

Pollutants of concern which reduce or lead to the reduction of DO were nutrients (especially phosphorus) and organic materials, which may be measured through various oxygen demand tests. Some applicable State water quality limits are total phosphorus (100 µg/L), chlorophyll-a (18 µg/L), diel DO flux (3.5 mg/L), and BOD_5 (2 mg/L).

Figure 6 - Trott Brook at Nowthen Blvd dissolved oxygen flow duration curve. The red dashed line indicates the 5 mg/L dissolved oxygen standard. (MPCA, 2017a)

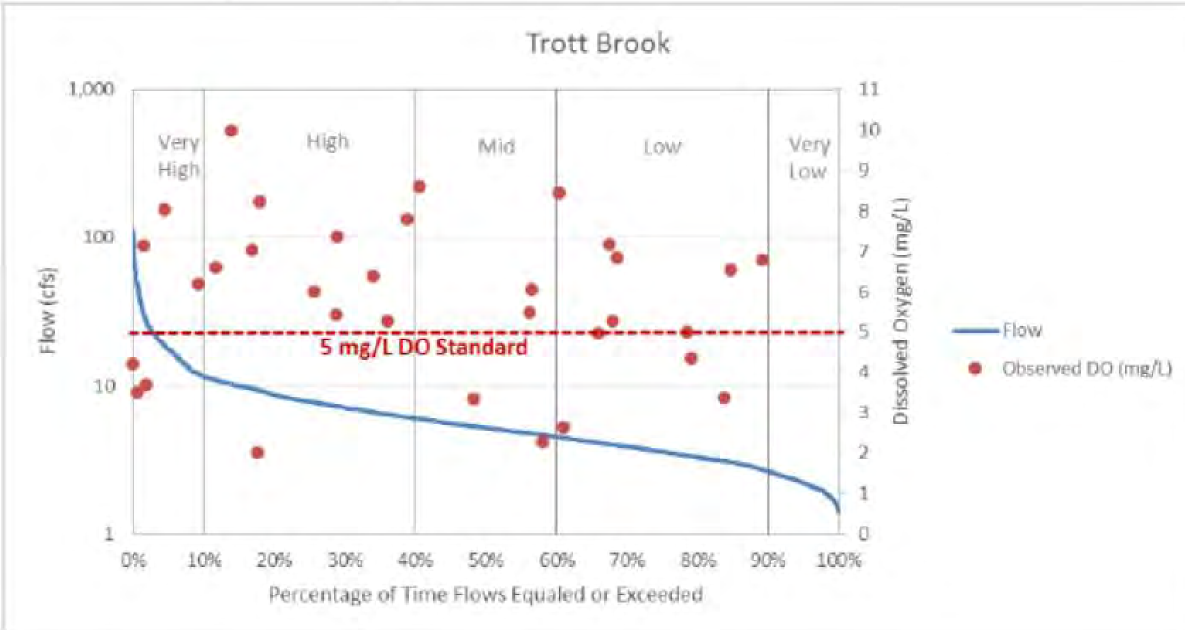


Figure 7 - Trott Brook at Nowthen Blvd total phosphorus flow duration curve. The red dashed line indicates the 100 µg/L total phosphorus standard. (MPCA, 2017a)

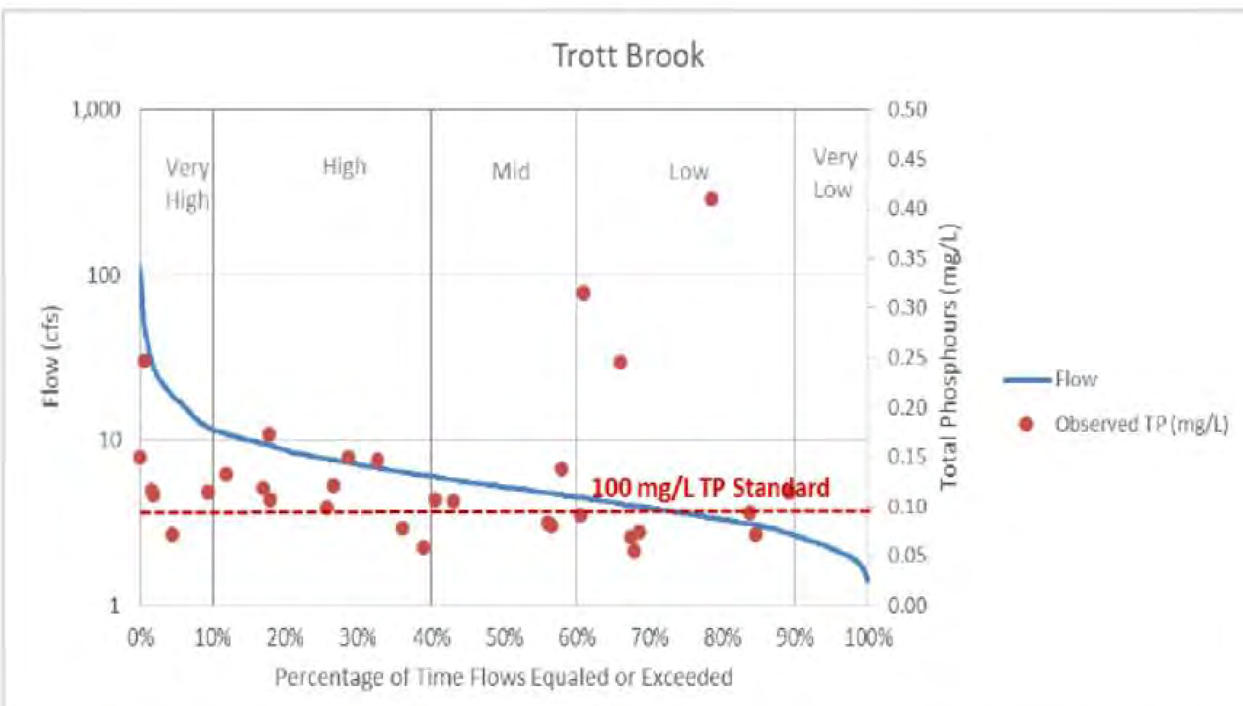


Figure 3-25. Trott Brook (Site S003-176) Monitored Total Phosphorus Concentrations Plotted on Flow a Duration Curve. The red dashed line indicates the 100 ug/L total phosphorus standard.

To achieve dissolved oxygen standards in Trott Brook, actions are required by four types of permitted entities. Two types, industrial and construction stormwater permittees, are assumed to be meeting the wasteload allocations of the TMDL if they install all required best management practices required under their permit. There are no permitted wastewater dischargers, the third type of entity. The final regulated group is MS4 communities.

The regulated MS4 stormwater communities include City of Elk River, City of Nowthen, City of Ramsey, Anoka County, and Sherburne County. The TMDL sets allowable oxygen demand for each; see Table 6. Each MS4 must comply with six minimum control measures in their permit (public education and outreach, public participation & involvement, illicit discharge detection & elimination, construction site runoff controls, post-construction stormwater runoff control & pollution prevention, & good housekeeping measures). Additionally, they must provide assurance that progress is being made toward achieving all TMDL WLAs. If they determine WLAs are not being met, a compliance schedule is required. The baseline for reductions needed is 2006. It's noteworthy that the TMDL allocations are calling for the MS4s to accomplish 272 lbs/day (82%) of the 332 lb/day oxygen demand reduction.

Table 6 - Wasteload allocations for municipal separate storm sewer systems contributing to Trott Book. (MPCA, 2017$_a$)

MS4	Permit No.	Contributing Area (acres)	Percent of MS4 Load	Allowable Oxygen Demand[a] (lb/day)
Elk River City	MS400089	10,479	63	171
Nowthen City	MS400069	1,610	10	26
Ramsey City	MS400115	4,440	27	72
Saint Francis City	MS400296	47	< 1	1
Sherburne County	MS400155	53	< 1	1
Anoka County	MS400066	36	< 1	1

(a) Oxygen demand accounts for the combination of SOD, NOD, and BOD.

In addition to reductions from the permitted sources, significant voluntary efforts will also be needed. The TMDL recommends general approaches. Recommended practices include Minimum Impact Design Standards (MIDS), urban & agricultural practices, wetland and stream modifications, and education.

To quantify reductions needed, the report considers several metrics of oxygen demand including biological, chemical, and sediment oxygen demand. The authors note that "while these laboratory measures from sampled waters are appropriate, they do not adequately describe the cumulative oxygen depletions from upland ditches, drained wetlands, eutrophic lakes…" While the HSPF model used for the TMDL is based largely on standard data for each land use found, it does not account for unique landscape factors such as the ditched wetlands prevalent in the Trott Brook watershed.

2017 Watershed Restoration and Protection Strategies (WRAPS)

The WRAPS management planning report recommends strategies for waterbody improvement (MPCA, 2017$_b$). It was compiled by the MN Pollution Control Agency, but included input from many stakeholder agencies. For Trott Brook, the recommendations to address low oxygen and biotic impairment were wetland restoration and urban stormwater practices.

2015 Assessment of Trout Potential

An Anoka-Ramsey Community College student prepared a paper assessing the suitability of Trott Brook for trout introduction (Phenow, 2015). This work was done to assist the City of Ramsey Parks and Recreation Department. Generally, the author found some possibility of trout habitation in the farthest downstream reach of Trott Brook, but there is discussion about limiting or concerning factors.

This study included a water chemistry monitoring, habitat assessment, rapid bioassessment, and MPCA's invertebrate monitoring procedures. Work was primarily at the Highway 47 crossing. This reach, the downstream-most extent of the stream, was chosen because it is higher gradient, not surrounding by broad floodplain wetlands, and not channelized. Sampling appears limited to one year with five measurements of water chemistry.

While the author is encouraging about the potential for trout reintroduction, there is discussion suggesting the stream capacity for trout is limited. Their study took place in one of the few sections of the stream that is not surrounded by broad floodplain wetlands. Other areas are known to have lower oxygen, higher temperatures, and even less recreational access. The author pointed to floodplain wetlands as a cause of low oxygen.

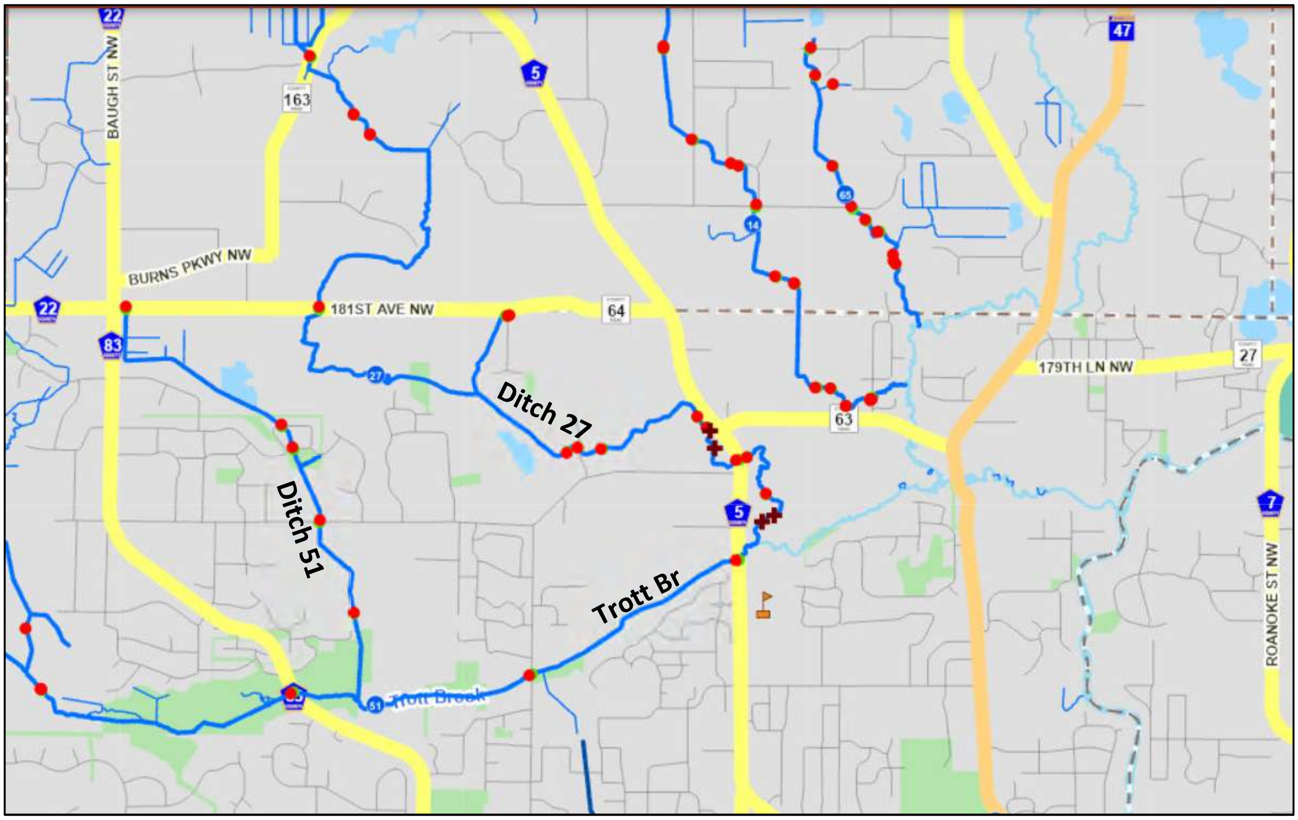
Past Stream Water Quality Monitoring

Past Trott Brook stream water quality monitoring has been done through two programs. First was the MPCA's every-ten-year assessment program beginning in 2013. That is described in earlier in this report in sections summarizing MPCA reports. The second was collaboration between the Lower Rum River Watershed Management Organization and the Anoka Conservation District (ACD). Data exists back to 1998 and is available through the MPCA electronic data access tool of from ACD. In this report, we focus on the last 10 years of data, consistent with the MPCA's guidance for assessing streams (MPCA, 2024)

Culvert Inventory

Cities have completed culvert inventories along the Anoka County portions of Trott Brook (Figure 8). It includes primarily publicly-managed culverts (city or county), and may exclude private culverts. The inventory is accessible at the Anoka County Water Resource Mapping Application (https://gis.anokacountymn.gov/acwr/).

Figure 8 - Culvert inventory. Source: Anoka County.



New Data Collected During This Study

2023-2024 Water Quality Monitoring

This study included water quality monitoring of Trott Brook in 2023 at seven sites and additionally in 2024 at Nowthen Blvd only. In this section we focus on 2023 monitoring which was designed to answer the following questions:

- **How does Trott Brook water quality vary along the stream length?** This can help determine where the causes of water quality degradation are located, and where practices should be installed.
- **How does water quality vary between storm and base flow conditions?** This can inform the degree of water quality degradation from watershed runoff as compared to in-stream conditions or groundwater contributions.
- **How does current water quality compare to state standards?** Previous impairment designations were made based on limited data at few sites in the past.

As opposed to previous monitoring which was almost exclusively at the Nowthen Blvd stream crossing, the 2023 monitoring was done at seven sites though out the stream length (Figure 9, Table 7). Trott Brook meanders through differing ecological sections – from peaty wetlands to developing neighborhoods – and historical data at one location wasn't enough to assess the extent of poor dissolved oxygen or phosphorus in Trott Brook. In addition to dissolved oxygen and total phosphorus, parameters monitored included pH, specific conductivity, turbidity, and temperature. Eight grab samples were taken, four during storms (immediately after 1" or more of rain) and four during base flow. Additionally, dissolved oxygen sondes on loan from the Minnesota Pollution Control Agency (MPCA) were deployed at four sites for a nine day time period (same days at all sites).

Figure 9 - Water quality monitoring sites 2023.

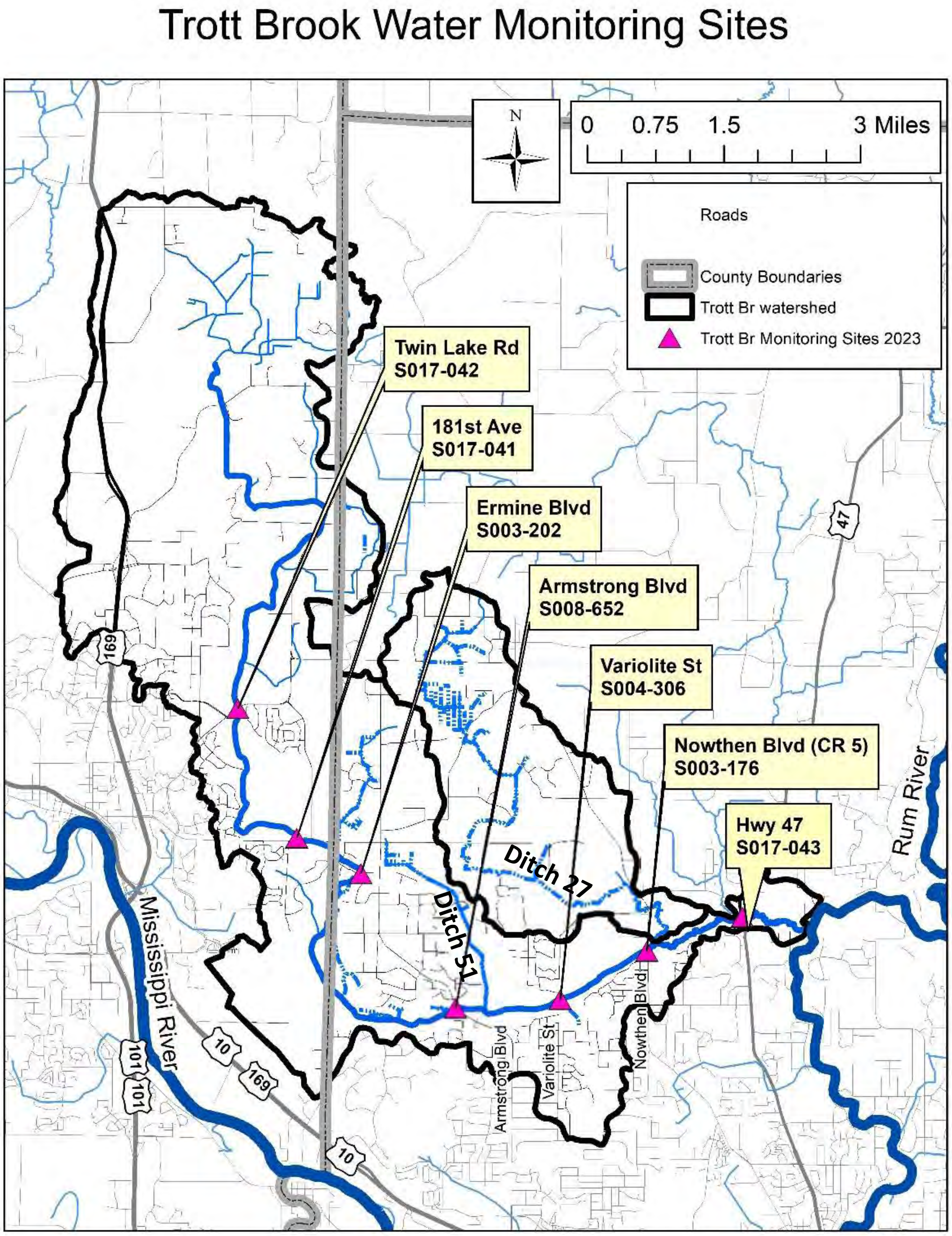


Table 7 - Key to site numbers in the water quality graphs. Numbering is from upstream to downstream.

Site Number on Figures of this Report	Site Name	MPCA Station Number
1	Trott Brook at Twin Lakes Rd	S017-042
2	Trott Br at 181st Ave	S017-041
3	Trott Br at Ermine Blvd	S003-202
4	Trott Br at Armstrong Blvd	S008-652
5	Trott Br at Variolite St	S004-306
6	Trott Br at Nowthen Blvd	S003-176
7	Trott Br at Hwy 47	S017-043

Dissolved Oxygen

Dissolved oxygen is necessary for aquatic life, including fish. Organic pollution causes oxygen to be consumed during decomposition and oxidation of inorganic ammonia. If oxygen levels in water fall below 5 mg/L, aquatic life begins to suffer. A stream is considered impaired if 10% of observations are below 5 mg/L in the last 10 years. Dissolved oxygen levels are typically lowest in the early morning because of decomposition consuming oxygen at night without the offsetting of oxygen production by photosynthesis.

For 2023 monitoring, all grab samples were taken in the early morning (prior to 9:00am) to measure oxygen concentrations at their lowest levels of the day. Additionally, samples were taken as close as possible to simultaneously. Finally, sondes were deployed for eight days at four of the sites that took measurements hourly.

In 2023, grab measurements of dissolved oxygen (DO) across all seven sites fell below 5 mg/L on five occasions during baseflow and two occasions post-storm. DO measurements below the state standard (5 mg/L) were most common at Twin Lakes Road (3 occurrences) and Variolite Street (two occurrences). The average and median data collected at each site is shown below (Table 8). The average DO for all Trott Brook sites was 6.8 mg/L during baseflow and 7.1 mg/L post-storm.

Table 8 - Dissolved oxygen grab sample summary statistics.

DO - 2023 Baseflow Data

	AVG	MED	TOTAL #	< 5 mg/L
Trott Brook @ Twin Lakes Rd	5.5	5.6	4	2
Trott Brook @ 181st Ave	6.2	6.4	4	1
Trott Brook @ Ermine Blvd.	7.3	7.4	4	0
Trott Brook @ Armstrong Blvd	7.9	8.3	4	0
Trott Brook @ Variolite St	6.0	6.5	4	1
Trott Brook @ Nowthen Blvd	7.2	7.4	4	0
Trott Brook @ Hwy 47	6.8	7.2	4	1

DO - 2023 Storm Data

	AVG	MED	TOTAL #	< 5 mg/L
Trott Brook @ Twin Lakes Rd	5.6	5.7	4	1
Trott Brook @ 181st Ave	6.2	5.8	4	0
Trott Brook @ Ermine Blvd.	7.1	6.8	4	0
Trott Brook @ Armstrong Blvd	7.8	8.2	4	0
Trott Brook @ Variolite St	6.3	6.8	4	1
Trott Brook @ Nowthen Blvd	6.7	7.1	4	0
Trott Brook @ Hwy 47	7.1	6.7	4	0

DO - 2024 Baseflow Data

	AVG	MED	TOTAL #	< 5 mg/L
Trott Brook @ Nowthen Blvd	6.1	6.6	8	3

DO - 2024 Storms Data

	AVG	MED	TOTAL #	< 5 mg/L
Trott Brook @ Nowthen Blvd	NA	NA	0	NA

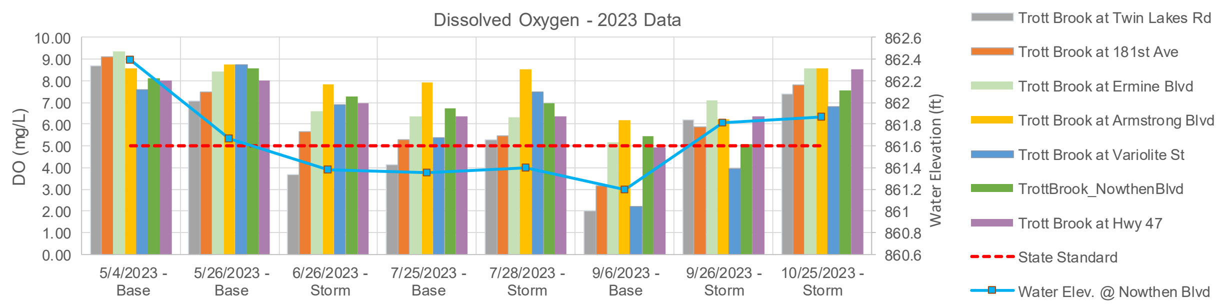
DO - 2015-2024 All Conditions

	AVG	MED	TOTAL #	< 5 mg/L
Trott Brook @ Twin Lakes Rd	5.9	6.2	10	3
Trott Brook @ 181st Ave	6.2	5.8	8	1
Trott Brook @ Ermine Blvd.	7.4	7.5	10	0
Trott Brook @ Armstrong Blvd	7.4	7.9	10	0
Trott Brook @ Variolite St	6.1	6.8	8	2
Trott Brook @ Nowthen Blvd	6.6	7.3	21	5
Trott Brook @ Hwy 47	6.9	6.7	8	1

In 2024, only the Nowthen Blvd site was monitored. Sampling times were mid-day (10am to 2:30pm) at regular intervals of twice a month (not corresponding with storms). DO was below the state standard on three of these occasions.

On any given date in 2023, dissolved oxygen varied amongst sites, but not in a consistent manner (Figure 10Figure 10 - Dissolved oxygen at Trott Brook sites during 2023 grab sampling.). The middle watershed (Armstrong Blvd or adjacent sites) typically had the highest DO in 2023. The lowest DO was most commonly at the farthest upstream site at Twin Lake Road or at Variolite Street in the lower watershed. It is not possible to highlight one reach that is a culprit for low oxygen.

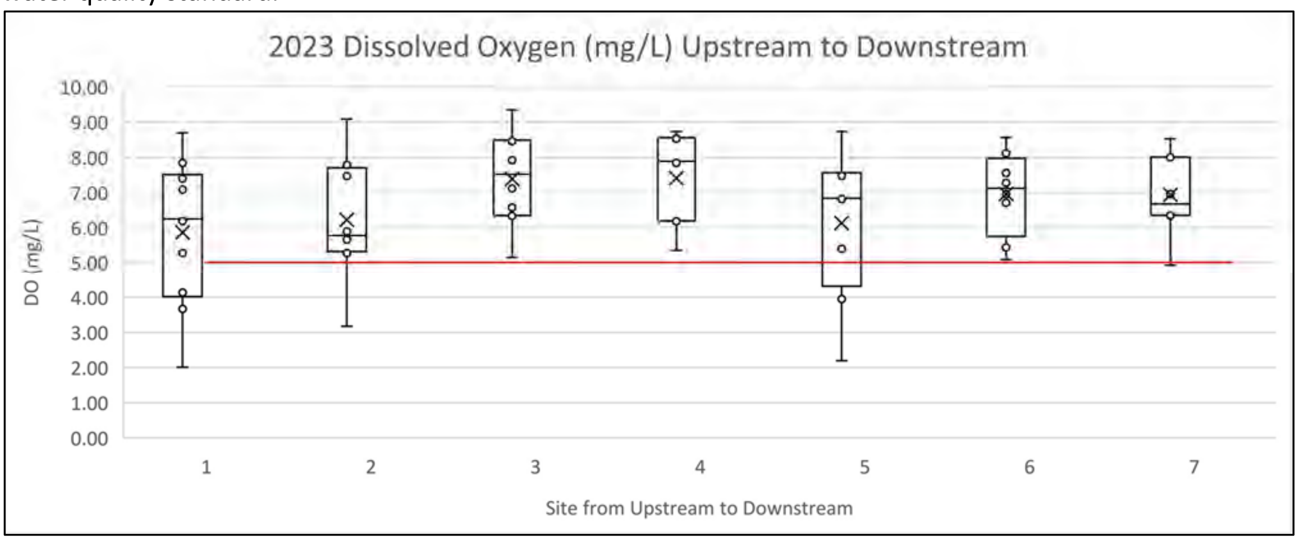
<u>Figure 10</u> - Dissolved oxygen at Trott Brook sites during 2023 grab sampling.



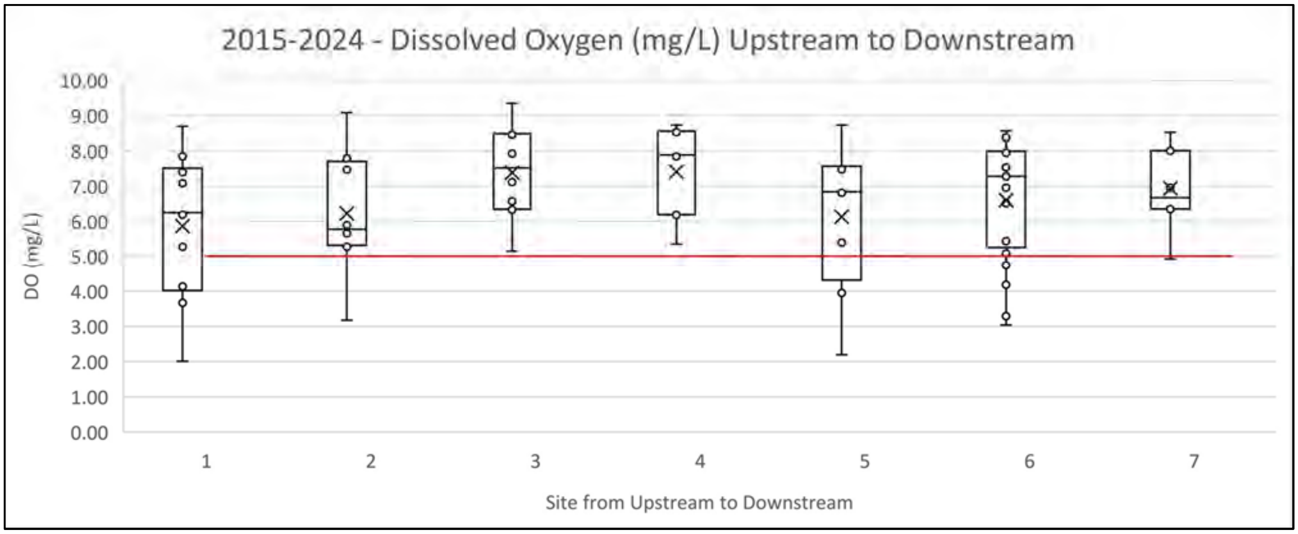
On most dates it appears that oxygen increases from upstream to downstream, at least for the first four sites. The sites were sampled in this order in 2023 and it would be expected that those sampled first (earliest in the morning) would have lower oxygen. Increased oxygen production from photosynthesis as the morning progressed could be responsible for the apparent trend.

Looking across all dates in 2023 (Figure 11) or 2015-2024 (Figure 12), dissolved oxygen is relatively consistent from upstream to downstream. Again, the middle watershed around Armstrong Blvd tends to have the highest oxygen overall.

<u>Figure 11</u> - Trott Brook dissolved oxygen from upstream to downstream in 2023. The red line is the state water quality standard.

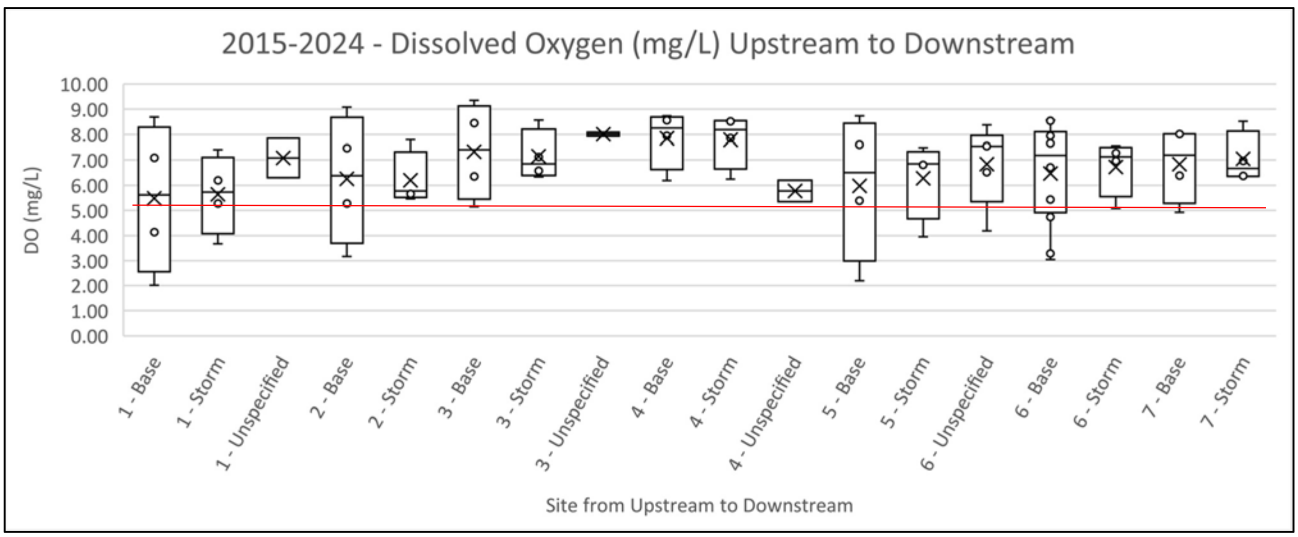


<u>Figure 12</u> - Trott Brook dissolved oxygen from upstream to downstream during 2015 to 2024. The red line is the state water quality standard.



There does not appear to be a difference between dissolved oxygen during storm flows and base flows in Trott Brook (Figure 13). This is consistent with the TMDL study (MPCA, 2017a) which found low oxygen and total phosphorus were independent of flow.

<u>Figure 13</u> - Trott Brook dissolved oxygen comparison during storm and base flows during 2015-2024. The red line is the state water quality standard.



During 2013 and 2023 deployable sondes were placed in Trott Brook to take dissolved oxygen measurements hourly. The purpose was to observe daily low oxygen levels and the diel fluctuations from highest to lowest dissolved oxygen. In 2013 a sonde was placed only at the Nowthen Blvd crossing. In 2023 they were placed at four sites to better compare conditions along the stream length. All sondes were owned and placed by the MPCA.

In 2013, the sonde found dissolved oxygen well below the state standard of 5 mg/L each day (Figure 14). The diel daily fluctuation was 5.64 mg/L which is significantly poorer than the state standard of 3.5 mg/L. Daily lows occurred around 5am. This data was considered when the stream was listed as impaired in 2015.

In 2023, the sondes found higher dissolved oxygen than 2013 (Figure 15). The 181st Ave and Variolite St sites dipped below 5 mg/L almost all days. The Armstrong Blvd and Nowthen Blvd sites did not, with the exception of minor exceedances on two days at Nowthen Blvd. Interestingly, these sites are not adjacent. This suggests multiple, diffuse impacts across the watershed are causing low oxygen. The diel oxygen fluctuation in 2023 ranged from 3.98 to 7.96 mg/L, poorer than the state standard of 3.5 mg/L.

Figure 14 - Dissolved oxygen sonde data from 2013. Data is from the Nowthen Blvd stream crossing (site S003-176).

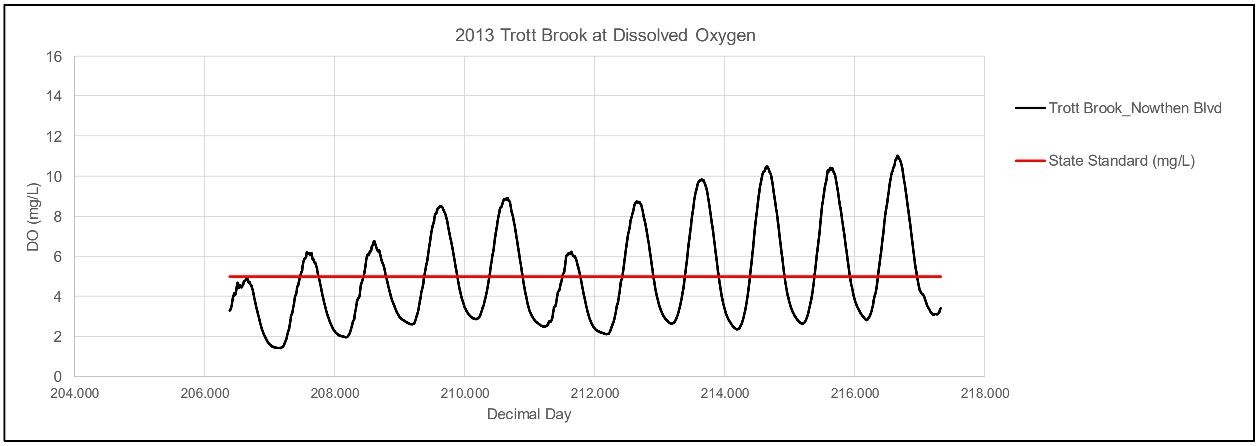
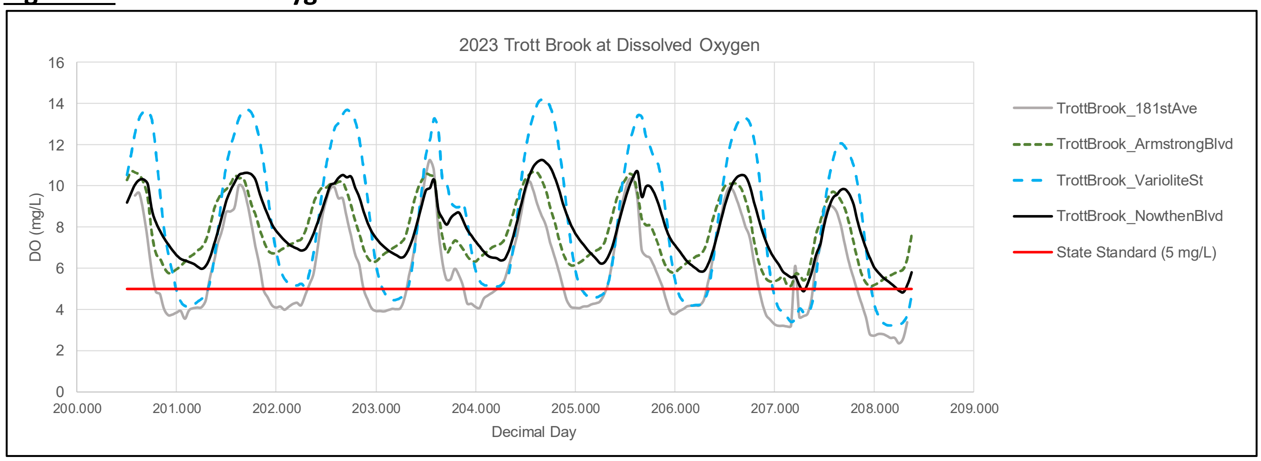


Figure 15 - Dissolved oxygen sonde data from 2023.



Phosphorus

Total phosphorus (TP) is a nutrient that is limiting for algae growth and other production. High phosphorus can result in a large range of oxygen levels due to high daytime photosynthetic production of oxygen and high oxygen consumption by decomposition. The MPCA examines stream phosphorus as a possible causative factor for low oxygen. Streams can also be listed as impaired for high phosphorus.

In 2023, average TP concentrations at the Trott Brook sites occasionally exceed the state standard (100 µg/L), but was usually lower. Thirty-two percent (18 of 56) of samples across seven sites were above the standard. Phosphorous levels during stormflow were higher than baseflow (Table 9). Thirteen of the 18 exceedances were during storm flows. The overall average total phosphorus in 2023 was 96.5 µg/L.

Table 9 - Total phosphorus grab sample summary statistics.

TP - 2023 Baseflow Data

	AVG	MED	TOTAL #	>100 µg/L
Trott Brook @ Twin Lakes Rd	103.3	78.0	4	1
Trott Brook @ 181st Ave	60.0	63.0	4	0
Trott Brook @ Ermine Blvd.	87.3	90.5	4	1
Trott Brook @ Armstrong Blvd	70.8	74.5	4	0
Trott Brook @ Variolite St	116.8	80.5	4	1
Trott Brook @ Nowthen Blvd	68.3	77.0	4	0
Trott Brook @ Hwy 47	87.0	97.5	4	2

TP - 2023 Storm Data

	AVG	MED	TOTAL #	>100 µg/L
Trott Brook @ Twin Lakes Rd	113.8	117.5	4	2
Trott Brook @ 181st Ave	98.5	88.0	4	1
Trott Brook @ Ermine Blvd.	126.8	122.5	4	3
Trott Brook @ Armstrong Blvd	101.8	99.5	4	2
Trott Brook @ Variolite St	93.3	89.0	4	1
Trott Brook @ Nowthen Blvd	102.0	97.0	4	1
Trott Brook @ Hwy 47	121.5	109.5	4	3

TP - 2024 Baseflow Data

	AVG	MED	TOTAL #	>100 µg/L
Trott Brook @ Nowthen Blvd	69.2	64.0	5	0

TP - 2024 Storms Data

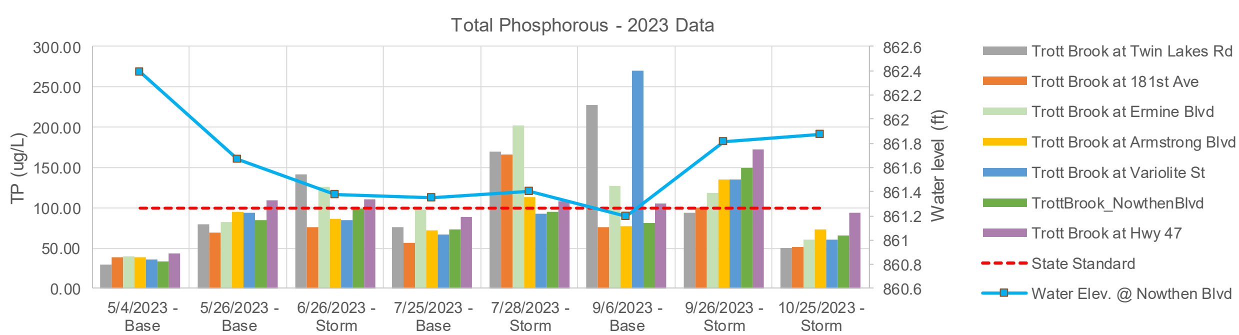
	AVG	MED	TOTAL #	>100 µg/L
Trott Brook @ Nowthen Blvd	NA	NA	0	NA

TP - 2015-2024 All Conditions

	AVG	MED	TOTAL #	>100 µg/L
Trott Brook @ Twin Lakes Rd	102.8	86.0	10	3
Trott Brook @ 181st Ave	79.3	72.5	8	1
Trott Brook @ Ermine Blvd.	103.0	101.0	10	5
Trott Brook @ Armstrong Blvd	85.4	81.5	10	3
Trott Brook @ Variolite St	105.0	89.0	8	2
Trott Brook @ Nowthen Blvd	82.7	81.0	17	8
Trott Brook @ Hwy 47	104.3	107.0	8	5

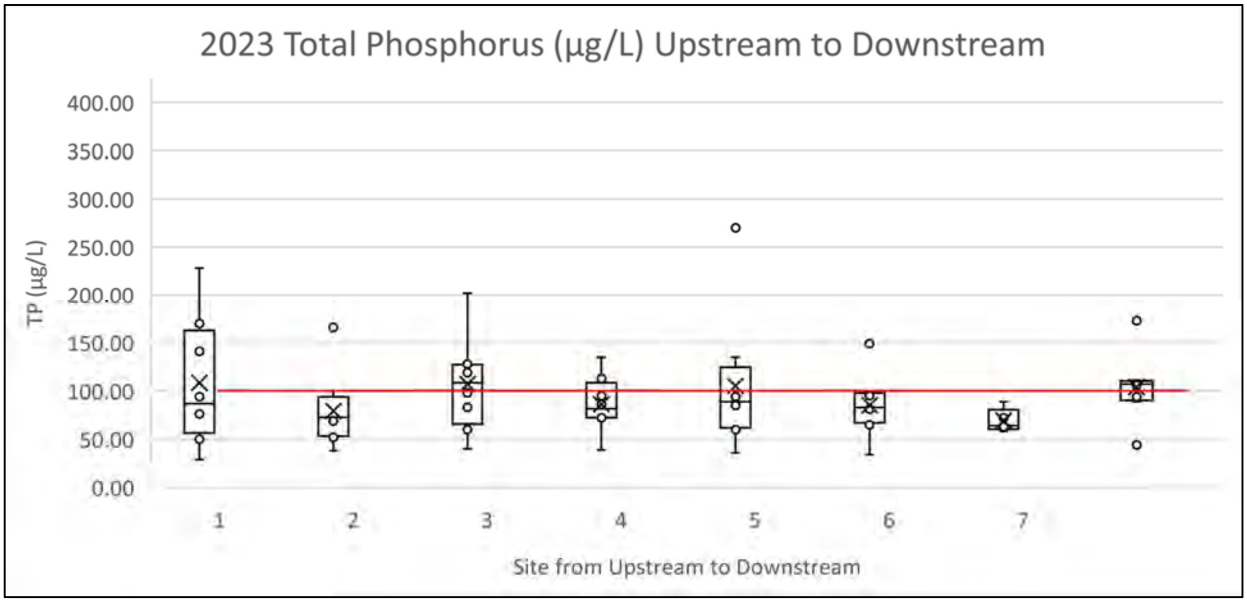
On any given date in 2023, total phosphorus varied amongst sites, but not in a consistent manner (Figure 16). No site routinely had the highest total phosphorus, nor did any routinely have the lowest. Overall, phosphorus increased throughout summer.

Figure 16- Total phosphorus at Trott Brook sites during 2023 grab sampling.

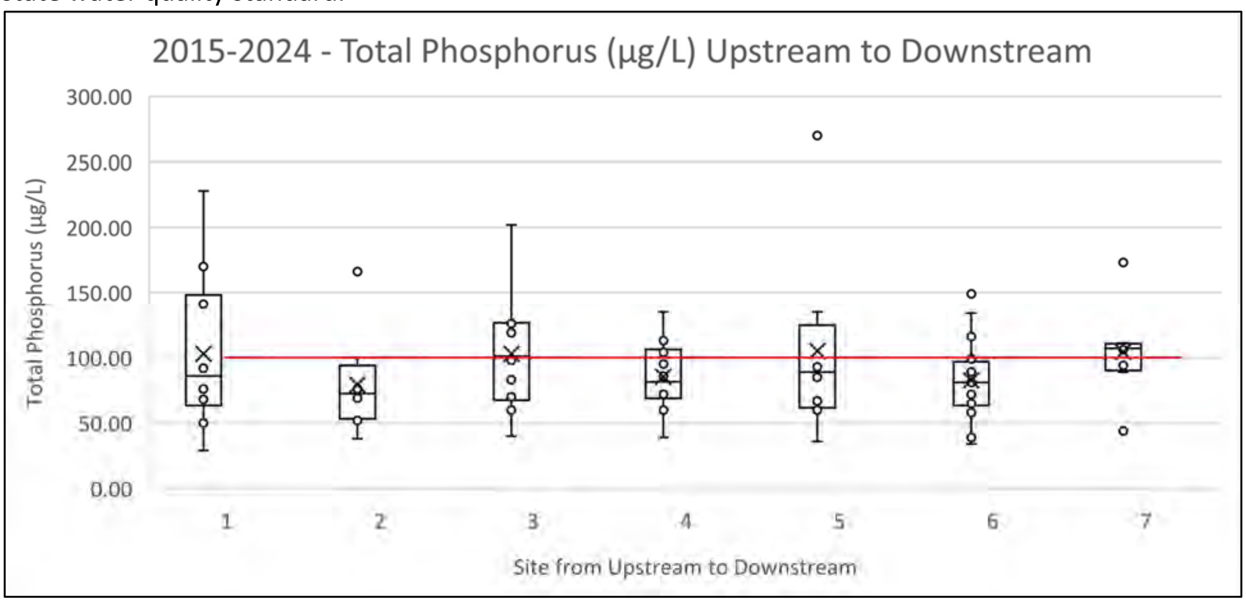


Looking across all dates in 2023 (Figure 17) or 2014-2023 (Figure 18), total phosphorus is relatively consistent from upstream to downstream. High phosphorus above 150 µg/L has been observed at four sites.

<u>Figure 17</u> - Trott Brook total phosphorus from upstream to downstream in 2023. The red line is the state water quality standard.



<u>Figure 18</u> - Trott Brook total phosphorus from upstream to downstream in 2015-2024. The red line is the state water quality standard.



Looking at all data from at Nowthen Blvd (the most-sampled site) the last 10 years, the average TP was similar to the 2023 results. Average TP was 95.7 µg/L during baseflow conditions and 135.0 µg/L post-storm. Of the 36 samples taken across all years at Nowthen Blvd, there have been 16 occurrences of the state standard being exceeded, the majority during post-storm conditions.

Turbidity

Turbidity is a measurement of solid material suspended in the water. Suspended material in water affects water transparency and aquatic life. Many other pollutants are attached to sediment particles. Suspended solids in the waterway can come from both internal and external sources. External sources can include a variety of particles in stormwater runoff. Internally, bank erosion and movement of the bottom substrate contribute to suspended sediments.

Average 2023 turbidity measurements for each Trott Brook site are shown below (Table 10). In all conditions, turbidity was low. On about half of the sampling dates in 2023 turbidity generally increased from upstream to downstream (Figure 19), but looking across all dates there was no clear trend of changing turbidity from upstream to downstream (Figure 20). Generally, turbidity was higher during baseflow than during stormflow conditions, which is atypical of most streams. It may be that in-stream sources are largest and diluted by storm inflows. Turbidity was lower during low water drought conditions in 2023.

Table 10 - Turbidity grab sample summary statistics.

Turbidity - 2023 Baseflow Data

	AVG	MED	TOTAL #
Trott Brook @ Twin Lakes Rd	3.5	3.5	4
Trott Brook @ 181st Ave	4.8	4.9	4
Trott Brook @ Ermine Blvd.	2.6	2.5	4
Trott Brook @ Armstrong Blvd	4.5	2.2	4
Trott Brook @ Variolite St	4.0	1.4	4
Trott Brook @ Nowthen Blvd	3.0	1.7	4
Trott Brook @ Hwy 47	6.0	5.4	4

Turbidity - 2023 Storm Data

	AVG	MED	TOTAL #
Trott Brook @ Twin Lakes Rd	2.4	1.9	4
Trott Brook @ 181st Ave	2.8	2.1	4
Trott Brook @ Ermine Blvd.	2.5	2.3	4
Trott Brook @ Armstrong Blvd	3.9	4.8	4
Trott Brook @ Variolite St	1.9	1.2	4
Trott Brook @ Nowthen Blvd	3.7	4.4	4
Trott Brook @ Hwy 47	9.9	11.9	4

Turbidity - 2024 Baseflow Data

	AVG	MED	TOTAL #
Trott Brook @ Nowthen Blvd	1.2	1.3	7

Turbidity - 2024 Storms Data

	AVG	MED	TOTAL #
Trott Brook @ Nowthen Blvd	NA	NA	0

Turbidity - 2015-2024 All Conditions

	AVG	MED	TOTAL #
Trott Brook @ Twin Lakes Rd	3.0	3.0	8
Trott Brook @ 181st Ave	3.8	2.7	8
Trott Brook @ Ermine Blvd.	2.5	2.3	8
Trott Brook @ Armstrong Blvd	4.2	3.8	8
Trott Brook @ Variolite St	3.0	1.2	8
Trott Brook @ Nowthen Blvd	2.4	1.4	15
Trott Brook @ Hwy 47	7.9	8.8	8

Figure 19 - Turbidity at Trott Brook sites during 2023 grab sampling.

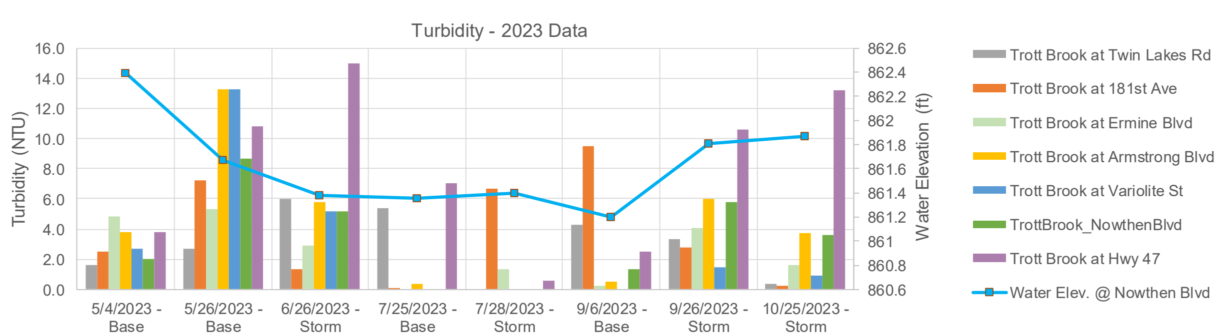
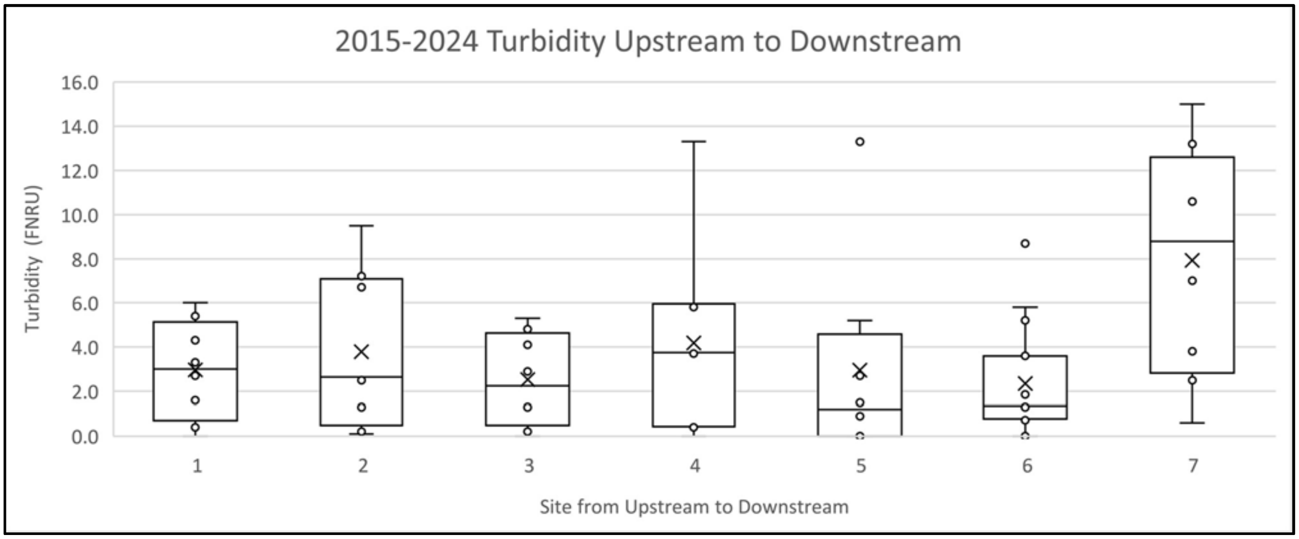


Figure 20 - Trott Brook turbidity from upstream to downstream in 2015-2024. The only years with data are 2023 & 2024.



Specific Conductivity

Dissolved pollutant sources include urban road runoff, salt, and agricultural or industrial chemicals, among many others. Conductivity is a broad measure of dissolved pollutants. High conductivity often triggers additional work to determine the cause. Specific conductivity was acceptably low in Trott Brook over the last 10 years. The average and median specific conductivity at each site in 2023 is listed in Table 11. There is no state water quality standard for conductivity, but it can be used as an indicator of many dissolved pollutants.

In 2023, specific conductivity in Trott Brook was observed higher on average during baseflow conditions than during stormflow conditions. This is consistent with trends observed in previous years, and it provides some insight into the pollutant sources. If dissolved pollutants were only elevated after storms, stormwater runoff would be suspected as the primary driver. However, because dissolved pollutants are highest during baseflow conditions, the suspected primary contributor is groundwater, which normally feeds the stream during baseflow. The largest sources are believed to be salts that have infiltrated into the shallow aquifer. Road deicing and water softening salts are believed to be significant contributors, and geologic materials can also contribute.

Table 11 - **Specific conductivity grab sample summary statistics.**

Specific Conductivity - 2023 Baseflow Data

	AVG	MED	TOTAL #
Trott Brook @ Twin Lakes Rd	0.561	0.578	4
Trott Brook @ 181st Ave	0.477	0.477	4
Trott Brook @ Ermine Blvd.	0.482	0.477	4
Trott Brook @ Armstrong Blvd	0.556	0.570	4
Trott Brook @ Variolite St	0.563	0.572	4
Trott Brook @ Nowthen Blvd	0.568	0.574	4
Trott Brook @ Hwy 47	0.552	0.587	4

Specific Conductivity - 2023 Storm Data

	AVG	MED	TOTAL #
Trott Brook @ Twin Lakes Rd	0.574	0.577	4
Trott Brook @ 181st Ave	0.462	0.460	4
Trott Brook @ Ermine Blvd.	0.492	0.494	4
Trott Brook @ Armstrong Blvd	0.530	0.527	4
Trott Brook @ Variolite St	0.542	0.552	4
Trott Brook @ Nowthen Blvd	0.545	0.553	4
Trott Brook @ Hwy 47	0.563	0.563	4

Specific Conductivity - 2024 Baseflow Data

	AVG	MED	TOTAL #
Trott Brook @ Nowthen Blvd	0.524	0.544	8

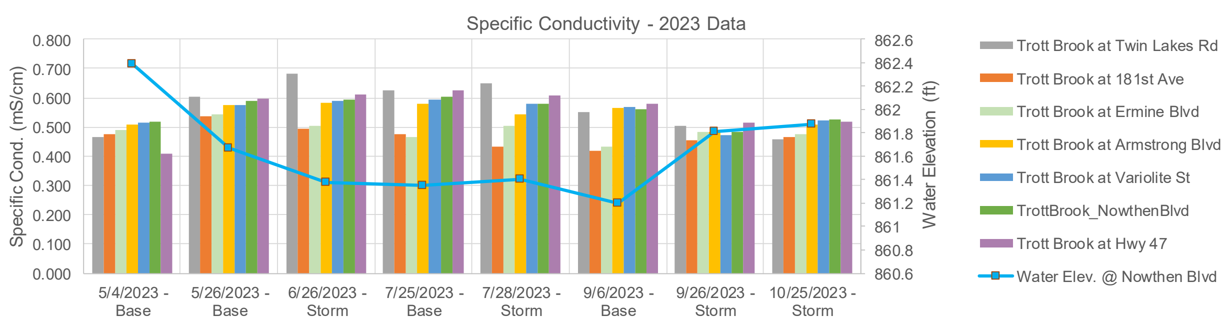
Specific Conductivity - 2024 Storms Data

	AVG	MED	TOTAL #
Trott Brook @ Nowthen Blvd	NA	NA	0

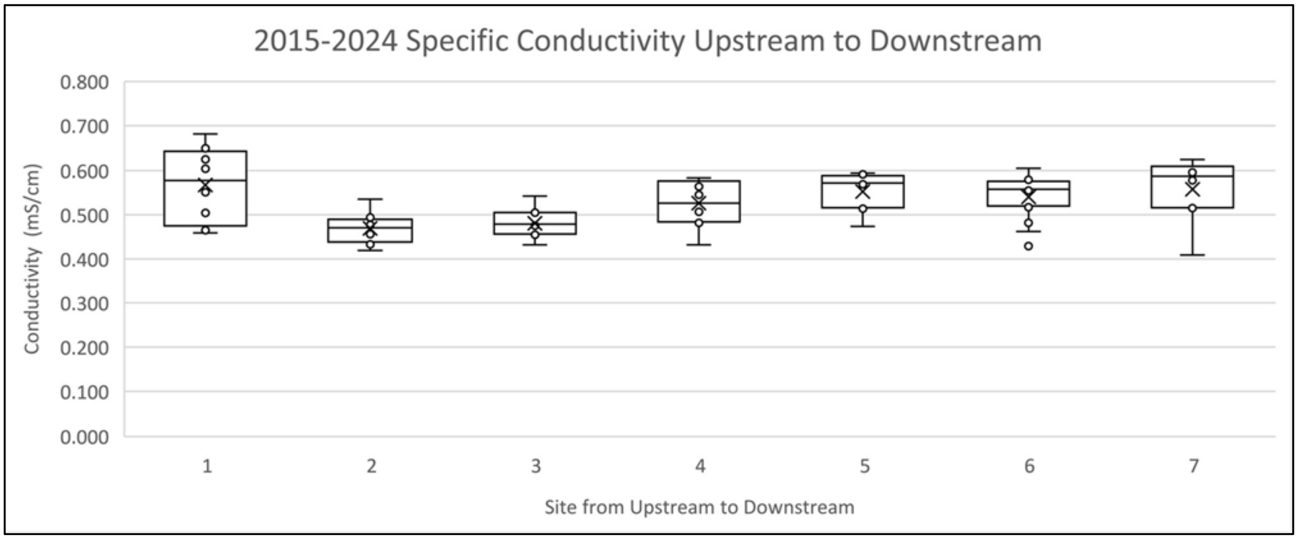
Specific Conductivity - 2015-2024 All Conditions

	AVG	MED	TOTAL #
Trott Brook @ Twin Lakes Rd	0.567	0.578	8
Trott Brook @ 181st Ave	0.469	0.471	8
Trott Brook @ Ermine Blvd.	0.481	0.479	10
Trott Brook @ Armstrong Blvd	0.526	0.527	10
Trott Brook @ Variolite St	0.553	0.572	8
Trott Brook @ Nowthen Blvd	0.540	0.558	16
Trott Brook @ Hwy 47	0.557	0.587	8

Figure 21 - **Specific conductivity at Trott Brook sites during 2023 grab sampling**



<u>Figure 22</u> - Trott Brook conductivity from upstream to downstream in 2015-2024.



pH

pH refers to the acidity of the water. The state standard for pH is between 6.5 - 8.5. pH is generally lower during storm events than during baseflow conditions because the pH of rain is typically lower (more acidic). While acid rain is a longstanding problem, its effect on this aquatic system is minimal.

In 2023, average pH in Trott Brook ranged from 7.61 - 7.80 during baseflow conditions, and 8.04 - 8.57 post-storm (Table 12). Based on current and historical data, pH in Trott Brook is within the healthy range.

<u>Table 12</u> - pH grab sample summary statistics.

pH - 2023 Baseflow Data

	AVG	TOTAL #	<6.5	>8.5
Trott Brook @ Twin Lakes Rd	7.61	4	0	0
Trott Brook @ 181st Ave	7.70	4	0	0
Trott Brook @ Ermine Blvd.	7.73	4	0	0
Trott Brook @ Armstrong Blvd	7.80	4	0	0
Trott Brook @ Variolite St	7.64	4	0	0
Trott Brook @ Nowthen Blvd	7.66	4	0	0
Trott Brook @ Hwy 47	7.77	4	0	0

pH - 2023 Storm Data

	AVG	TOTAL #	<6.5	>8.5
Trott Brook @ Twin Lakes Rd	8.04	4	0	0
Trott Brook @ 181st Ave	8.24	4	0	0
Trott Brook @ Ermine Blvd.	8.25	4	0	0
Trott Brook @ Armstrong Blvd	8.51	4	0	0
Trott Brook @ Variolite St	8.57	4	0	0
Trott Brook @ Nowthen Blvd	8.53	4	0	0
Trott Brook @ Hwy 47	8.56	4	0	0

pH - 2024 Baseflow Data

	AVG	TOTAL #	<6.5	>8.5
Trott Brook @ Nowthen Blvd	7.52	8	0	0

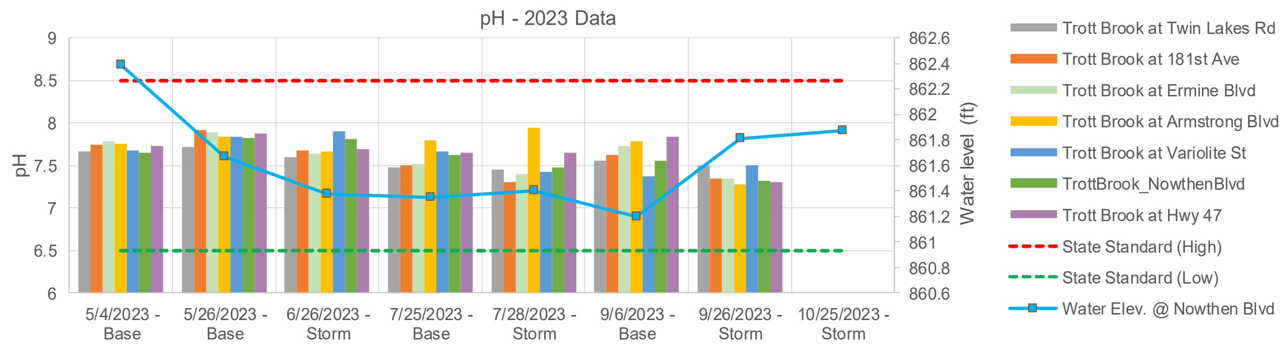
pH - 2024 Storms Data

	AVG	TOTAL #	<6.5	>8.5
Trott Brook @ Nowthen Blvd	NA	0	NA	NA

pH - 2015-2024 All Conditions

	AVG	TOTAL #	<6.5	>8.5
Trott Brook @ Twin Lakes Rd	7.62	9	0	0
Trott Brook @ 181st Ave	7.59	7	0	0
Trott Brook @ Ermine Blvd.	7.66	9	0	0
Trott Brook @ Armstrong Blvd	7.70	9	0	0
Trott Brook @ Variolite St	7.62	7	0	0
Trott Brook @ Nowthen Blvd	7.55	19	0	0
Trott Brook @ Hwy 47	7.68	7	0	0

Figure 23 - **pH at Trott Brook sites during 2023 grab sampling.**



Habitat Assessments

This study included a 2023 Trott Brook habitat assessment (Table 13). It can be used alone and compared to the habitat assessment by the MPCA reported in their 2016 Monitoring and Assessment Report (MPCA, 2016$_a$). The MPCA assessment was only at Nowthen Blvd. The 2023 assessment was at seven sites along Trott Brook. Both used the same methodology: the MPCA's Minnesota Stream Habitat Assessment (MSHA; MPCA, 2017$_c$).

Only the Nowthen Blvd site was scored in both 2016 and 2023. While stream and near-stream conditions did not notably change between 2016 and 2023, the habitat scores differ slightly. In 2016 MPCA tallied a score of 54.87, while Anoka Conservation District staff tallied 47 in 2023. Both scores equate to a "fair" condition. The differences are likely due to the perspectives of the scorers.

At other sites, habitat scores varied along the stream length but were all "poor" or "fair." The conditions most often leading to lower scores were substrate (sandy or mucky) and channel morphology (few pool/riffle sequences, little velocity variability, and little sinuosity). The habitat conditions that had high scores at most sites were land use and the riparian corridor because the lands adjacent to the stream are mostly natural vegetation. Fish cover was variable, but not high at any site due to channelization.

Habitat assessments include an assessment of channel stability. It ranks from 0-9. In 2023 one site ranked 3 (moderate), three ranked 6 (moderate/high), and four ranked 9 (high stability). Overall, the streambanks are largely stable. However, the stream bed is mostly unstable shifting sands and muck. Stream velocities at baseflow are 1 ft/sec or less, and have little erosive potential. The stream gradient is low. Channel stability was also assessed by a Pfankuch evaluation (see next section).

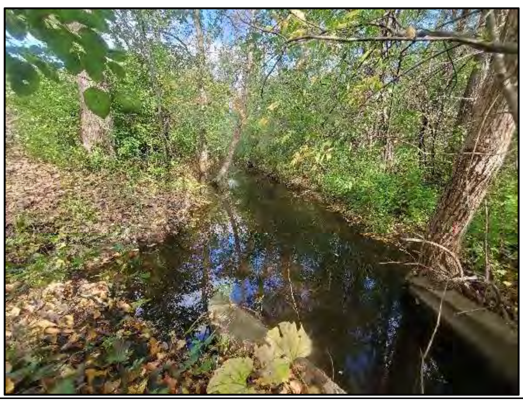
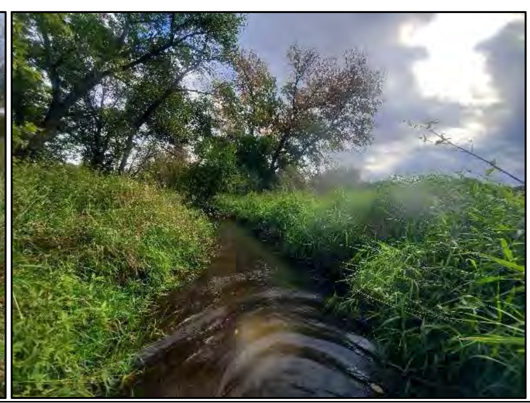
Table 13 - **Minnesota Stream Habitat Assessment (MSHA) results for Trott Brook.**

# visits	Year	Land Use (0-5)	Riparian (0-14)	Substrate (0-28)	Fish Cover (0-18)	Channel Morph. (0+35)	MSHA Score (0-100)	MSHA Rating*
Trott Brook at Twin Lakes Rd (S017-042)	2023	5	12	0	5	6	28	Poor
Trott Br at 181st Ave (S017-041)	2023	5	12	9	14	16	57	Fair
Trott Br at Ermine Blvd (S03-202)	2023	5	8	8	7	12	41	Poor

# visits	Year	Land Use (0-5)	Riparian (0-14)	Substrate (0-28)	Fish Cover (0-18)	Channel Morph. (0+35)	MSHA Score (0-100)	MSHA Rating*
Trott Br at Armstrong Blvd (S008-652)	2023	5	11	2	12	11	42	Poor
Trott Br at Variolite St (S004-306)	2023	5	10	1	1	9	26	Poor
Trott Br at Nowthen Blvd (13UM044)	2016 2023	2.38 5	10.5 10	11.53 4	13 12	17 15	54.87 47	Fair Fair
Trott Br at Hwy 47 (S017-043)	2023	5	10	14	13	21	63	Fair

*Good: MSHA score above the median of the least-disturbed sites (MSHA>66)
Fair: MSHA score between the median of the least-disturbed sites and the median of the most-disturbed sites (45 < MSHA < 66)
Poor: MSHA score below the median of the most-disturbed sites (MSHA<45)

<u>Figure 24</u> - Photos at each stream site.

# visits	Photos Upstream (left) and Downstream (right)	
Trott Brook at Twin Lakes Rd (S017-042)		
Trott Br at 181st Ave (S017-041)		

# visits	Photos Upstream (left) and Downstream (right)	
Trott Br at Ermine Blvd (S03-202)		
Trott Br at Armstrong Blvd (S008-652)		
Trott Br at Variolite St (S004-306)		
Trott Br at Nowthen Blvd (13UM044)		

# visits	Photos Upstream (left) and Downstream (right)	
Trott Br at Hwy 47 (S017-043)		

Streambank Stability

To further investigate the causes of dissolved oxygen and biotic impairments, we conducted a level III Pfankuch stream reach inventory and channel stability evaluation (Pfankuch, 1975). This method requires scoring the stream bottom, lower banks, and upper banks. Fifteen factors are scored, including vegetative bank protection, channel capacity, cutting, deposition, bottom materials composition, and aquatic vegetation. The method produces a numeric score for each stream reach that can be compared to published values to rank stream stability. Stability ranking is dependent upon stream type, which was determined using the methodology of Rosgen (Rosgen, 1994). Field work was done in September 2023 at seven reaches, each centered on one of the 2023 water quality monitoring stations (Figure 9).

Overall stream stability is fair or good (Table 14). Visible streambank erosion is modest. Bottom composition is either unconsolidated sand or unconsolidated muck.

Table 14 - Pfankuch stream stability rankings.

Reach Location	Stream Type	Pfankuch Rating	Reach Condition /Stability
Trott Brook at Twin Lakes Rd (S017-042)	E5	80	Fair
Trott Br at 181st Ave (S017-041)	E5	64	Good
Trott Br at Ermine Blvd crossing nearest to Eaton St (near S003-202)	E5	84	Fair
Trott Br at Armstrong Blvd (S008-652)	E5	82	Fair
Trott Br at Variolite St (S004-306)	E6	80	Fair
Trott Br at Nowthen Blvd (S003-176)	C5	76	Good
Trott Br at Hwy 47 (S017-043)	E5	61	Good

Good stream stability is expected for peatland streams like Trott Brook. While ditching/straightening creates stream stresses that would normally lead to more erosion and re-meandering the channel over time, Trott Brook has little bank erosion and remains straight. Channel migration of peat streams is slow compared to alluvial streams that flow through sand, and has been studied in nearby Cedar Creek which is similar to Trott Brook (Nittrouer, 2024). Sheer stress is relatively low in low gradient streams such as these during in-channel flows, and cannot overcome the bank strength of the peat. During higher flows, these streams spill outward into broad peatland floodplains, further keeping in-channel shear stress lower than bank strength. If Trott Brook were re-meandered by digging new channels, the stream might contact more alluvial deposits on the outer fringes of its floodplain, but would still primarily flow through peatland.

Invertebrate Monitoring

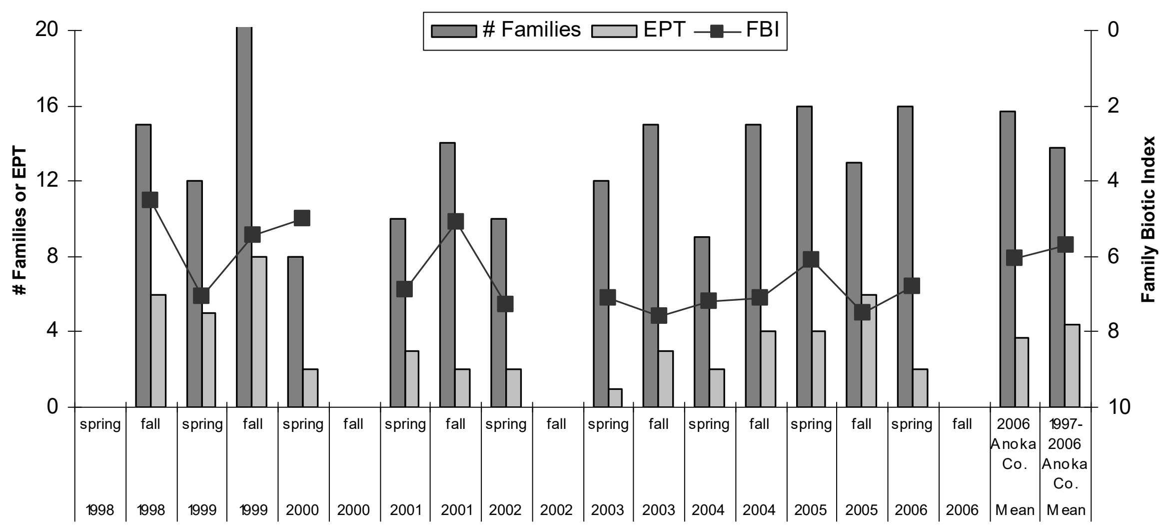
Aside from the fish and invertebrate surveys done by the MN Pollution Control Agency as part of their monitoring and assessment program (MPCA, 2016_a), there has been no other recent biological monitoring. The Nowthen Blvd crossing was monitored by the Anoka Conservation District for macroinvertebrates from 2019 to 2006, except 2000 was not monitored.
Three indices of stream health were examined:

<u># Families**</u>**	Number of invertebrate families. Higher values indicate better quality.
EPT	Number of families of the generally pollution-intolerant orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies). Higher numbers indicate better stream quality.
Family Biotic Index (FBI)	An index that utilizes known pollution tolerances for each family. Lower numbers indicate better stream quality.

FBI	Stream Quality Evaluation
0.00-3.75	Excellent
3.76-4.25	Very Good
4.26-5.00	Good
5.01-5.75	Fair
5.76-6.50	Fairly Poor
6.51-7.25	Poor
7.26-10.00	Very Poor

The invertebrate data through 2006 suggest below average stream health (Figure 25). Family biotic index (FBI) has consistently been below average. The number of families found has been similar to the average for other Anoka County streams. The number of sensitive EPT families found has varied. Because this data is more than 10 years old, we include it in this report only for historical perspective.

Figure 25 - Invertebrate biomonitoring results for Trott Brook at Hwy 5. Sampling was by the Anoka Conservation District.



Modeling Updates

An HSPF model was used by MPCA for the Trott Brook TMDL and we have used that model to further explore the magnitude and type of practices that may be needed to improve stream conditions. This model's strength is that it includes fate and transport of pollutants, represents pollutant loadings that actually enter the stream as opposed to field scale, and allows "what if" scenarios including land use changes and BMP installations. The model can estimate which BMPs are most cost effective in each subwatershed and estimate the costs of implementing them to achieve various numeric pollutant goals. Its weakness is that it is coarse (subwatershed-level) and primarily draws conclusions based on land uses. It does not place practices at specific locations.

The current version of HSPF is calibrated with water monitoring data through 2015 and 2013 land use data. The MN Pollution Control Agency periodically extends the model with new monitoring data. This would be exceptionally useful for Trott Brook since much more monitoring data has been recently collected, especially in 2023 (6 additional sites monitored). Also, land use changes have occurred since, particularly conversion of upland undeveloped to developed (Figure 26). Multiple requests for HSPF SAM model extension were made, but MPCA did not respond. We therefore utilized the model as-is, calibrated to data through 2015. This is termed the "base" scenario model from which other scenarios were created.

The HSPF model breaks the Trott Brook basin into three subwatersheds (Figure 27). They include:

- **A433** - Trott Brook main stem from the headwaters to the confluence with Ditch 27. This includes Ditch 51.
- **A431** - Ditch 27, which enters the main stem of Trott Brook 600 ft downstream of Nowthen Blvd (Co Rd 5).
- **A443** - Trott Brook between Ditch 27 and the Rum River.

A443 was not included in the models presented below. The TMDL and previous assessments were based on the Nowthen Blvd (Co Rd 5) crossing, which is the bottom of the A431 and A433 subwatersheds. It excluded A443. Consistency with previous work allows greater comparability.

<u>Figure 26</u> - Example of conversion to developed land uses in the Trott Brook subwatershed.

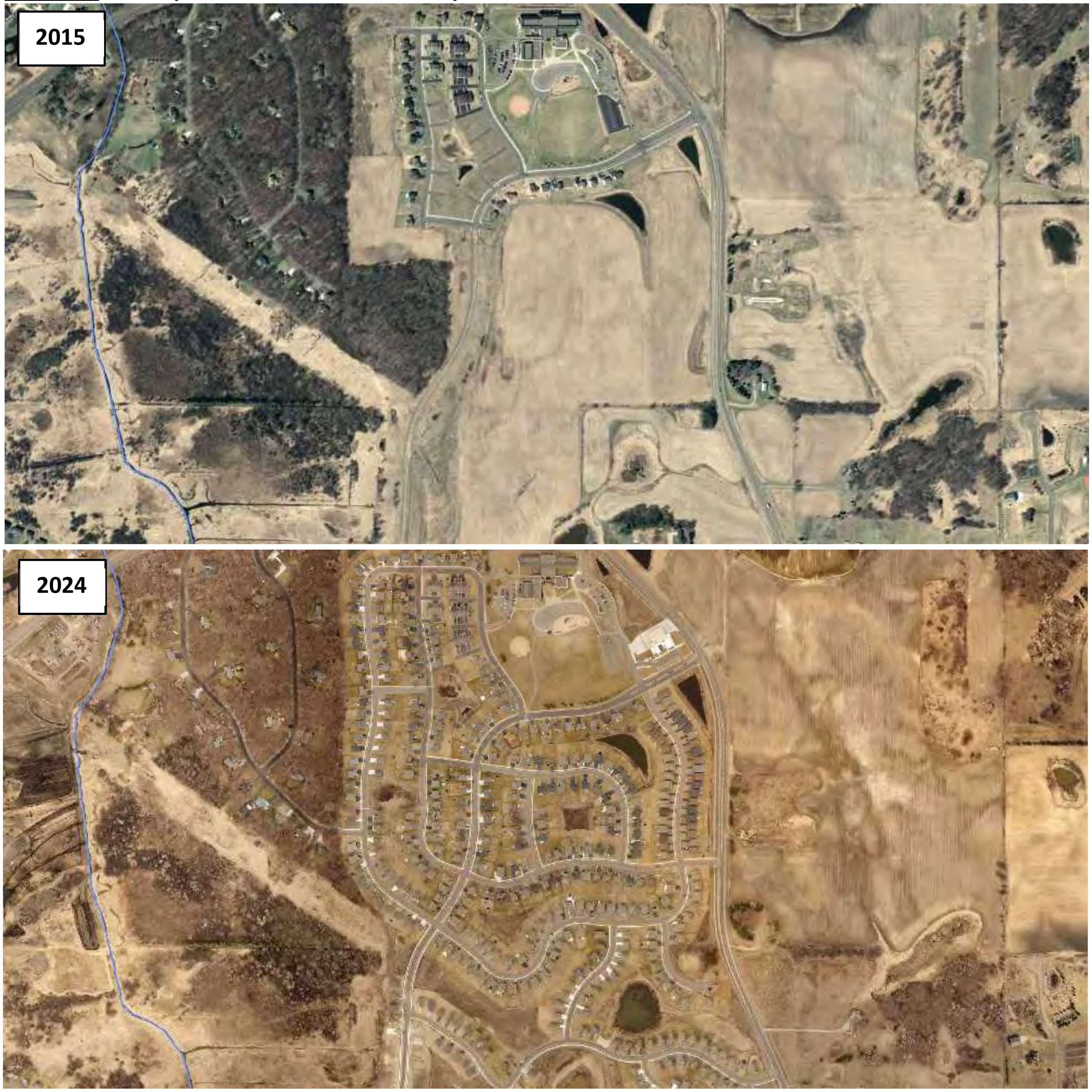
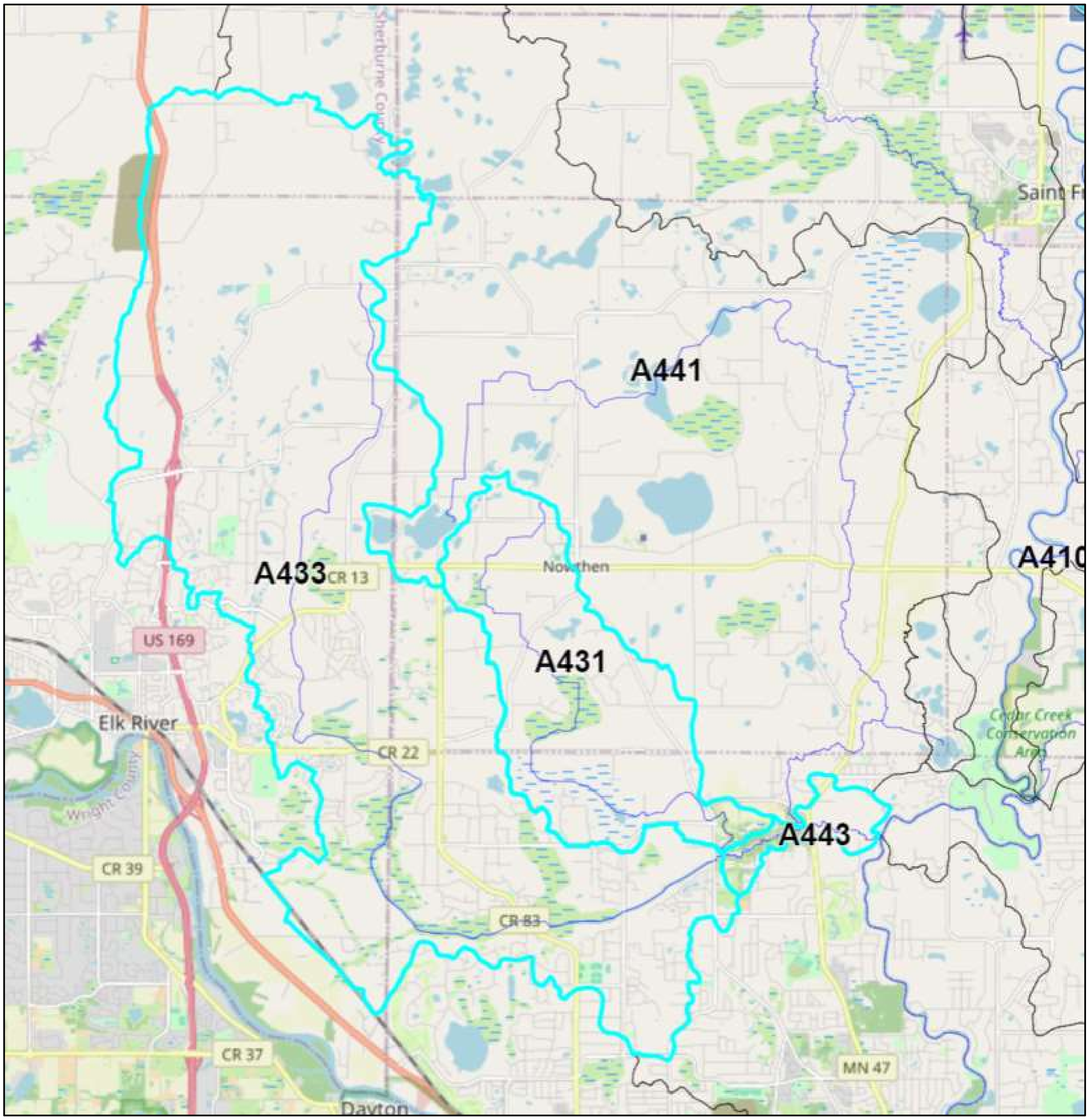


Figure 27 - **HSPF SAM model Trott Brook subwatersheds.**



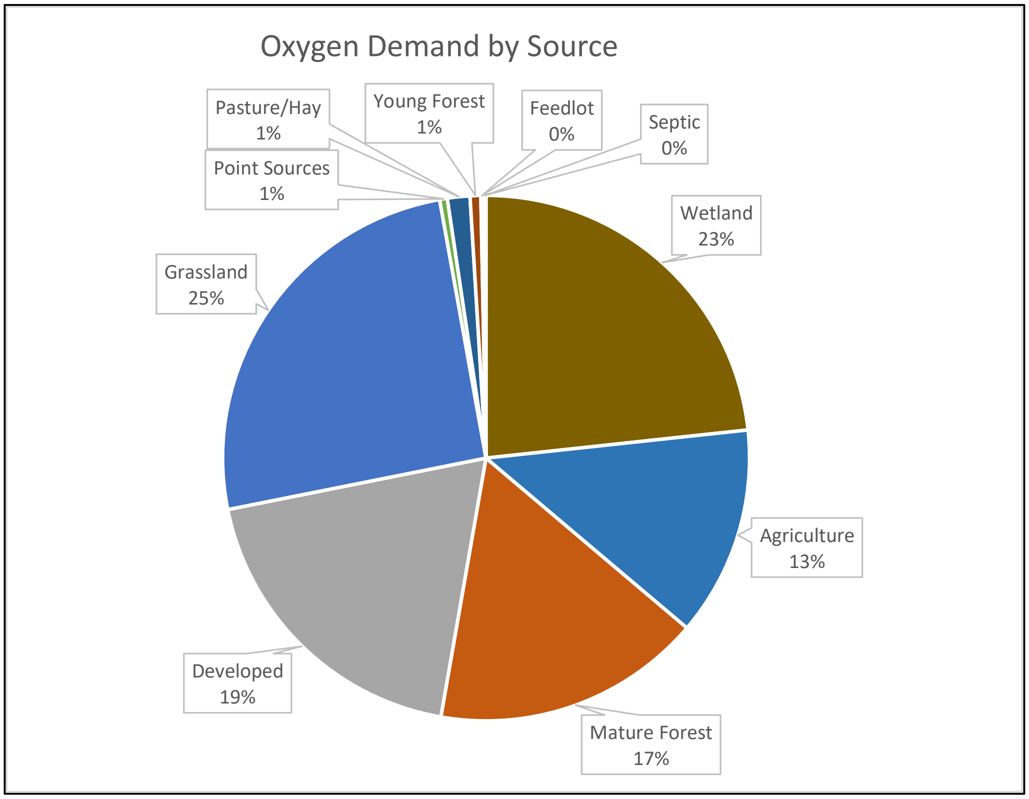
Model Run: Oxygen Demand – Base Scenario

We first ran the HSPF SAM model to estimate oxygen demand loading in the base scenario. The base scenario is default 2013 land uses and no added BMPs. The TMDL report (MPCA 2017_a) included this same model run, estimating 661 lbs/day. Our model re-run estimated 551 lbs/day. It appears the TMDL may contain a typo.

The TMDL authors also ran a base model estimating the oxygen demand reduction needed to have dissolved oxygen above 5 mg/L 95% of the time, meeting an important part of the state water quality standard. They found that condition was achieved when oxygen demand loading was reduced to 332 lb/day. Using our base loading estimate of 551 lbs/day, this means a 40% reduction in oxygen demand is needed, not the 50% reported in the TMDL.

HSPF provides an estimate of oxygen demand sources by land use (Figure 28). These utilize estimated export rates for each land use type. It estimates that the sources responsible for >10% of loading were grasslands, wetlands, developed, mature forests, and agriculture.

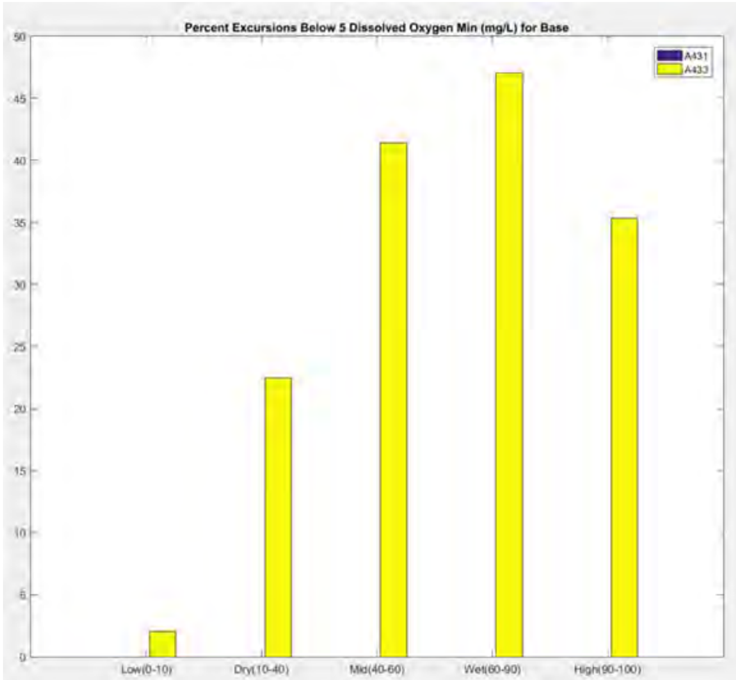
Figure 28 - Oxygen demand sources in the base scenario.



The model predicts that low oxygen is most common in the Trott Brook main stem, but not in the Ditch 27 tributary. Figure 29 shows no excursions of dissolved oxygen below 5 mg/L in that tributary. We do not have monitoring data to confirm dissolved oxygen in Ditch 27.

The model indicates low oxygen is relatively independent of flow (Figure 29). The TMDL report (MPCA, 2017_a) reached the same conclusion.

Figure 29 - **Percent of dissolved oxygen excursions below 5 mg/L by flow regime**. Note subwatershed A431 had no excursions.



The model predicts that diurnal oxygen fluctuation of >3.5 mg/L (the state standard) occurs in both the A431 and A433 subwatersheds, but under different conditions (Figure 30). Excessive oxygen fluctuation is predicted to be most common at lower flows in subwatershed A431 (Ditch 27) and higher flows in subwatershed A433 (main stem Trott Brook). Both subwatersheds are predicted to have the greatest number of exceedances in late summer (Figure 31).

Figure 30 - **Percent exceedance of 3.5 mg/L dissolved oxygen daily flux by flow.**

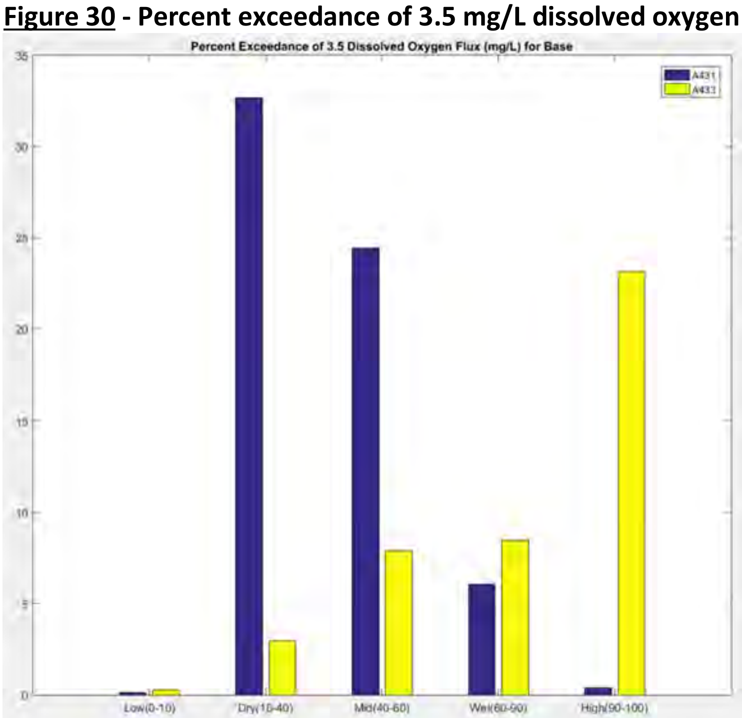
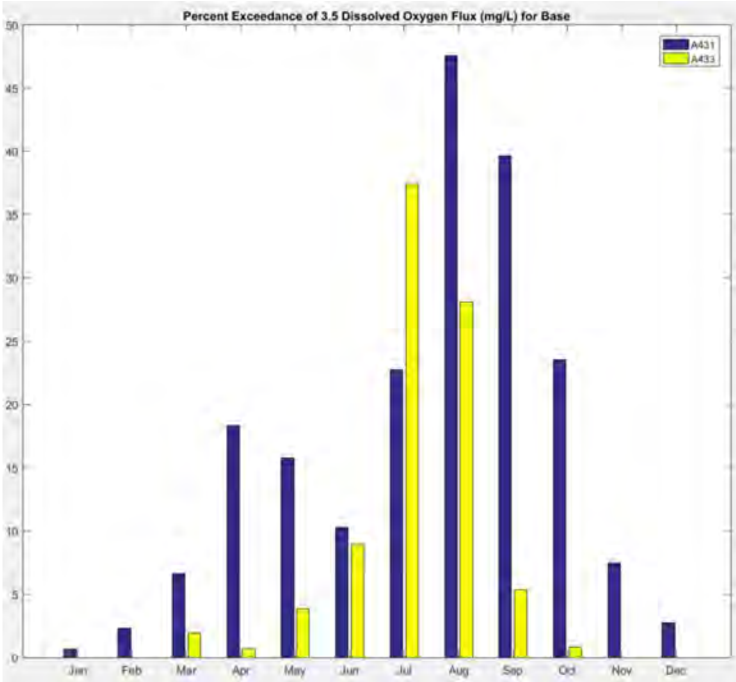


Figure 31 - Percent exceedance of 3.5 mg/L dissolved oxygen daily flux by month.



Model Run: Total Phosphorus Loading – Base

TMDL authors pointed to phosphorus reduction as a primary means to achieve higher dissolved oxygen. So, we ran a base scenario model to estimate phosphorus loading. The model estimates total phosphorus loading of 3,636 lbs/yr.

HSPF outputs are consistent with the monitoring data that found phosphorus in Trott Brook is near, but not exceeding the state water quality standard of 100 µg/L. HSPF estimates that subwatershed A431 exceeds the state TP water quality standard 6.8% of the time and A433 exceeds the standard 11.4% of the time.

Model Run: 5% Phosphorus Reduction

A 5% phosphorus reduction goal has been set in the Rum River Comprehensive Watershed Management Plan (ISG, 2022) and Lower Rum River Watershed Management Organization Watershed Plan (LRRWMO, 2021). While their target is the Rum River, the general management goal of a 5% reduction includes tributaries like Trott Brook. The purpose of this goal is to ensure total phosphorus concentrations remain below the 100 µg/L state standard. The average TP concentration in the Rum River near Trott Brook is 87.2 µg/L during baseflow and 104.5 µg/L post-storm.

A 5% phosphorus reduction for Trott Brook would be 182 lbs/yr. This would seem to be an achievable medium-term goal for Trott Brook. It will ensure phosphorus standards continue to be met and may also be a reasonable start toward dissolved oxygen improvement.

The highest percentage of total phosphorus exceedances over 100 µg/L are estimated by the HSPF model to be during higher water conditions (Figure 32). This consistent with 2023 monitoring data which found phosphorus >100 µg/L occurred twice as often during storms than base flows. The TMDL flow duration curve (Figure 7) is unclear that phosphorus is higher during high flow. The model predicts multiple land uses contribute phosphorus (Figure 33).

Figure 32 - Phosphorus percent exceedance of the 100 µg/L state standard. Base scenario.

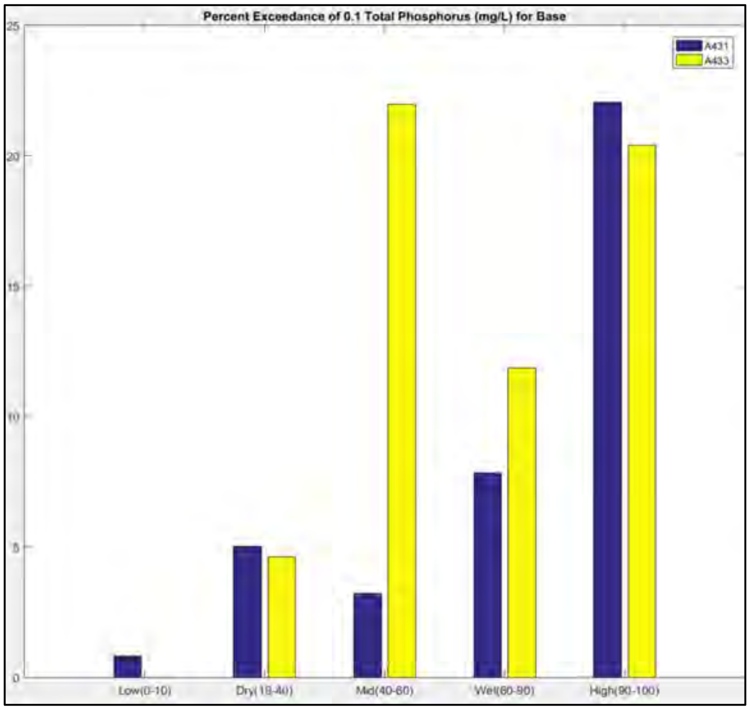
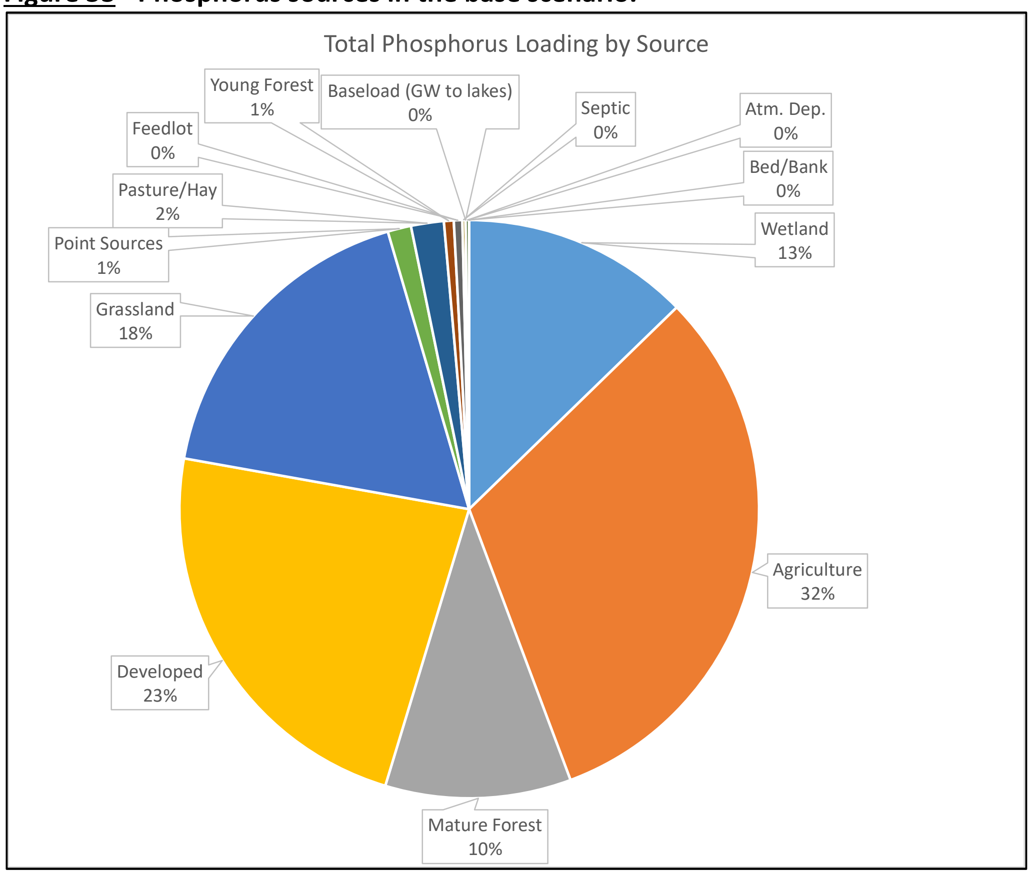


Figure 33 - Phosphorus sources in the base scenario.



Model Run: Cropland Conversion to Development Scenario

We modeled a scenario with conversion of cropland to development. This was to estimate the impact of rapid development has already occurred since the model was last updated in 2013, and future development. Cropland tends to be the most suitable of all lands for development, but forests, grasslands, and other uplands are also being developed.

The cropland to development scenario changed all suitable cropland to developed. Developed lands increase from 30,148 acres to 31,601 acres. Cropland decreases from 1,631 acres to 178 acres. No changes were made to other land uses.

The model predicts water quality conditions will improve in the cropland to development scenario. This is because HSPF SAM assigns a phosphorus export rate of 0.92 lbs/ac/yr for cropland and 0.33 lbs/ac/yr for developed lands. It is understood that in reality developed lands conversion might also come from grassland, forested, or similar land uses which have lower pollutant loading rates. HSPF SAM does not display an explicit export rate for dissolved oxygen demand, and treats it as a response variable to changes in other parameters including phosphorus.

The model estimates a 21.3% phosphorus reduction and 5.4% oxygen demand reduction in the cropland to development scenario compared to the base scenario (Table 15). This should not imply that development is a solution, but rather that robust stormwater treatment within development is an effective step in comparison to cropland which is assumed to have no water quality practices. Models are approximations only.

Table 15 - Modeled phosphorus and oxygen demand in base and developed scenarios.

	Total Phosphorus		Oxygen Demand	
Scenario	**Load (lbs/yr)**	**% Change**	**Load (lbs/day)**	**% Change**
Base	3,636		551	
Cropland to Development	2,861	↓21.3%	521	↓5.4%

Monitoring data appears to agree with at least the direction of model-predicted phosphorus and dissolved oxygen change during development (Table 15). Both were lower in 2023 than during 2013-15 grab sampling. However, this observation should be taken with caution – many variables can influence these parameters and longer term data are needed to confidently draw conclusions.

Table 16 - Observed phosphorus and dissolved oxygen during the last 11 years. Trott Brook at Nowthen Blvd.

Time Period	Total Phosphorus			Dissolved Oxygen		
	TP (µg/L)	**n**	**# exceedances of 100 µg/L state standard**	**DO (mg/L)**	**n**	**# exceedances of 5 mg/L state standard**
2013-15	105	19	10	5.71	25	6
2023-2024	79	13	1	6.53	16	3

We note that the model acreage of cropland is less than actual cropland. The model has 1,631 acres of cropland. As part of the targeting analysis for this study we hand-digitized row crop, hay, and sod land uses. That exercise found 2,323 acres of row cropland. This 692 acre difference may be of little consequence as row crops are still just 10% of the land uses and are under pressure to be converted to developed lands.

Re-evaluation of Low Dissolved Oxygen Impairment

Condition & Severity

Data collected during this study indicates a likely impairment for low oxygen, however less severe than previous data. The last 10 years of data (2015-2024) at Nowthen Blvd are sufficient to meet the MPCA's minimum data requirements for assessment (20 measurements the last 10 yrs). There, five of 21 measurements were <5mg/L. That exceeds the allowable state threshold of 10% of measurements being <5mg/L. Other sites have inadequate data for official assessment, but sufficient data to generally understand conditions. Official re-assessment of the stream will occur by the MPCA in approximately 2026.

We can compare data from the 2015 stream assessment to present. Only one site has data from the MPCA monitoring and assessment in 2013-14 and in 2023-2024: the Nowthen Blvd crossing. 2023 and 2024 had higher dissolved oxygen. In 2013-2014, the average dissolved oxygen was 5.4 mg/L (n=20) and measurements were in mid-morning to early afternoon. In 2023 the average dissolved oxygen was 6.96 mg/L (n=8) and measurements were all taken prior to 9:00am (when oxygen would be expected to be lowest), except for one taken at 10:55am. None were <5 mg/L. In 2024, eight measurements at midday averaged 6.1 mg/L but three of those were <5mg/L.

At other sites, which have insufficient data for an official assessment, it is unclear whether the dissolved oxygen might be deemed below state standards. At those sites all data in the last 10 years is from 2023 (8 measurements/site) and 2015 (2 measurements, applies to three sites). Two sites have no instances of dissolved oxygen <5 mg/L, two sites have one such instance, one site has two such instances, and one site has three such instances. If more data were collected, it is reasonable to think that some sites may meet the impairment criteria.

Minimum daily DO readings from sondes indicate a less severe oxygen impairment in 2023 than 2013. In 2013 a sonde at the Nowthen Blvd crossing found that oxygen dipped below 3 mg/L every night. In 2023, oxygen levels at that site were better, bottoming out near 5-6 mg/L. Similar minimum daily DO was observed at the three other sites with sondes in 2023 (Figure 15). Across the four sites with sondes in 2023, only two had oxygen levels that dipped below 5 mg/L (the state standard). Interestingly, the sites going below 5 mg/L were not adjacent to each other.

Daily dissolved oxygen fluctuation exceeded the 3.5 mg/L state standard at all four sites with sondes in 2023 (Figure 15). This diel oxygen flux is used by MPCA in their stream assessments as a response indicator to excess nutrients.

Extent

Low oxygen is throughout the length of Trott Brook. There was no clear upstream to downstream pattern of improvement or deterioration. No sites were notably or consistently worse than others. Monitoring up- and down-stream of the Ditch 51 and 27 confluences does not find dissolved oxygen changes due to ditch inputs.

Causes

We can look at several possible factors to determine causes of low oxygen. These factors include land uses, nutrient concentrations throughout the stream length, landscape features, and others. The evidence and deduction lead us to believe ditched peat wetlands that are expansive along the Trott Brook's length are a large cause of low dissolved oxygen.

We find little correlation between land uses and oxygen levels. Low oxygen is found throughout the stream length, from the more rural upstream areas to more developed downstream areas. Modeling results attribute nearly equal amounts of oxygen demand loading to all the major land uses – cropland, developed, forested, grassland, and wetland (MPCA, 2017$_a$). "Low dissolved oxygen is a chronic condition and driven from persistent watershed sources, is not driven by stormwater runoff" (MPCA, 2017_a). HSPF modeling indicates oxygen demand is greatly outpaced by re-aeration and algal production in Trott Brook (MPCA, 2017_a).

The TMDL study speculates that nutrients, especially phosphorus, are a cause of low oxygen (MPCA, 2016_a; MPCA 2016_b). This is based observations of macrophytes & filamentous algae, as well as phosphorus grab samples until 2014 (MPCA, 2016_a; MPCA, 2016_b). During this study, we did observe macrophytes and filamentous algae at the Nowthen Blvd crossing, which is the same site that MPCA utilized in its previous work. However, we did not observe this farther than 100 ft from that location, nor was it prevalent at other monitored sites.

We evaluated phosphorus concentrations during this study because previous works have listed diel oxygen fluctuation as a response variable to excess TP (MPCA, 2016_a; MPCA, 2016_b). As a result of this study, we have 8-10 TP measurements at each of seven sites along Trott Brook in the last 10 years. The average TP at each site ranges from 79 to 105 µg/L, with an all sites average of 94.6 µg/L and standard deviation of 10.7 µg/L. In other words, the stream overall is slightly below or at the state water quality standard of 100 µg/L. It is also lower than the median of Anoka County streams (119 µg/L) and the median total phosphorus for minimally impacted streams in the North Central Hardwood Forest Ecoregion mean is 100 µg/L (MPCA, 2019). Most nearby streams have similar or higher phosphorus concentrations do not have low oxygen. It does not appear that phosphorus is a primary contributing factor to low oxygen in Trott Brook.

Multiple studies of Trott Brook have identified decomposition in adjacent wetlands as a likely major source of low dissolved oxygen levels and/or nutrients, a phenomena accelerated by lateral ditches (MPCA, 2016_a; MPCA, 2016_b). For example, the MPCA Monitoring and Assessment Report states, "channelization appears to be draining a wetland complex and may be contributing to the elevated nutrient concentrations along with the low DO concentrations observed" (MPCA, 2016_a). The guidance document for determining impairment (MPCA, 2024) recognizes this can occur, noting that "Some low-gradient, heavily wetland-influenced streams may never meet the current DO standard of 5 mg/L, even though pollutant sources and anthropogenic influences are insignificant or even non-existent. In such cases, the current DO standard is not a useful indicator of the health of the water."

Observations supporting the idea that stream corridor peatlands are a large source of oxygen demand include:

- The prevalence of these peatlands along Trott Brook (see Map 4, Map 5, Map 6, Figure 34). It is a dominating land use in the stream corridor, comprising 37.8% of lands within 1,000 feet of the stream. Floodplain wetlands are 300 to >1,300 feet wide depending on location.
- MPCA monitoring of the stream found invertebrate assemblages characteristic of wetlands, indicating a more wetland-like ecological condition.
- The abundance of lateral ditches draining the peatlands into Trott Brook. There are more than 20 man-made lateral ditches and additional drainages that appear natural (not straightened).
- Dissolved oxygen and total phosphorus are independent of flow regime (MPCA 2017_a) suggesting that stormwater runoff is not a primary cause.
- In-stream phosphorus concentrations are not high enough to be the causative factor for the observed diel oxygen fluctuation. This stream's phosphorus levels are the same or lower than other nearby streams, but oxygen levels are much lower. Oxygen demand in floodplain wetlands would not necessarily be reflected in in-stream nutrient concentrations.
- The lack of other sources. Agricultural land uses are light. Development is mostly rural residential in sandy soils or newer suburban residential with robust stormwater treatment. Near-stream activity is small due to expansive wetlands – in many areas the stream can only be accessed at road crossings.

- The HSPF SAM watershed model cannot reach more than about 15% dissolved oxygen demand reduction (40% is the goal) by incorporating every possible land use best management practice with no limit on costs (see modeling section of this report). This suggests that a source not well accounted for in the model is important.
- Scientific studies elsewhere. Cycles of drying and re-wetting, often prevalent in ditched wetlands, can increase decomposition during dry periods and deliver by byproducts to the stream during wet periods (Koltz and Lin, 2001; Turner & Haybarth, 2001).

Figure 34 - Example of the prevalence of peatland wetlands and lateral ditches along Trott Brook.

The allocation of oxygen demand load reductions in the TMDL (MPCA, 2017_a) might confuse some readers regarding oxygen demand sources. Of the reductions needed, it calls for 272 lbs/day (82.7%) of it to be achieved by MS4 permitted communities. This is because those permitted communities cover approximately that percentage of the watershed. It is not because the stormwater conveyances in those communities are the source. Municipal stormwater conveyances are absent in large parts of the watershed. The TMDL has a "load allocation" of 24 lbs/day (7.2%) allowable to come from non-permitted sources. These are pollutants from non-point sources such as dispersed runoff outside of MS4 regulated communities. The reality is that pollutants and pollutant reductions will be from almost entirely voluntary practices addressing non-point sources.

Re-evaluation of Biotic Impairment

Severity

Trott Brook has been determined to have a biotic impairment. Some, but not all, biotic monitoring has found a degraded community. This includes monitoring in 2000, 2013, and 2015. There are both fish and benthic macroinvertebrate impairments.

The fish community met healthy stream expectations in 2000 but did not in 2013 or 2015. In 2000 it earned a score of 49 (above 42 indicates meeting stream health expectations). The fish index of biological integrity (IBI) was 35.04 in 2013 and 33.18 in 2015.

The invertebrate community also surpassed stream health expectations in 2000 and maybe in 2013. The threshold for acceptable conditions is an invertebrate score of 43 or above. The year 2000 score was 64.6. In 2023 the reported score is 46.47 or 42.2 – there are conflicting numbers in two MPCA reports (MPCA, 2016_a; MPCA, 2016_b).

The invertebrate monitoring by the Anoka Conservation District during 1998-2006 used different metrics and is not directly comparable to monitoring by MPCA mentioned above. However, that monitoring generally concluded below average stream health based on the invertebrate assemblage.

These assessments are based on conventional stream standards that may not be appropriate for Trott Brook. MPCA has recognized that altered stream channels may have different use or health expectations, and they have developed Tiered Aquatic Life Use standards (TALU). Because Trott Brook has been extensively ditched and included in Minnesota's Altered Waterways Inventory, the TALU standards' applicability should be considered for Trott Brook.

Extent

Biotic monitoring has occurred only at the Nowthen Blvd (Co Rd 5) crossing, so it is not possible to assess the stream length. We might expect that similar biotic shortcomings throughout the rest of the stream because oxygen, phosphorus, and stream morphology (the primary causes of impaired biota (MPCA 2016_b)), are similar throughout the stream length.

Causes

The MPCA has determined that primary causes of impaired biota in Trott Brook are low dissolved oxygen (DO,) eutrophication (based on DO diurnal flux & observed aquatic plants and periphyton), and altered channel which drains adjacent wetlands which increases nutrients (MPCA 2016_b). They did not find that physical habitat, which they scored at one site, was a cause. However, additional habitat assessments done at seven sites as part of this study found habitat was "poor" or "fair."

Overarching Causes of Stream Health Concerns

Trott Brook's depressed biota, low oxygen, and moderate total phosphorus appear to share the same causes and are interlinked. The primary cause appears to be that the stream flows through broad floodplain peatlands with significant main stem and lateral ditching. This results in:

- Reduced habitat due to reduced sinuosity.
- Oxygen consumption by decomposition in ditched, floodplain wetlands.
- Nutrient contributions from ditched, floodplain wetlands.

Other considerations are natural occurrences, including:

- Low gradient, slow flows with drop of 2.1-6.7 ft/mile, with the highest gradient near discharge to the Rum River.
- Little variation in substrate results in reduced habitat. The substrate is primarily sand or muck.

Finally, there are always watershed sources from various land uses, but these are not exceptionally degraded in the Trott Brook subwatershed. Stormwater from the developed land uses are robustly treated and most is not piped directly to the stream. Our monitoring did not find poorer water quality in or immediately downstream of suburbanized areas. We also did not find deteriorating water quality over time as suburbanization progressed, however the datasets are admittedly small. Agricultural land uses are not dominant and few discharge to the stream. There are abundant natural areas and native upland soils with high infiltration rates.

Modeling: Practice Targeting and Optimization for TP and Oxygen Demand Reduction

We ran the HSPF SAM model base scenario to determine practices and subwatersheds for implementing water quality practices. The targeting and optimization function selects the most cost effective practices and estimates total cost to achieve a specified pollutant reduction goal. While only estimates, this function can point managers to effective strategies and likely costs.

Ideally, we would run targeting and optimization to determine practices needed to reduce oxygen demand (our primary concern) to state standards. This model function is not available for dissolved oxygen demand. Instead, it was run for total phosphorus because previous TMDL and stressor identification reports identified total phosphorus as a possible causative factor for low oxygen (MPCA 2017$_a$, MPCA 2016$_b$). We iteratively modeled the practices needed to achieve various phosphorus reduction goals (Table 17). For each iteration, we then saved the scenario and ran it using the "analyze" function to see the associated oxygen demand reductions that are achieved.

<u>Table 17</u> - HSPF model targeting and optimization results. The HSPF SAM model outputs the most cost effective practices and costs to achieve each phosphorus reduction. Associated model-estimated oxygen demand reductions are also presented. Only subwatersheds A431 and A433 are included in the model to approximate benefits near Nowthen Blvd (Co Rd 5), consistent with the TMDL. Additional downstream loading does occur in subwatershed A443, and therefore if the outfall to the Rum River is the target, additional practices will be needed in subwatershed A443 to achieve the listed pollutant reductions.

TP Reduction	Oxygen Demand Reduction	Estimated Cost to Achieve	Most Cost Effective Practices* (in order of best to least)
4.5%	2.0%	$3,621	Reduced tillage (cropland)
22.4%	9.2%	$17,993	Reduced tillage (cropland)
33.4%	14.3%	$1,773,270	Reduced tillage (cropland) Forestry riparian management Water & sediment control basins (cropland) Restore tiled wetlands Conservation cover perennials Constructed wetland
36.2%	14.5%	$36,263,501	Reduced tillage (cropland) Water and sediment control basins (cropland) Restore tiled wetlands (cropland) Conservation cover perennials Constructed wetland Constructed stormwater pond Bioretention Infiltration basins
36.3%	15.0%	$69,870,786	Same as row above

*The 10 practices in the optimization represent all those that have reasonable likelihood of being implemented to a significant degree in the Trott Brook subwatersheds. Those practices included restore tiled wetlands (cropland), water and sediment control basins (cropland), reduced tillage (no till) forestry riparian management zones, stream/in-channel restoration, constructed stormwater pond, constructed wetland, infiltration basins, biofiltration, and conservation cover.

Key findings from this exercise are:

- Reduced tillage or no-till is estimated by the model to be the most cost effective practice.
- Initial phosphorus and oxygen demand reductions are inexpensive, provided widespread adoption of no till agriculture (a low cost BMP) is achieved.
- Additional oxygen demand reductions over 9.2% become extremely expensive.
- Oxygen demand reductions above 14.3% or phosphorus reductions above 33.4% are exceedingly expensive, with costs well over $36M for tiny additional benefits.
- It is not possible to reduce TP enough to bring oxygen demand near state standards. The goal is a 40% oxygen demand reduction from the base model scenario but even the most aggressive phosphorus reduction scenario yields only a 15% oxygen demand reduction.
- The model does not include a practice for restoring ditched peatlands which are believed to be a large source of oxygen demand in Trott Brook. Such practices, if installed, may result in greater pollutant reductions and better cost-effectiveness than the model predicts for other practices.

The model likely over-estimates the availability agricultural practices like no till. The model assumes 100% adoption rates by landowners. Actual adoption rates will be lower. As agricultural lands are converted to developed, fewer places will be available for this practice.

The model likely over-estimates the cost of urban stormwater practices that would be realized by local government agencies. Many urban stormwater practices are required of the developer by ordinances, so the cost burden does not fall directly on local agencies. The cost is nonetheless real and presumably passed to property buyers.

In areas developed prior to the 1980's, the cost of urban BMPs will be higher than projected by the model. This is because development at that time did not include robust stormwater treatment. Practices must now be "retrofitted" into the developed landscape. Fortunately, most of the land developed prior to the 1980's in the Trott Brook watershed is large lot rural residential. In those situations, stormwater treatment is largely achieved by infiltration to the native sandy soils.

The model is to be used with caution with respect to oxygen demand. It does not directly estimate dissolved oxygen changes. Rather, it estimates the reduction of other pollutants that have an explicit reduction efficiency (phosphorus, nitrogen, and sediment). Dissolved oxygen is a response variable to changes in these other pollutants. While imperfect, it is workable as a planning-level tool. Other models for dissolved oxygen are not known, and understandably so given that dissolved oxygen is affected by many variables.

Practices to Improve Stream Health

Practice Identification and Ranking

Practices to restore Trott Brook water quality were compiled and ranked by cost:benefit (Table 18). The cost:benefit rankings are relative, with a basis in both HSPF modeling and professional judgement. Benefits are for total phosphorus and dissolved oxygen unless otherwise stated. Site-specific costs and benefits would need to be calculated for any individual projects selected in the future.

Model-estimated benefits are least certain for oxygen demand reductions and the benefits of wetland restorations. The HSPF SAM model treats dissolved oxygen as a response variable to other primary constituents like phosphorus. While wetland restorations are one of the practices in the HSPF model, the model is assuming restoration of tiled wetlands or constructed wetlands. The benefits of our likely practice, plugging lateral ditches in peatlands, may not be well represented. Nutrient reductions achieved by wetland restorations are notoriously variable.

Table 18 - Practices to improve Trott Brook. Additional descriptions of some strategies are on the following pages.

Practice	Description	Cost*	Benefits	Opportunities	Maintenance	Location
Best Cost:Benefit						
Wetland Restoration	Restoration of wetlands that are currently drained into Trott Brook. Likely method is blocks in lateral ditches. Impacts must remain on willing properties and not affect drainage rights of upstream properties.	$$	High	Many	Low	Trott Br corridor. See Map 7 of lateral ditch block wetland restoration opportunities.
Agricultural BMPs	Practices may include no till, reduced tillage, cover crops, water and sediment control basins, or others.	$-$$	High	Moderate	Low	See Map 9 of cultivated lands. Prioritize fields directly discharging to stream.
Stormwater Treatment for New Development	Robust treatment of stormwater in new development is commonly achieved by ordinances and permitting. See comparison of water quality standards by each local government unit on the following pages. Recommended improvements are requiring no increase in TP or TSS following development and implementation of Minimum Impact Development Standards (MIDS).	$	High	Many	Low	Watershed-wide. See Map 8 for LGUs.

Practice	Description	Cost*	Benefits	Opportunities	Maintenance	Location
Urban Stormwater Retrofits and Maintenance	Add practices into existing development, where warranted. Practices include settling ponds, infiltration practices, iron-enhanced sand filters, or others. Prioritize areas developed before the 1980's when current requirements for stormwater treatment in new development were enacted. Maintaining older existing practices is critical. A subwatershed study to identify and rank potential practices is the recommended first step.	$$	Medium	Few	Medium	See Map 10 of stormwater pipes. TBD by subwatershed study
Enhanced Street Sweeping	An enhanced street sweeping can increase pollutant removal from roads that drain to priority waters by altering the location and frequency of sweeping. An enhanced sweeping study using standardized methods (Kalinosky et al. 2014) can determine the most cost-effective sweeping locations and schedule.	$	High	Few	Medium	See Map 10 of stormwater pipes. Areas directly discharging to the stream.
Medium Cost:Benefit						
Stream Re-meandering	Re-meander ditched/straightened segments of the stream to a more sinuous condition, adding additional habitat including riffle-glide-pool sequences. The stream would still be flowing through large floodplain peatlands that would continue to contribute nutrients and oxygen demand, so benefits for those parameters would likely be low.	$$$$	High – habitat Low – DO and TP	Many	Low	Upstream of Nowthen Blvd
Reforestation of the Stream Corridor	Create shade to cool water temps. Cooler water is capable of holding more oxygen. Offers habitat benefits. Opportunities are limited due to streamside peatlands already in a naturally vegetated state.	$	Low	Many	Low	Streambank
Velocity Flume Aerators	Increase stream velocity and thereby aeration with Parshall flumes or aerating weirs. Would need to incorporate fish passage. Beaver blockages may increase maintenance.	$$	Low	Many	Medium	In-stream, multiple

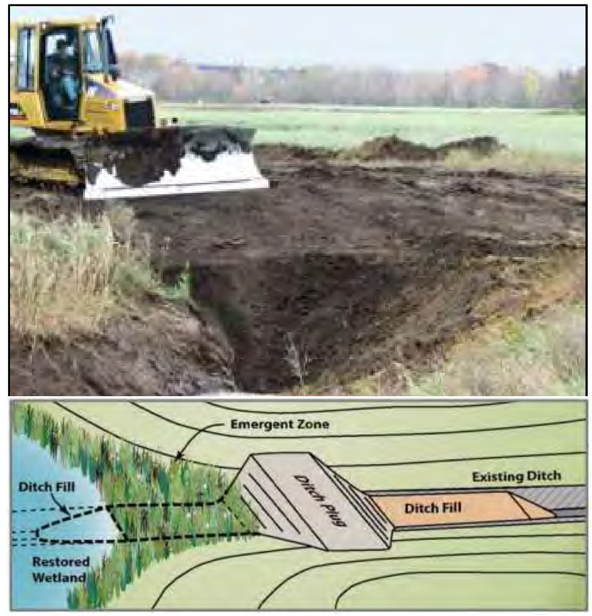
Practice	Description	Cost*	Benefits	Opportunities	Maintenance	Location
Aerators	In-stream bubblers that introduce pure oxygen or compressed air. Concerns include maintenance and that electrical failure could result in fish kills. Best placed at accessible, public lands locations.	$$	High	Many	High	In-stream, multiple
Poor Cost:Benefit						
Streambank Stabilization	Correct streambank erosion. Sites in need of stabilization are limited. Pfankuch stream reach inventory and channel stability evaluation found “fair” and “good” conditions at inventoried sites. A full inventory of stream conditions is recommended to identify sites before implementation.	$$	Low	Few	Low	In-stream, sites not yet identified
In-Stream Habitat that Increases Aeration	Adding rock or woody material that causes riffles or turbulence to increase aeration. The low gradient of the stream will limit this practice. Prioritize areas downstream of Nowthen Blvd due to proximity to the Rum River and likelihood the area can be used for game fish spawning.	$-$$	Low	Many	Low	In-stream, multiple
Other						
Re-evaluate Impairment Status	Re-evaluate whether stream conditions are: - Meeting impairment criteria or - Impaired, but due to natural background conditions or the ditched nature of the waterway. 2025-2026 MPCA will conduct watershed monitoring and assessment. A report is anticipated in 2026.	$	NA	NA	NA	NA
Effectiveness monitoring	After installation of BMPs, effectiveness monitoring will be warranted.	$	NA	NA	NA	TBD

*Costs: $ $0-$100K
$$ $100K-$250K
$$$ $250K-$500K
$$$$ $1M+

Costs are for 1-3 projects of modest size. Most practices could be up-scaled as funding and available sites allow. See the “Magnitude of Reductions Needed” section of this report for an estimate of the total number of BMPs and associated costs to reach goals.

Lateral Ditch Wetland Restorations

Lateral ditches with potential for wetland restoration by ditch blocks were identified (Map 7). This practice is a top candidate for reducing oxygen demand and phosphorus. Lateral ditches drain wetlands adjacent to Trott Brook, and are abundant in the stream corridor. Many appear to have served past agricultural purposes, but do not serve present day land uses. Earthen or other ditch plugs, or weirs, can be a simple and effective way to restore those drained wetlands.



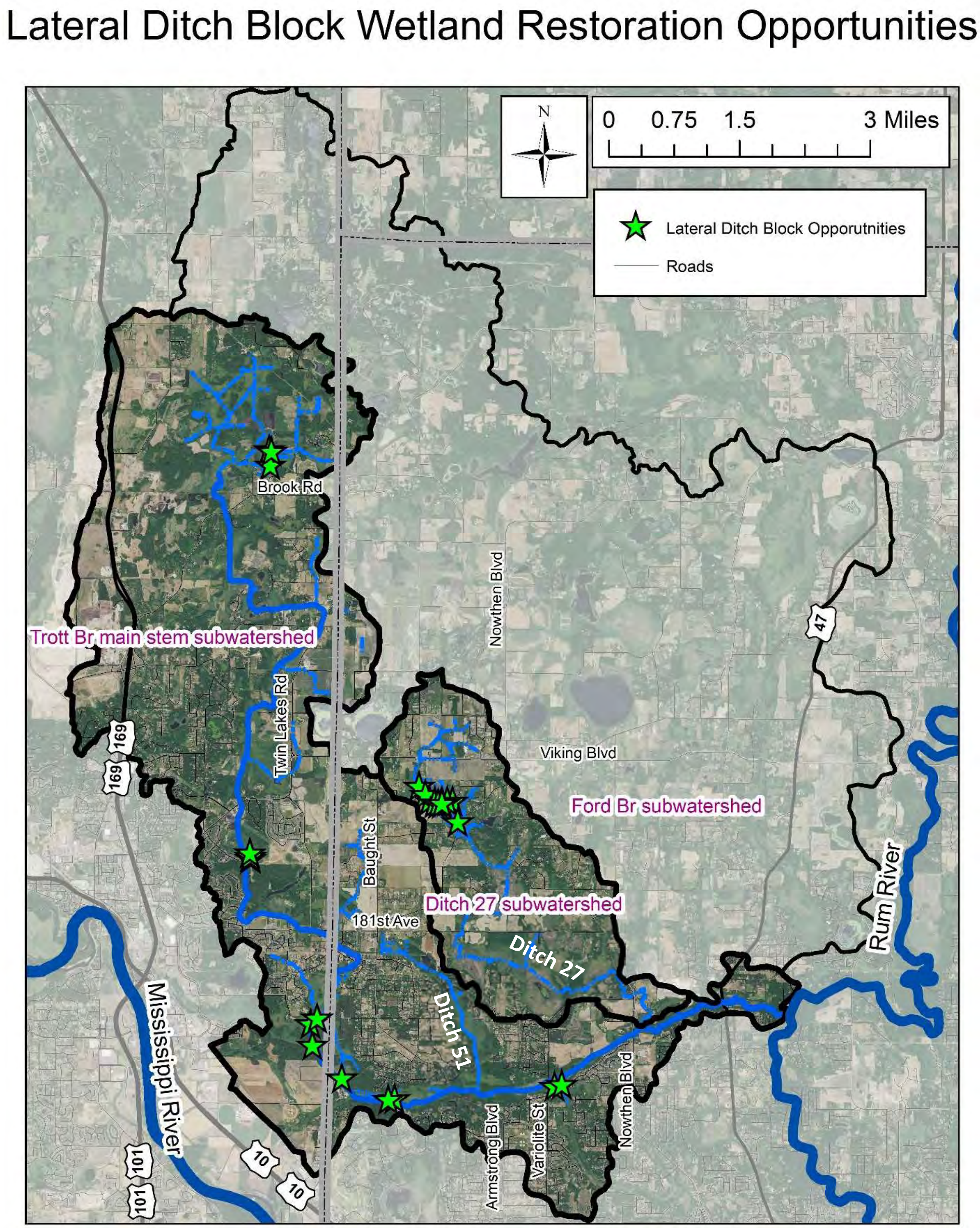
<u>Figure 35</u> - Earthen lateral ditch plug concept and installation. Source: MN Wetland Restoration Guide, BWSR.

Additional analyses are needed at each candidate site. A willing landowner(s) are needed. Feasibility analysis must include determining if the project would back water onto non-target parcels or interfere with drainage rights of upstream parcels. On Map 7 only those lateral ditches that were clearly man-made and had small drainage through degraded or drained wetland were identified.

Cleanout of existing lateral ditches should be discouraged. Most have not been re-excavated for many decades, if ever. Over time many have begun to fill in a way that reduces flow. Re-excavation may exacerbate water quality problems in Trott Brook.

Additional wetland restoration opportunities that are not lateral ditch blocks exist in the Trott Brook watershed. These include basins farther from the stream, farmed wetlands, and others that are not direct and immediate drainage to Trott Brook. These practices can be worthwhile but are secondary to lateral ditch blocks.

Map 7 - Lateral Ditches



Stormwater Treatment for New Development

Given the suburbanizing nature of the subwatershed, implementing robust stormwater treatment requirements during development is an important strategy for Trott Brook health. Local governmental units with land use and planning authorities implement these requirements for new development. Those authorities (Map 8) include the Cities of Ramsey, Elk River, and Nowthen, and Sherburne County. Additionally, the Lower Rum River Watershed Management Organization (LRRWMO) does permitting with respect to water quality protection in an area that overlaps the City of Ramsey.

A brief review of stormwater ordinances of these governmental units found all have generally the same key components, which are industry standards (Table 19). Room for improvement is in two areas:

1. **Pollutant control** - Only some governmental units require no increase in suspended solids or total phosphorus from pre-development conditions. The LRRWMO and Elk River might consider adding this.
2. **Minimum Impact Development Standards (MIDS)** - Governmental units may find that adopting Minimum Impact Development Standards (MIDS) results in essentially the same protective measures, but with the added benefit of getting crediting towards MS4 state permits for stormwater treatment achieved. MIDS also has added flexibility for dealing with situations in which infiltration is not suitable. Elk River is currently the only permitting entity using MIDS.

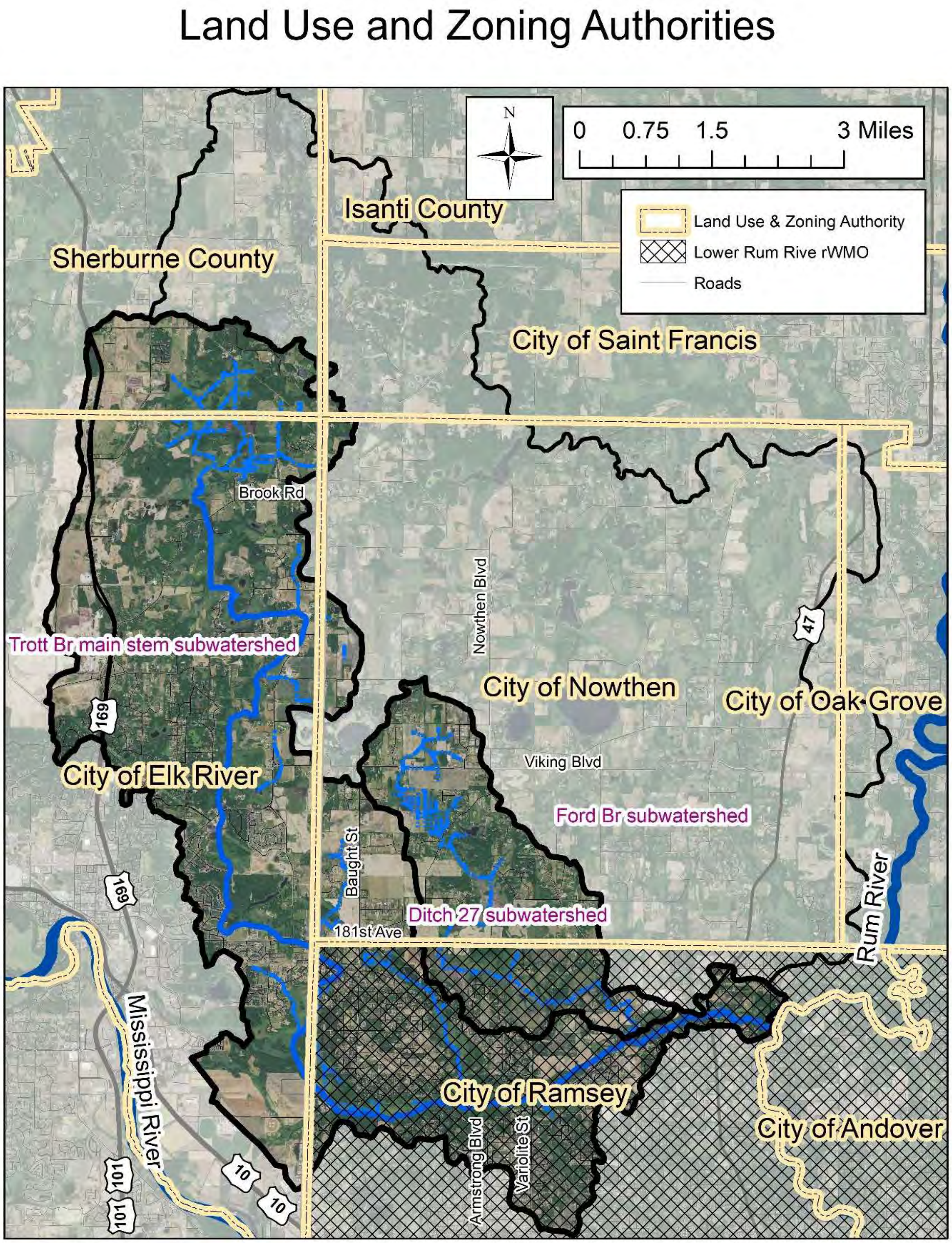
Table 19 - Comparison of stormwater requirements for new development in the Trott Brook watershed.

Standard	Sherburne Co	Nowthen	Elk River	Ramsey	LRRWMO
Volume control					
Retain runoff volume equal to one inch from proposed impervious surfaces.	X	X		X*	X
Retain runoff volume equal to 1.1 inches from all impervious surfaces			X		
Redevelopment - Retain 1.1 inches of runoff from new impervious.			X	X	
No net increase of stormwater volume from pre-development conditions	X			X*	
Retain the post construction runoff volume on the site for the 95th percentile storm.				X*	
Rate control					
Proposed discharge rates shall be equal to or less than the predevelopment discharge rates for the 2-year, 10-year, and 100-year events.		X	X	X	X
Pollutant removal					
No increase in TSS or TP from pre-development conditions	X	X**		X	
60% of phosphorus and 80% of suspended solids removal			X		
For redevelopment, achieve a net pollutant reduction from pre-project conditions.			X	X	
Alternatives					
Utilize the MIDS design sequence flow chart to address situations where meeting above requirements is not feasible.			X		

*Allowable options.

** Lesser volume control allowed if this is achieved

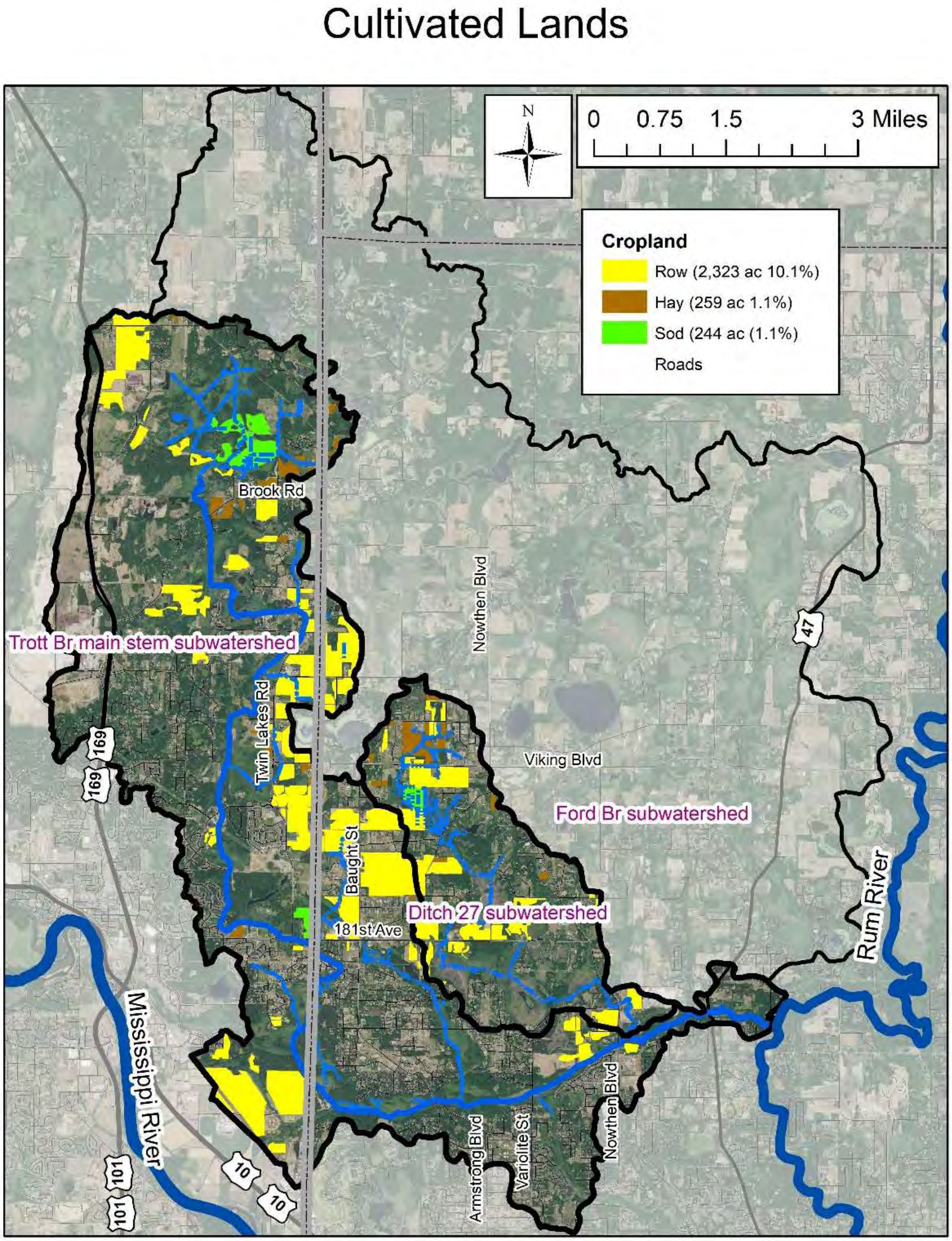
<u>Map 8</u> - Local Governmental Units



Agricultural BMPs

Cultivated lands were identified using 2024 aerial photos to aid in outreach for various agricultural practices (Map 9). Practices may include residue and tillage management, conservation cover, cover crops, contour buffer strips, filter strips, or others. Priority practices are those reducing nutrient loads to Trott Brook. Priority locations are fields directly draining to waterways that connect to Trott Brook.

<u>Map 9</u> - Cultivated Lands



Row crop, hay, and sod land uses were digitized by the Anoka Conservation District using 2024 aerial photos. When needed, year 2020 to 2023 aerial photos and Google Street View were referenced. The information depicted in this map was compiled by the Anoka Conservation District from a variety of sources and cannot be guaranteed.

Urban Stormwater Retrofits & Maintenance

Priority areas for urban stormwater retrofitting and maintenance in the Trott Brook subwatershed are relatively few. Drainages of greatest concern would be those that directly discharge to the stream and are older (pre-1990's when urban stormwater treatment requirements became commonplace). Little of the watershed is served by stormwater pipes, there are few outfalls to Trott Brook, and most such areas have new stormwater practices meeting modern requirements.

To gauge the extent of areas served by urban stormwater conveyances, we obtained stormwater pipe datasets from the cities of Ramsey and Elk River (Map 10). Initially, we found less than 7% of the area within the state's Trott Brook watershed boundary is served by urban stormwater conveyances. But some stormwater pipes shown as "in" the watershed appear to drain to wetlands outside the watershed boundary. This is because the watershed boundary map is older than some stormwater conveyances. Considering this, it appears <6% of the watershed is served by stormwater pipes.

Some stormwater pipes discharge to Trott Brook and some do not. Some discharge to isolated basins that lack an outlet in normal conditions. There are approximately five stormwater pipe outfalls directly to Trott Brook and approximately 10 into the riparian wetland fringe more than 100 ft from the stream.

Many areas with stormwater pipes, which is mostly the larger residential developments, were constructed after 2000 and can be a focus for maintenance. Abundant stormwater ponds and infiltration basins (approximately 58) are present. These practices are less likely to warrant modification because they would have been built to modern stormwater treatment standards. Maintenance, often at 25-30 intervals for many practices, is needed.

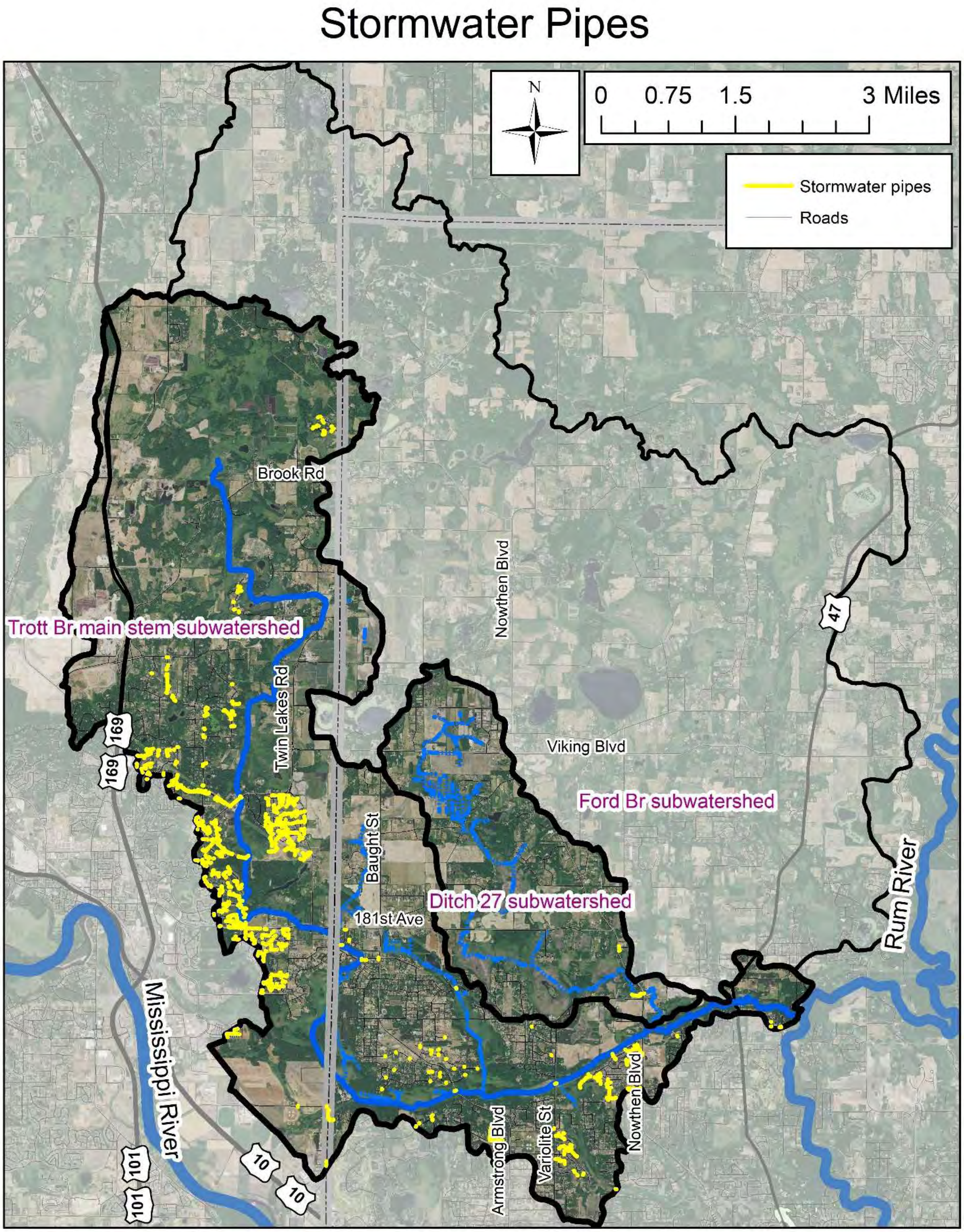
The reasons additional stormwater treatment practices are generally not needed where stormwater pipes do not exist are low percentages of impervious cover and high infiltration rates. Most developed areas, aside from new developments with stormwater pipes, are low density residential. The area's sandy soils have high infiltration rates, and the landscape is relatively flat. Soils tend to be covered with vegetation (by comparison, agricultural lands are not for a portion of the year). Little runoff reaches Trott Brook as surface flow.

A subwatershed assessment study could refine the watershed boundary and identify/rank opportunities to better treat stormwater. Preliminarily it appears such a study would be warranted in few areas, focusing on those with stormwater pipes built before the 1990's.

Enhanced Street Sweeping

Enhanced street sweeping involves revising the frequency or areas for sweeping. An analysis can recommend sweeping schedules based on tree cover and where runoff is directly discharged to priority waters. The preceding section notes that areas with direct discharge to Trott Brook are few, so there are few areas that are likely to be strong candidates for enhanced sweeping. However, cities may want to consider it to reduce solids that reach stormwater basins, thereby increasing the maintenance interval.

<u>Map 10</u> - Stormwater pipes. Source: Cities of Elk River and Ramsey.



The information depicted in this map was compiled by the Anoka Conservation District from a variety of sources and cannot be guaranteed. Source of stormwater pipes data is the Cities of Elk River and Ramsey.

BMP Targeting

For greatest cost effectiveness, BMPs should be targeted toward phosphorus and dissolved oxygen demand reductions as follows:

- **Trott Brook main stem subwatershed**, rather than the Ditch 27 subwatershed. Modeling has estimated low dissolved oxygen and high total phosphorus problems are less prevalent in Ditch 27, though this has not been field-verified with monitoring. Those issues are verified along the full length of the Trott Brook main stem.
- **Direct drainage to Trott Brook**. These projects have the most direct and significant impact on water quality. These might include lateral ditch blocks, agricultural lands in close proximity to the ditch, or where urban stormwater is conveyed to the stream by pipes.
- **Practices as prioritized in the previous section**.

Below are maps to facilitate targeting of projects. Further exploration of each location is needed to verify suitability. The practice types shown are voluntary and would require landowner willingness.

Magnitude of Practices Needed

In summary, the current best estimate of reductions need is:

- **Dissolved oxygen** – Up to 332 lbs/day (40%) oxygen demand reduction is needed. This TMDL-based estimate does not include 2023 monitoring data. If 2023 data with higher oxygen levels were incorporated into the modeling, the reduction needed would be lesser but still large.
- **Total phosphorus** – While not currently an impairment, watershed plans are seeking a 5% reduction in the Rum River watershed to avoid impairment, and this goal is appropriate for its tributary, Trott Brook. This could be viewed as an interim achievable goal.
- **Phosphorus reductions to reduce oxygen demand** - Sufficient phosphorus reductions to achieve dissolved oxygen goals in Trott Brook are not realistic to achieve, even if every conceivable practice is implemented.

The TMDL study (MPCA, 2017a) used an HSPF model to estimate that a 50% reduction in oxygen demand is needed to achieve state water quality standards. In this report we have revised that to 40% based on detection of a likely typographical error in the TMDL report. If this were to be achieved, the stream would be below the 5 mg/L oxygen standard less than 5% of the time during the open water months of April through November. This equates to a 332 lbs/day oxygen demand reduction.

Based on 2023 water quality data, the magnitude of oxygen demand reduction needed may be lower than the previous 40% estimate. The HSPF SAM model does not incorporate this newest 2023 data. At Nowthen Blvd the dissolved oxygen concentrations were 5.71 mg/L in 2013-2015 grab samples, but was 6.53 mg/L in 2023-2024 grab samples. At that location the 2013 deployable sonde measuring dissolved oxygen hourly for 11 days found daily low oxygen near 2 mg/L each day. The 2015 sonde over eight days at that location found daily lows at or above 5 mg/L, with most nights above 6 mg/L.

Total phosphorus reductions can ensure the stream does not become impaired for excess nutrients and can help make progress toward the oxygen standards. The Lower Rum River Watershed Management Organization and Rum River Comprehensive Watershed Management Plan both include 5% phosphorus reduction goals watershed-wide based on Rum River phosphorus concentrations. Trott Brook phosphorus is similar to the Rum River (both average 90-95 µg/L depending in the years selected), so the same goal seems appropriate for Trott Brook. The state standard is 100 µg/L.

We used HSPF SAM modeling to determine what an approximately 5% phosphorus reduction would achieve for oxygen demand. We found it would achieve only a 2% oxygen demand reduction. Understanding that phosphorus reduction has been identified in previous studies as a primary way to achieve oxygen demand reductions, we scaled up the modeled total phosphorus reductions. Even when the model installs every likely practice on the landscape, phosphorus reductions of 36.3% only result in a 15% oxygen demand reduction (Table 17).

We believe that ditched peat wetlands through which Trott Brook flows are likely a larger source of nutrients and oxygen demand than the HSPF SAM model suggests. In fact, field data and professional judgment suggest this is the largest cause of problems. Improvements may be achieved by blocking lateral ditches draining these riparian wetlands, or even re-meandering the main stem of Trott Brook. However, even then the “natural” peatland sources of phosphorus oxygen consumption will reach the waterway and may maintain the stream in a low oxygen impaired state. That low oxygen is linked to biotic impairments.

Funding for Practice Implementation

Primary available funding sources to implement practices include:

- **Clean Water Legacy competitive grants** – Annually available through the MN Board of Water and Soil Resources with a focus on water quality improvement.
- **Watershed Based Implementation Funds non-competitive grants** – Available every other year through the MN Board of Water and Soil Resources for water quality improvement projects.
- **Conservation Partners Legacy grants** – Available annually through the MN Department of Natural Resources. Eligible practices include ditch blocks, water level control structures, in-stream habitat modification, and others. Must be used on permanently protected lands or waters.
- **Outdoor Heritage Fund** – Annually available with a focus on habitat.
- **Lower Rum River Watershed Management Organization** – A joint powers organization of three cities including the Trott Brook subwatershed within Anoka County.
- **RIM Easement Funding** – State funding to secure conservation easements in sensitive areas, such as the stream corridor.
- **Soil Health Grants** – The Anoka Conservation District receives state funds every two years to incentivize soil health practices. These typically include agricultural practices such as cover crops or reduced tillage.

Other sources may be available from time to time.

Literature Cited

Lower Rum River Watershed Management Organization. Watershed Management Plan 2022-2031. 2021. https://lrrwmo.org/wp-content/uploads/2018/04/LRRWMO_WMP_2022_2031_Final_12202021.pdf

ISG. 2022. Rum River Comprehensive Watershed Management Plan. https://www.millelacsswcd.org/wp-content/uploads/2022/05/FINAL_2022-05-03_rumRiverComprehensiveWatershedManagementPlan_ISG.pdf

Kalinosky, P., L.A. Baker, S.E. Hobbie, R. Binter, and C. Buyarski. 2014. User Support Manual: Estimating Nutrient Removal by Enhanced Street Sweeping. Minneapolis, MN.

Koltz, R.L. and S.A. Linn. 2001. Influence of factors associated with water level drawdown on phosphorus release from sediments. Lake and Reservoir Management. 17(1): 48-54.

Nittrouer, Jeff. 2024. Evaluating the geomorphology of Cedar Creek: The archetype of peat streams. Cedar Cr Ecosystem Science Reserve Lunch with a Scientist. https://mediaspace.umn.edu/media/t/1_r4004yqc

Minnesota Pollution Control Agency (MPCA). 2016_a. Rum River Watershed Monitoring and Assessment Report (wq-ws3-07010207b). https://www.pca.state.mn.us/sites/default/files/wq-ws3-07010207b.pdf

Minnesota Pollution Control Agency (MPCA). 2016_b. Rum River Watershed Stressor Identification Report (*wq-ws5-07010207*). https://www.pca.state.mn.us/sites/default/files/wq-ws5-07010207.pdf

Minnesota Pollution Control Agency (MPCA). 2017_a. Final Rum River Watershed Total Maximum Daily Load (wq-iw8-56e). https://www.pca.state.mn.us/sites/default/files/wq-iw8-56e.pdf

Minnesota Pollution Control Agency (MPCA). 2017_b. Rum River Watershed Restoration and Protection Strategy Report. (wq-ws4-34a). https://www.pca.state.mn.us/sites/default/files/wq-ws4-34a.pdf

Minnesota Pollution Control Agency (MPCA). 2017_c. MPCA Stream Habitat Assessment (MSHA) Protocol for Stream Monitoring Sites. (wq-bsm3-02). https://www.pca.state.mn.us/sites/default/files/wq-bsm3-02.pdf

Minnesota Pollution Control Agency (MPCA). 2019. Regionalization of Minnesota's Rivers for Application of River Nutrient Criteria. (wq-s6-18). https://www.pca.state.mn.us/sites/default/files/wq-s6-18.pdf

Minnesota Pollution Control Agency (MPCA). 2024. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List. (wq-iw1-04m). https://www.pca.state.mn.us/sites/default/files/wq-iw1-04m.pdf

Pfankuch, Dale. (US Department of Agriculture, US Forest Service). 1975. Stream Reach Inventory and Channel Stability Evaluation.

Phenow, Aurore Y. 2015. Assessing the Ability to bring Trout Fishing to the MN North Metro Area through Stream Quality Assessments and Summarization of the Economic Impact of Anglers. Unpublished. Anoka Ramsey Community College.

Rosgen, D.L. 1994. A Classification of Natural Rivers. Catena, 22: 169-199.

Turner, B.L. and P.M. Haygarth. 2001. Phosphorus solubilization in rewetted soils. Nature. 411:256.