Watershed

April 2019

Vermilion Stressor Identification Report

Assessment of stress factors affecting aquatic biological communities and other aspects of streams and lakes

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms & abbreviations

AUID.....	Assessment Unit (Identification Number) MPCA's a pre-determined stream segments used as units for stream/river assessment – each has a unique number.
CALM.....	Consolidated Assessment and Listing Methodology. The protocol used in MPCA's assessment of designated use attainment for surface waters.
CR.....	County Road
CSAH.....	County State Aid Highway
DO.....	Dissolved Oxygen
DNR.....	Minnesota Department of Natural Resources
DS.....	Downstream
EPA.....	United States Environmental Protection Agency
GIS.....	Geographic Information System
HDS.....	Human Disturbance Score – a measurement of human disturbance at and upstream of a biological monitoring site.
HUC.....	Hydrologic Unit Code (a multi-level coding system of the US Geological Survey, with levels corresponding to scales of geographic region size)
HSPF.....	The hydrologic and water quality model **H**ydrologic **S**imulation **P**rogram **F**ortran.
IBI.....	Index of Biological Integrity – a multi-metric index used to score the condition of a biological community.
IWM.....	MPCA's **I**ntensive **W**atershed **M**onitoring, which includes chemistry, habitat, and biological sampling.
m.....	The abbreviation for meter
mg/L.....	Milligrams per liter
µg/L.....	Micrograms per liter (1 milligram = 1000 micrograms)
Macrophyte.....	Macro (= large), phyte (= plant). These are the large aquatic plants, such as *Elodea* and Coontail.
MSHA.....	Minnesota Stream Habitat Assessment
MS4.....	Municipal Stormwater Plan, level 4
NPDES.....	National Pollutant Discharge Elimination System
Natural background....	An amount of a water chemistry parameter coming from natural sources, or a situation caused by natural factors.
Palustrine wetland.....	A US Fish and Wildlife Service wetland classification which includes marshes, small ponds, wet meadows, fens, and bogs.
SID.....	Stressor Identification – The process of determining the factors (stressors) responsible for causing a reduction in the health of aquatic biological communities.

Taxa..... Plural form - refers to types of organisms; singular is taxon. May refer to any level of the classification hierarchy (species, genus, family, order, etc.). In order to understand the usage, one needs to know the level of biological classification being spoken of. For MPCA fish analyses, taxa/taxon usually refers to the species level, whereas for macroinvertebrates, it usually refers to genus level.

TMDL.....Total Maximum Daily Load

TSS..... Total Suspended Solids (i.e. all particulate material in the water column)

TSVS..... Total Suspended Volatile Solids (i.e. organic particles)

TP..... Total Phosphorus (measurement of all forms of phosphorus combined)

US..... Upstream

VRW..... Vermilion River Watershed

WRAPS..... Major Watershed Restoration and Protection Strategy, with watershed at the 8-digit Hydrological Unit Code scale.

Executive summary

This report documents the efforts that were taken to identify the causes, and to a degree, the source(s) of impairments to aquatic biological communities in the Vermilion River Watershed (VRW). Information on the Stressor Identification (SID) process can be found on the United States Environmental Protection Agency's (EPA) website http://www.epa.gov/caddis/ .

The VRW is completely contained in St. Louis County, and situated within a heavily forested region of northeastern Minnesota. Much of the VRW is in public ownership; both state and federal (Figure 1). Agricultural land very sparse, and is primarily pasture/hay, with a very small amount of cultivated acreage. One mine-tailings storage basin is located within the VRW, in the extreme southern portion, just northeast of Virginia. A majority of the VRW is within the Superior National Forest, including an area within the Boundary Waters Canoe Area Wilderness, and three State Parks are found at least partly within the VRW; Lake Vermilion, Soudan Underground Mine, and Bear Head Lake. The large percentage of public land holdings mean that development in much of the watershed is very low density. The city of Tower, at population 500 (2010 US Census), is the largest urban area in the VRW, with the only other town being Orr. Undeveloped parts of Mountain Iron, Gilbert, and Virginia are located within the VRW at the extreme southern boundary.

In addition to forest, another major landscape feature in the VRW is the extensive wetland acreage, much of it being the palustrine type, both forested and herbaceous, bogs and fens. This large amount of wetland significantly influences the water quality of VRW lakes and streams.

Two Assessment Unit Identification (AUID) reaches, one on each of two streams were brought into the SID process. One has biological community impairment and the other had an aquatic life use parameter Dissolved Oxygen (DO) that did not meet its standard and had a mediocre (though not impaired) fish community. The 2017 Assessment phase of the Intensive Watershed Monitoring (IWM) portion of the Watershed Restoration and Protection Strategy (WRAPS) project determined that Tributary to Sand Creek (AUID-645) was biologically impaired. Subsequent to the SID process, this AUID's impairment status was brought up for review as being caused by natural factors, and the review committee agreed with that determination and ruled that the impairment be moved to impairment category 4D (natural background, no Total Maximum Daily Load (TMDL) required).

Streams with low-scoring biological communities and other investigations (Figure 1):

Official impairment:

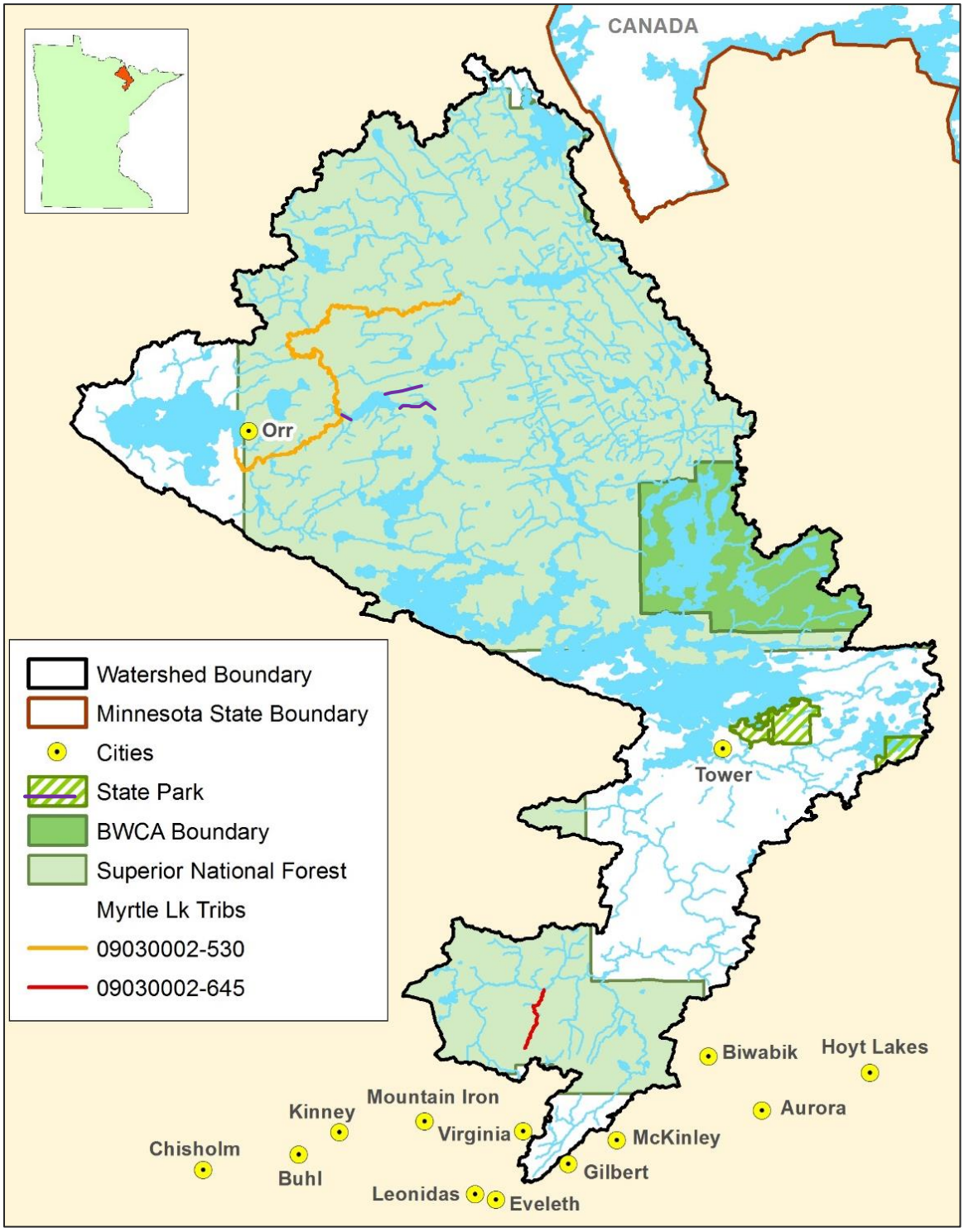
- **Tributary to Sand Creek** (AUID 09030002-645) - Fish and Macroinvertebrates, low DO

Not impaired:

- **Pelican River** (AUID 09030002-530) - Fish, low DO

Biological monitoring of lakes was not completed for the VRW because an FIBI for Canadian Shield area lakes has not yet been developed by Minnesota Department of Natural Resources (DNR). Two tributaries to Myrtle Lake and the lake's outlet were monitored to help determine the phosphorus dynamics in the lake shed of this nutrient-impaired lake. Those results are presented in this report.

Figure 1. State and national boundaries of parks, forests, and designated wilderness, and stream reaches receiving SID investigations in the VRW.



Introduction

The Minnesota Pollution Control Agency (MPCA), in response to the Clean Water Legacy Act, has developed the Major Watershed Restoration and Protection Strategy (WRAPS) for improving water quality of the state's streams, rivers, wetlands, and lakes in Minnesota's 80 Major Watersheds. A WRAPS is comprised of several types of assessments. The MPCA conducted the Intensive Watershed Monitoring Assessment (IWM) part of the VRW WRAPS during the summers of 2015 and 2016. The IWM assessed the aquatic biology and water chemistry of VRW streams, rivers, and lakes. The Stressor Identification Assessment (SID) builds on the results of the IWM. The MPCA conducted the SID assessment during 2016 - 2017. This document reports on this second step of the multi-part WRAPS for the MRHW.

It is important to recognize that this report is part of a series, and thus not a stand-alone document. Information pertinent to understanding this report can be found in the Vermilion River Watershed Monitoring and Assessment Report. That document should be read together with this Stressor ID Report and can be found from a link on the MPCA's VRW webpage: https://www.pca.state.mn.us/water/watersheds/vermilion-river.

Landscape of the VRW

A detailed description of various geographical and geological features of the landscape of the VRW is documented in the Vermilion River Watershed Monitoring and Assessment Report (MPCA, 2018). That information is useful and necessary for understanding the settings of the various VRW's subwatersheds, and how various landscape factors influence the hydrology within the VRW. The following information is intended to provide a basic description of the VRW landscape.

The original, pre-settlement landscape was almost exclusively forests, wetlands, and lakes (Figure 2). The forest types formed a complex mosaic. However, the original forest harvest at the turn of the 19th century changed much of the forest from older growth to the younger forests that exist now. Most of the upland landscape is still in a forested state. A very small amount of the VRW's acreage is devoted to agriculture, essentially all of which is animal/hay/pasture. The very small amounts of land area classed as row crop agriculture in the National Land Cover Dataset were checked against aerial photography, and these locations are misclassified, and typically are hay fields. The primary area in the VRW where agricultural lands are found is the southern region, just to the north of the point where Hwy 53 and Hwy 169 split, and the area just to the east of there, along the northern side of Hwy 169. The percentages of various categories of land cover are presented in Table 1.

Many of northern Minnesota's major watersheds have extensive wetland acreages, which are influential on the other water resources in those watersheds. The extent of VRW land area that is Palustrine wetland is shown in Figure 3. Note that there is a significant transition of landscape character, beginning at the southern and western boarder of the VRW. The wetlands in most of the VRW are very similar to the region to the east; small, well-distributed wetlands, as opposed to the region to the west, which does have small wetlands, but also many much larger wetlands. These large wetlands are only present in the very southern part of the VRW, for about the first 15 miles north from Eveleth. The opposite pattern occurs for lakes, with the VRW having many large lakes, whereas just to the south and west, there are almost no lakes over a large region.

Figure 2. Original vegetation of the VRW and adjacent watersheds, (Marschner, 1930). White lines are the HUC8 Watershed boundaries.

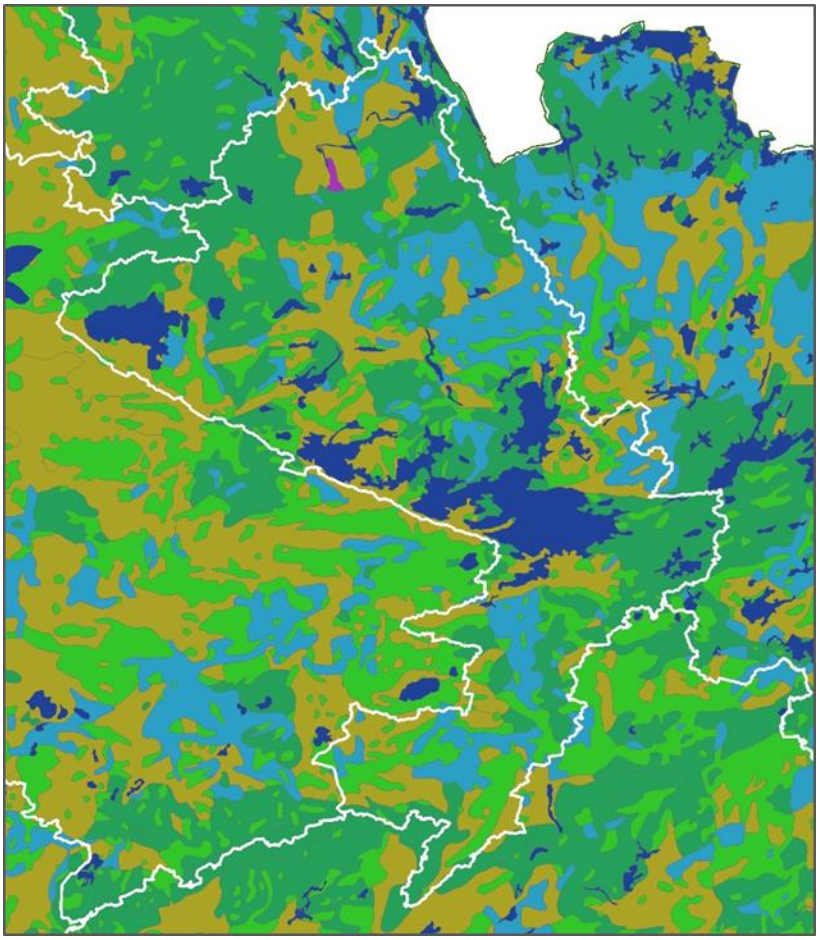
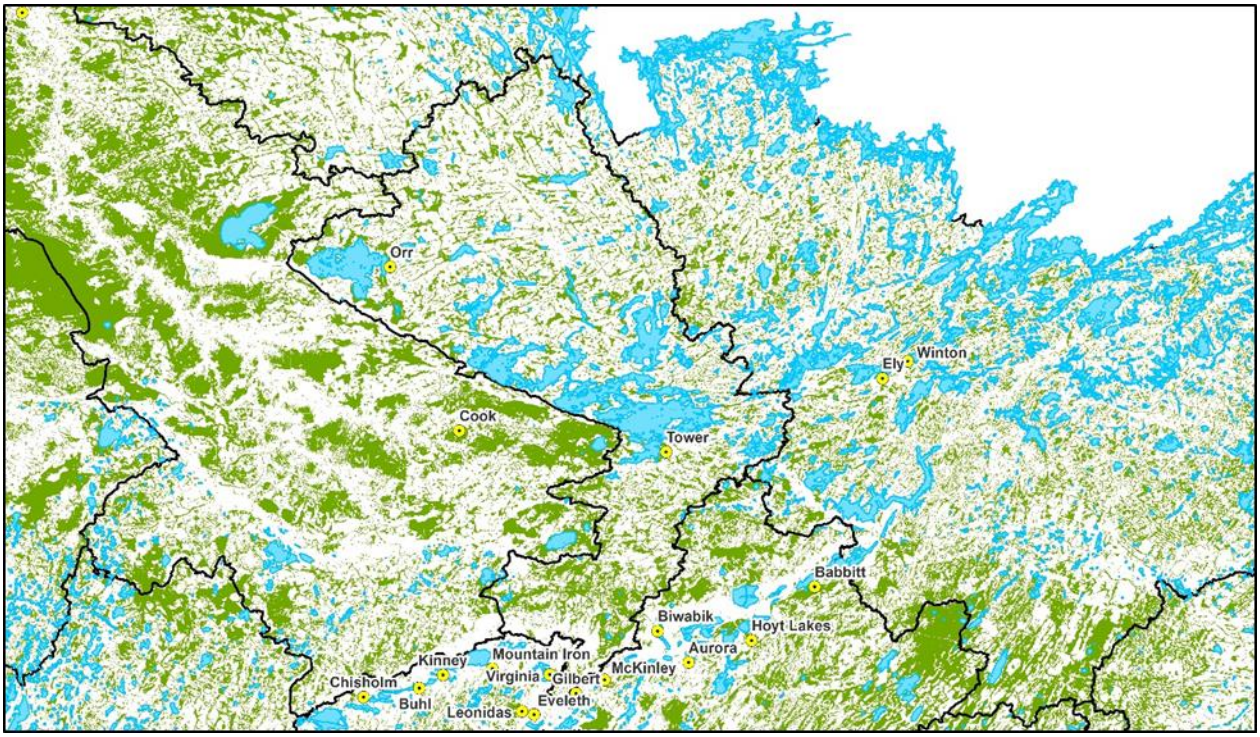


Table 1. Percentages of the various land cover types from 2011 NLCD GIS coverage (MPCA, 2018).

Land cover type	Percent of land area
Developed (all intensities grouped)	**1.8**
Cultivated crops and range	0.06 + 2.0 = **2.1**
Water, wetlands, and forest lands	13.0 + 26.1 + 57.0 = **96.1**

Figure 3. Palustrine wetlands (green) and lakes (blue) of the VRW and surrounding major watersheds.



Determination of candidate stressors

The process

A wide variety of human activities on the landscape can create stress on water resources and their biological communities, including urban and residential development, industrial activities, agriculture, and forest harvest. An investigation is required in order to link the observed effects on an impaired biological community to the cause or causes, referred to as stressors. The EPA provides a long list of stressors that have potential to lead to disturbance of the ecological health of rivers and streams (see EPA's CADDIS website - http://www.epa.gov/caddis/). Many of the stressors are associated with unique human activities (e.g. specific types of manufacturing, mining, etc.) and can be readily eliminated from consideration due to the absence of those activities in the watershed. The initial step in the evaluation of possible stressor candidates was to study several existing data sources that describe land usage and other human activities. The data sources include numerous GIS coverages, aerial photography, and the DNR Watershed Health Assessment Framework. Additionally, census records and various MPCA records, such as NPDES-permitted locations, added to preliminary hypotheses generation and the ruling out of some stressors or stressor sources.

In conjunction with the anthropological and geographical data, actual water quality, habitat, and biological data were analyzed to make further conclusions about the likelihood of certain stressors impacting the biological communities. Water chemistry and flow volume data has been collected within the VRW for many years, though less data exists in this part of the state than in some other parts of Minnesota. The determination of candidate stressors used both historical data and data collected during the 2015-2016 IWM. Preliminary hypotheses were generated from all of these types of data, and the SID process (including further field investigations) sought to confirm or refute the preliminary hypotheses.

DNR Watershed Health Assessment Framework

The DNR developed the Watershed Health Assessment Framework (WHAF), which is a computer tool that can provide insight into stressors within Minnesota watersheds (http://www.dnr.state.mn.us/whaf/index.html). The WHAF includes an assessment of the nonpoint source pollution threat to water quality within the water quality component. The data shows non-point pollution, relative to other parts of the state, is not a widespread stressor in the VRW (Figure 4). According to the Non-point Source Pollution Index, the VRW ranks as tied for 8th best out of the 80 watersheds in Minnesota (where the best has the least threat). This equates to the 90th percentile of major watersheds. A major urban source of non-point pollution is runoff from impervious surfaces. Due to the small sizes of most of the cities/towns in the VRW, this threat is very low overall. There are localized situations, such as immediate shoreline properties of lakes with significant development, where impervious surfaces may be an important water quality issue. Streams and rivers in the VRW generally do not have anywhere near the amount of shoreline development as area lakes, and thus this threat is particular to lakes. Additional statistics for several stressors are presented in Table 2.

Figure 4. Categorical ranking of the 80 Minnesota Major Watersheds for the DNR Non-point Source Pollution Index. The arrow points to the VRW. Map downloaded in April 2019.

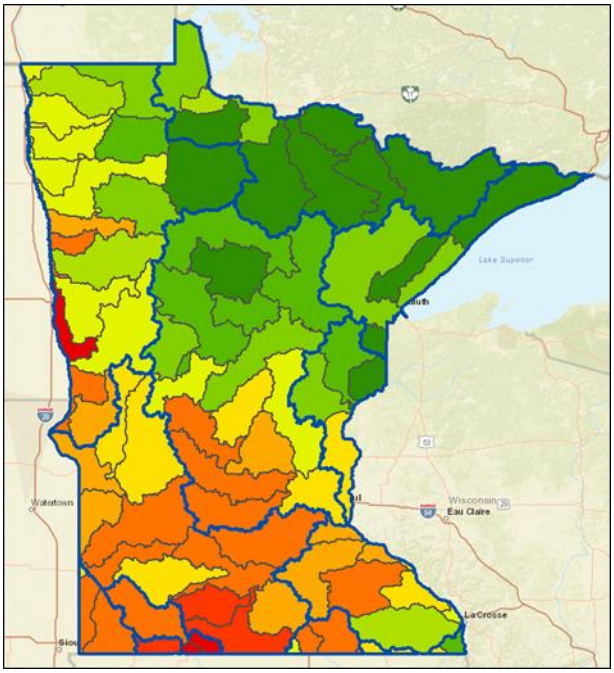


Table 2. Ranking of several attributes of the VRW relative to Minnesota's 80 watersheds. A low rank number is a positive, while a higher rank is a negative for water quality. Calculations used data from DNR's WHAF, downloaded in April 2018.

	Impervious Surface	Nonpoint Threat	Point Sources	Water Storage Loss	Perennial Cover	Phosphorus Risk	Aquatic Connectivity
Rank	5 (t)	8 (t)	10	3	2 (t)	10 (t)	5 (t)

(t) = tied with other watersheds for these ranks.

The overall WHAF scorecard, which includes many more metrics, can be found at: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/scorews_all.pdf.

Desktop review

Urbanization/Development/Population density

Census data provides a way to look at human-induced stress or pressure on the water resources of a region. Stressor sources that are related to population density include wastewater effluent, impervious surface areas, and stormwater runoff, which all increase with population density. The VRW is sparsely populated relative to the state as a whole.

Only two towns are situated within the VRW; Tower (pop. 500) and Orr (pop. 267) - population data from the 2010 US Federal Census (MSDC). Neither town is large enough to require an MS4 stormwater plan. Recent GIS-derived land use statistics showed that 1.8% of the watershed area is categorized as Residential/Commercial (MPCA, 2018). Statistics for urban stressors such as impervious cover and point source pollution were shown above. The census and urbanization information suggests that most stressors related to population density are likely only active at very localized areas (e.g., near the two towns or lakeshore development acting on a particular lake).

One potential source of water resource stressors in rural areas is subsurface sewage treatment systems (SSTS). Un-sewered areas can have old septic systems that are either failing or not conforming to current design standards. Most rural homes/cabins in the VRW are not connected to a municipal sewer system, and thus have individual treatment systems. Rural areas may also have residences that discharge wastes directly to streams, though this is unlawful, and the numbers are declining. These systems can contribute significant levels of nutrients and other chemicals to water bodies. Somewhat-recent septic system statistics for Koochiching and St. Louis Counties estimate ten and 3% of the individual treatment systems to be “Imminent Public Health Threats” (i.e., direct discharge to stream), 67% and 32% “Failing”, and 23% and 65% of systems in compliance (MPCA, 2013). Though several counties had more Immanent Public Health Threats, Koochiching County had the highest estimated number of failing septic systems of all of Minnesota’s counties. Given that a many of these systems are on lakeshore properties, failing septic systems could be a problem for lake water quality, but should not be a significant contributor to water quality problems in VRW streams, except perhaps in very localized places.

Mining/Industrial activities

Industrial activities are another potential cause of water quality impairments within watersheds. The VRW has relatively little industry except at its southern border, where it is adjacent to the world-renowned Mesabi Iron Range. No mining occurs in the VRW, but one large tailings pond does lie within the VRW, near Virginia, and a number of mines have excavated right up to the watershed boundary. The potential of mining activities was considered at the biologically impaired site, which was close to a tailings basin. There is no industrial activity along the studied Pelican River AUID.

Forestry

Forest harvest can stress on water resources if practices reduce stream shading or lead to erosion. Significant amounts of land within the VRW are used for timber production and historical large-scale forest removal occurred in the watershed in the late 1800’s and early 1900’s. Most of the non-wetland land area in the VRW was originally forested (Marchner, 1930). Therefore, stressors related to historical and current forest management practices are possibly occurring in the VRW, and conversions of forest to non-forest landcover may still occur.

Agricultural activities

The lands of the VRW, as with those in much of north central Minnesota, are not commonly used for row crop agricultural production. An extremely small amount of the VRW’s acreage is devoted to agriculture, essentially all of which is animal/hay/pasture. The very small amounts of land area classed

as row crop agriculture in the NLCD layer were checked against aerial photography, and these locations are misclassified, and typically are hay fields. The primary area in the VRW where agricultural lands are found is the southern region, just to the north of the point where Hwy 53 and Hwy 169 split, and the area just to the east of there, along the northern side of Hwy 169. The review of the VRW's land use, shown previously (Table 1), indicates that essentially none of the land cover is in cultivated crops. The subwatersheds of the streams studied in this project did not contain agricultural activity, including hay/pasture.

Pesticides

Pesticides as stressors were not given any consideration in the few locations studied in this report, due to the prevailing non-agricultural land use patterns at those locations. Pesticide testing is very expensive, and monitoring for pesticides is difficult as applications are spotty, and occur irregularly. MDA conducts Minnesota pesticide monitoring, and no sampling has been done in the streams discussed below. More information about pesticide occurrence in Minnesota's environment continues to be gathered via Minnesota's statewide pesticide sampling program and results are available from the MDA at http://www.mda.state.mn.us/monitoring.

Summary of candidate stressor review

Based on the review of human activity in the VRW in general, and then specifically in the subwatersheds of the three locations studied, the initial list of candidate/potential causes was narrowed down to those stressors deemed most likely to occur in the VRW, resulting in eight of the candidate causes moving forward for more detailed investigation.

Eliminated causes

- Urban development/municipal stressors (altered hydrology, riparian degradation, high levels of impervious surfaces, residential chemical use, and specific conductance via effluent discharges). There are no urbanized areas within the subwatersheds studied in this report
- Pesticides - Impacts from pesticides are deemed unlikely due to small human population and little agricultural land use.
- Elevated nitrogen
  - Ammonia
  - Nitrate as nutrient
  - Nitrate as a toxicant

Inconclusive causes

- Forest management stressors - historical/legacy effects are difficult to determine. Impaired subwatersheds have had some recent current forest harvest, though understanding and quantifying the effects of forest harvest, and threshold levels for stress to occur to streams is not well known. There are current efforts underway or planned to better understand the effects of forest harvest impacts on streams.

Candidate causes

- Low Dissolved Oxygen
- Excess sediment (both suspended and deposited)
- Altered hydrology
- Altered geomorphology
- Habitat loss

- Connectivity loss
- Elevated phosphorus
- Mining stressors/Industrial stressors (i.e., toxic chemical, high conductivity discharges)

General Assessment of Stressors

Mechanisms of candidate stressors and applicable standards

A separate document has been developed by MPCA describing the various candidate stressors of aquatic biological communities, including where they are likely to occur, and their mechanism of harmful effect, and Minnesota's Standards for those stressors (MPCA, 2017). Many literature references are cited, which are additional sources of information. The document is titled "Stressors to Biological Communities in Minnesota's Rivers and Streams" and can be found on the web at: https://www.pca.state.mn.us/sites/default/files/wq-ws1-27.pdf. Additional information on Stressor Identification in Minnesota can be found on MPCA's website: https://www.pca.state.mn.us/water/your-stream-stressed. EPA (2012) has yet more information, conceptual diagrams of sources and causal pathways, and publication references for numerous stressors on their CADDIS website at http://www.epa.gov/caddis/ssr_home.html .

Notes on analysis of biological data

Biological data (the list of taxa sampled and the number of each) form the basis of the assessment of a stream or lake's aquatic life use status. Various metrics can be calculated from the fish or macroinvertebrate sample data. An Index of Biological Integrity, a collection of metrics that have been shown to respond to human disturbance, is used in the assessment process. An internet search using "MPCA biological monitoring" and "MPCA index of biological integrity" will bring up the MPCA webpages that discuss the stream biological monitoring program and information about the MPCA's stream Indices of Biological Integrity, respectively.

Metrics calculated from biological data can also be useful in determining more specifically the cause(s) of a biological impairment. Numerous studies have been done to search for particular metrics that link a biological community's characteristics to specific stressors (Hilsenhoff, 1987; Griffith et al., 2009; Álvarez-Cabria et al., 2010). This information can be used to inform situations encountered in impaired streams in Minnesota's WRAPS process. This is a relatively new science, and much is still being learned regarding the best metric/stressor linkages. Use of metrics gets more complicated if multiple stressors are acting in a stream (Statzner and Beche, 2010; Ormerod et al., 2010; Piggott et al., 2012).

Staff in MPCA's Standards, Biological Monitoring, and Stressor ID programs have worked to find metrics that link biological communities to stressors, and work continues toward this goal. Much work in this area was recently done to show the impact of nutrients (particularly phosphorus) on biological stream communities when Minnesota's River Nutrient Standards were developed (Heiskary et al., 2013). The Biological Monitoring Units of MPCA have worked to develop Tolerance Indicator Values for many water quality parameters and habitat features for species of fish, and genera of macroinvertebrates. This is a take-off on the well-known work of Hilsenhoff (1987; EPA, 2006). For each parameter, a relative score is given to each taxon regarding its sensitivity to that particular parameter by calculating the weighted average of a particular parameter's values collected during the biological sampling for all sampling visits in the MPCA biological monitoring database. Using those scores, a weighted average community score (a community index) can be calculated for each sample. Using logistical regression, the biologists have also determined the probability of a sampled community being found at a site meeting the Total

Suspended Solids (TSS) and/or DO standards, based on a site's community score compared to all MPCA biological sites to date. Such probabilities are only available for parameters that have state standards, though community-based indices can be created for any parameter for which data exists from sites overlapping the biological sampling sites.

Some of these stressor-linked biological metrics and/or biological community indices will be used in this report as contributing evidence of a particular stressor's responsibility in degrading the biological communities in an impaired reach. It is best, when feasible, to also include field observations, chemistry samples, and physical data from the impaired reach in determining the stressor(s).

Similar to the above approach used for stream biological monitoring, the DNR has developed biological monitoring approaches for lakes, currently using the fish community, and also eventually the aquatic macrophyte (plant) community. More information can be found on the DNR webpages by an internet search using "Minnesota DNR index of biological integrity".

Notes on analysis of chemical data

Water chemistry data was interpreted in the context of what is known about regional patterns and relative to Minnesota's water quality standards.

Stream investigations organized by AUID

Note: From this point on, the AUIDs referred to in the text (except main headings) will only include the unique part of the 11-number identifier for VRW AUIDs, which is the last three digits.

Pelican River (AUID 09030002-530)

Assessment: The river was assessed as meeting biological standards for its fish community, though both sites scored slightly under the passing FIBI threshold. Biologists determined that the fish community discovered is appropriate for the natural conditions (very low gradient and wetland-influenced) found here. The river was too deep to collect a sample of the macroinvertebrate community. The numerous chemistry samples showed TP concentrations always below the region's river nutrient standard. All five DO concentration measurements collected in summer 2016 were below the 5 mg/L standard, so DO levels likely limit the natural fish community potential in this AUID. There were two biological monitoring sites, 15RN023 - near Pelican Lake, and 15RN006 - farther downstream at the crossing of Forest Road 609.

The VRW SID effort included additional sampling from this AUID to better understand the chemistry dynamics of the Pelican River. It was decided for modeling purposes that placing a flow gage on the Pelican River would help the HSPF model of hydrology in the VRW. Additionally, it was felt that some basic water chemistry parameters should be collected at the gage site, which also helps the accuracy (calibration) of the HSPF model. With a little extra effort (adding an additional chemistry monitoring site upstream, at the outlet of Pelican Lake), insight could be gained as to what causes the DO concentration in the Pelican River to be lower than the standard.

Subwatershed characteristics:

The Pelican River subwatershed (i.e., the land contributing to flow at the biological site) is a very natural landscape, with densely forested uplands, numerous lakes, and riparian wetlands. Much of the water in the river at the biological and EQuIS site has passed through these lakes, especially 7,277-acre Pelican

Lake. The HDS score for site 15RN006 is 76.63, a very high score for absence of human disturbance (81 is max. score).

Data and analyses

Chemistry

Chemistry data collected during the IWM biological visits are shown in tables 3 and 4. These chemistry data were generally good. The exception was TP at the DS site (15RN006), which was about double the region's river nutrient standard, though no anthropogenic sources of phosphorus seemed likely based on aerial photography review and the dominant extent of public, forested land.

Table 3. Water chemistry measurements collected at 15RN023 (S008-597) during the 2015 IWM. Values in mg/L.

Date	Time	Water Temp.	DO	DO % Sat.	TP (µg/L)	Nitrate	Ammonia	Un-ionized Ammonia	pH	TSS	TSVS
July 9, 2015	7:11	19.5	6.25	71	0.031	< 0.05*	< 0.1*	**	6.56	< 4*	< 4*

* These values are below the lab detection limit.
**Cannot be calculated without a specific ammonia value, but would be far less than the standard.

Table 4. Water chemistry measurements collected at 15RN006 (S008-431) during the 2015 IWM. Values in mg/L.

Date	Time	Water Temp.	DO	DO % Sat.	TP (µg/L)	Nitrate	Ammonia	Un-ionized Ammonia	pH	TSS	TSVS
July 16, 2015	8:37	24.2	5.92	74	0.097	< 0.05*	< 0.1*	**	7.91	6.2	< 4*

* These values are below the lab detection limit.
**Cannot be calculated without a specific ammonia value, but would be far less than the standard.

SID chemistry data was collected at the DS biological station 15RN006 (EQuIS # S008-431) and at a new second station, upstream at the outlet of Pelican Lake (EQuIS # S014-887), the start of the AUID. This second site was a short distance upstream of the US biological site 15RN023. The reasoning for adding this second site was to investigate how much the riparian wetlands between Pelican Lake and 15RN006 were contributing to the phosphorus concentration, and influencing the DO, at the DS biological site. The new upstream site is a very short distance from Pelican Lake, and as such is mostly lake water. There is significant, hydrologically connected wetland acreage on the landscape between the outlet of the lake and 15RN006 (Figure 5). These wetlands predominantly lie along the flowpaths of tributaries to the Pelican River, or along the mainstem of the Pelican River.

The parameters collected at the two sites included specific conductance, water temperature, DO, DO % saturation, TP, DOC, and, only at 15RN006, TSS and Total Suspended Volatile Solids (TSVS)). Mid-day instantaneous DO concentrations were consistently lower at the downstream site, sometimes by as much as 3.75 mg/L (Figure 6).

The TP showed an interesting pattern, where late spring TP was higher in the lake outlet water, followed by a period of about 1.5 months where the TP is almost identical between sites, and then in late summer/fall, TP becomes quite a bit higher at the downstream location (Figure 7). This may be the result of the contributing wetlands becoming relatively anoxic in mid-summer and exporting dissolved phosphorus. Another possible contributor to the TP measurement is TSVS, the organic particulate portion of suspended material in the water column. A correlation was run between TP and TSVS, which showed no correlation between TP and TSVS (Figure 8).

Figure 5. Upper half of the Pelican River (AUID-530) subwatershed, showing wetlands, tributaries, and monitoring sites. The opaque area is the subwatershed for point S014-887, while the whole area is the subwatershed draining to 15RN006. The non-opaque area is the land the adds flow to point 15RN006 after the river passes through S014-887, and is the landscape that could explain the difference in water chemistry between the two sites.

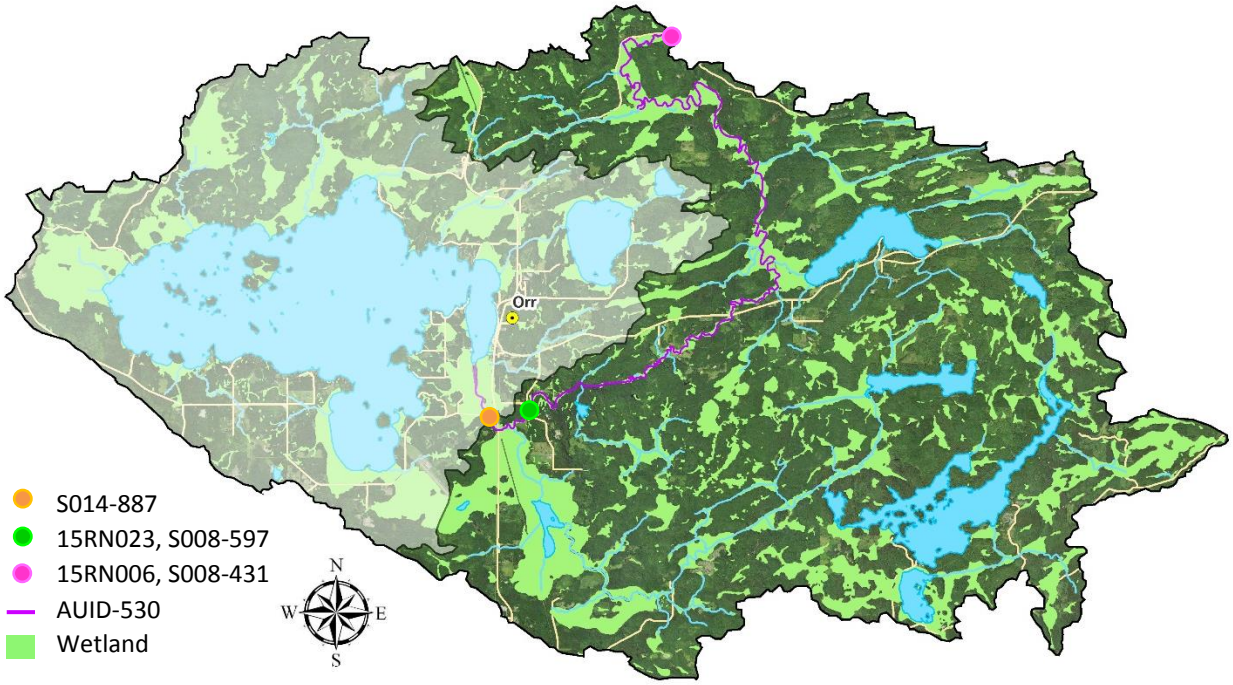


Figure 6. Paired DO samples collected in 2017. The red line is the DO standard.

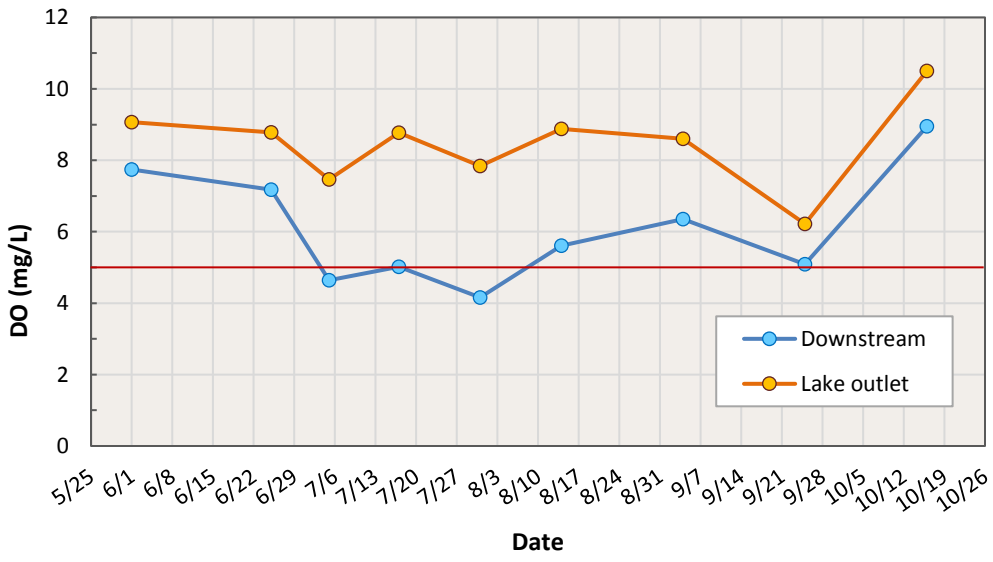


Figure 7. Paired TP, samples collected in 2017 at S0014-887 (lake outlet) and well downstream (S008-431).

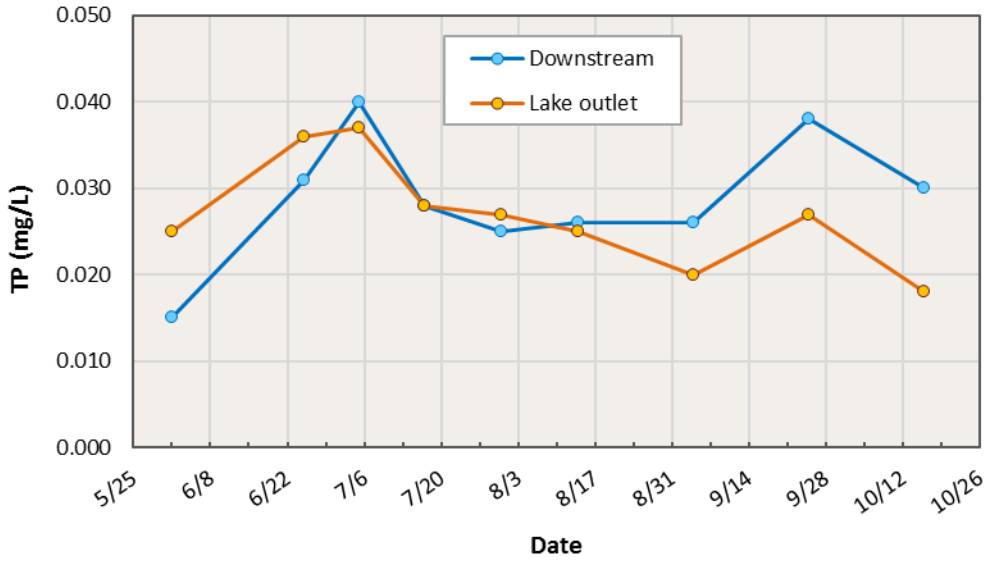
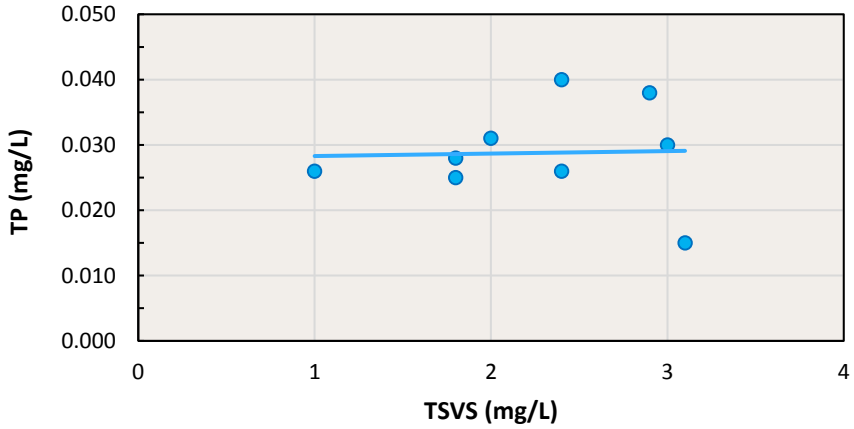
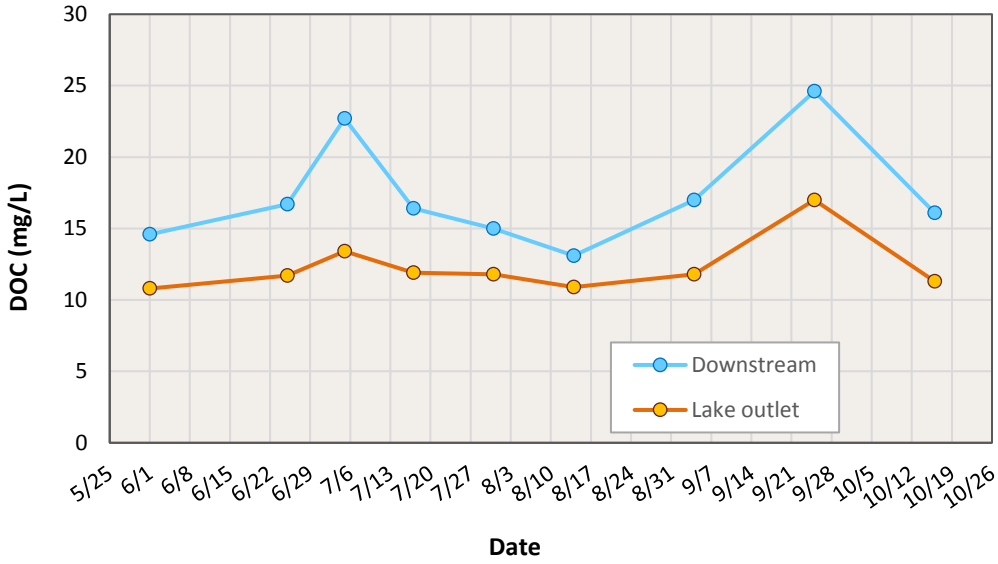


Figure 8. Correlation of TP and TSVS at 15RN006 (S008-431) with regression line (R^2 = 0012).



DOC is a result of plant breakdown, which occurs more significantly in wetlands than in streams, due to the typical abundance of aquatic plants that grow in wetlands, and the relatively stagnant water that resides in wetlands (including hydric soils). Thus, DOC concentration is a good indicator of the input of wetland-sourced water to streamflow. DOC samples were taken at the comparison locations, with a hypothesis that DOC concentrations would be higher at the downstream site, since there are significant riparian wetlands along the channel and the tributaries that enter the Prairie River between the sites. The data affirmed this expectation, with DOC being consistently higher at the downstream site (Figure 9).

Figure 9. Paired DOC samples collected in 2017.



The DO, DOC, and TP data all provide evidence that wetlands are influential on water chemistry of the Pelican River. This analysis suggests that the fish community in the Pelican River is naturally somewhat limited, and provides an explanation as to the landscape factors that cause this limitation.

Temperature

There are no significant human impacts along the reach that would lead to significant changes to water temperature.

Habitat

The MSHA scores of 59 and 65, at sites 15RN023 and 15RN006 respectively, though only at the top end of the "Fair" range of scores, are good for this type of river, which due to its low gradient nature has some natural limitation in its scoring potential. Habitat disturbance does not appear to be limiting the fish community.

Geomorphology and hydrology

No geomorphology fieldwork was done on AUID-501 due to the natural condition of the subwatershed and the low gradient of the channel, thus the unlikely occurrence of altered hydrology leading to channel instability. The common activity of forest harvest in the watershed will alter the hydrology somewhat from a purely natural state.

Conclusions

Human activity/development on the landscape that contributes flow to the Pelican River is light, and likely does not significantly factor into the mediocre fish community found in the IWM monitoring effort. Rather, the fish community is limited in the Pelican River due to a combination of the natural conditions of low channel gradient, limited habitat diversity, and wetland influence (contributing to low DO). Documentation has been made to this effect in the MPCA assessment meeting records, and subsequent monitoring has provided additional evidence to support this conclusion. Wetlands do influence water quality parameters from the point at which the river begins as the outlet of Pelican Lake to the lower biological monitoring site.

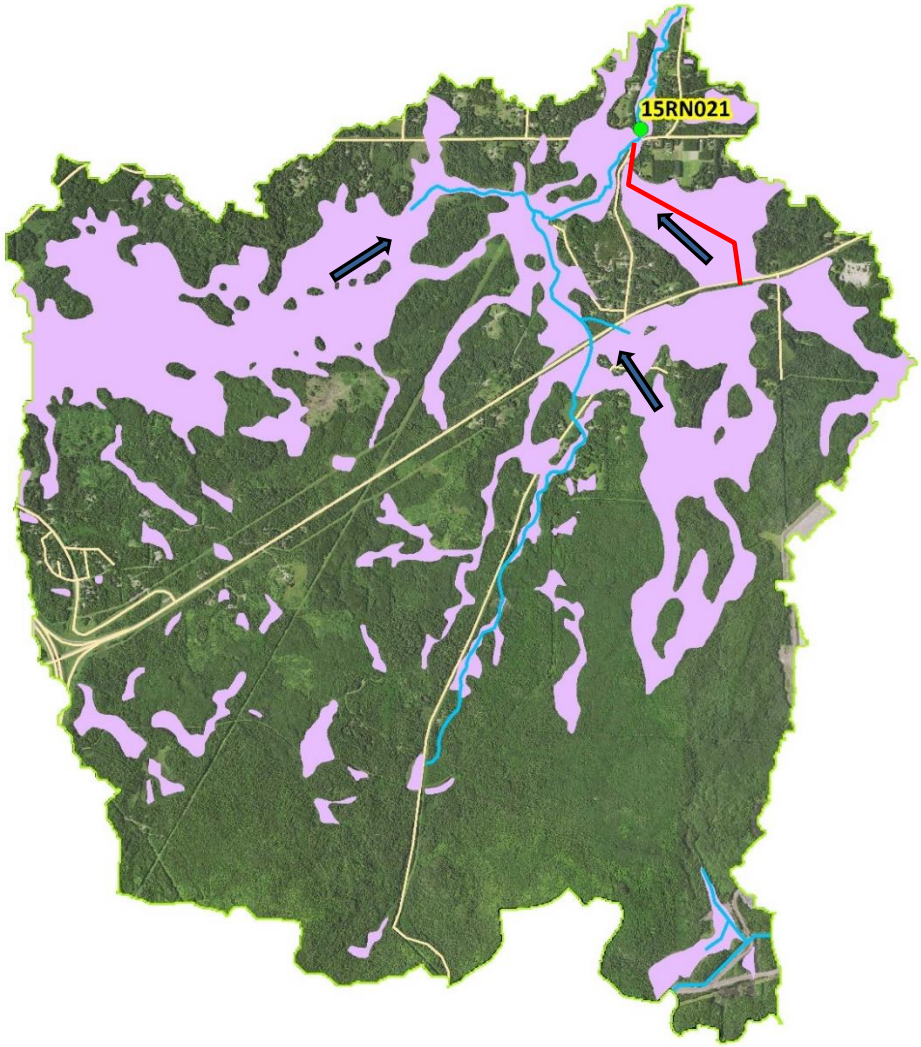
Tributary to Sand River (AUID 09030002-645)

Assessment: The creek was originally assessed as impaired for not meeting the fish and macroinvertebrate community thresholds at site 15RN021, located just downstream of Wouri Road, two miles southeast of Britt. After SID work, the current stream characteristics limiting the fish community have been determined to be natural. The impairment category for this AUID has been changed from Category 5 to Category 4D (no TMDL required). The culvert at the Wuori Road Crossing at the time of the original IWM fish sample was perched, and was backing up water in wetland habitat, potentially exacerbating the low DO conditions found in the AUID. The culvert was replaced the year after fish sampling, and no longer backs up water. The low DO situation that remains is considered natural, the result of upstream riparian wetlands and significant beaver activity impounding water in those wetlands.

Subwatershed characteristics:

The subwatershed of AUID-645 is predominantly forest covered, with a significant amount of wetland in the northern half (Figure 12). State Highway 169 cuts across the middle of the subwatershed. A small number of residences are located along the AUID-645 stream corridor. There are no towns within the subwatershed.

Figure 10. Map of the AUID-645 subwatershed showing land cover and infrastructure. Much wetland acreage is hydrologically connected to the AUID (purple = palustrine wetland from NWI, the red line is a small ditch.



Data and analyses

Chemistry

Water chemistry data from the two IWM visits are presented in table 5.

Table 5. IWM chemistry data from AUID-645 (15RN021), in mg/L.

Site	Date	Time	Temp.	DO	DO % Sat.	Cond.	pH	TP	Nitrate	TSS	TSVS	T-tube (cm)
15RN021	7/7/2015	16:02	20.4	2.02	24	--	6.2	0.046	< 0.05	10	6.8	--
15RN021	8/20/2015	8:06	13.0	4.04	40	143.2	6.3	--	--	--	--	--
15RN021	9/20/2016	13:45	15.0	3.07	30	70	6.8	--	--	--	--	--

Dissolved oxygen

Because dissolved oxygen was quite low at the IWM visits, it was further investigated during the SID effort. In July 2018, the three water sources directly contributing to 15RN021 were checked for DO, as well as at the Trillium Road crossing well upstream (Table 6 and Figure 11). The three sites just upstream from 15RN021 were the main channel on the upstream side of Wouri Road, the Wouri roadside ditch that enters from the west, and a wetland ditch that enters from the east. DO levels were low given the late afternoon time of sampling, though this was a completely overcast day. The lowest concentration was the main channel of AUID-645, followed by the ditch that comes in from the east. The Wouri roadside ditch was only contributing a very small amount of the flow this day to 15RN021.

Table 6. SID sampling in AUID-645 on 7/20/2018, including two locations on the main channel, the Wouri roadside ditch, and the wetland ditch that enters AUID-645 at Wuori Road. The weather for this date was heavily overcast with light rain. See figure 11 for exact locations. Data is in mg/L.

Site	Time	Water Temp.	DO	DO % Sat.	Cond.	TP
Main channel just upstream of Wouri Rd	17:10	20.02	2.35	25.8	75	--
"Wetland Ditch"	17:20	17.78	3.63	38.1	150	--
Wouri roadside ditch	17:35	17.59	6.29	65.9	108	--
S015-154	18:00	17.44	5.54	57.9	71	0.052

Nutrients - phosphorus

Though few samples exist, the phosphorus is well in line with natural levels found in wetland-influenced streams in northern Minnesota.

Nutrients - nitrogen

The lone nitrate sample showed extremely low concentration, which is again typical of natural conditions in small northern Minnesota streams.

Conductivity

All conductivity measurements are very low, which is evidence that no mine tailings seepage is entering this AUID.

pH

Two of the three pH measurements were a bit below the pH standard, and one was slightly above it. This is likely due to the contribution of bog waters to the stream.

Suspended solids - TSS and TSVS

Only one TSS and TSVS sample was collected. The suspended solids were just over two-thirds comprised of organic material. This is not surprising, given that much of the riparian corridor is wetland. The low gradient nature of the stream, beaver impoundments, and wetland corridor suggest that TSS consisting of eroded mineral soils would not be a problem here, thus the choice of not collecting additional samples.

Figure 11. The four 2018 DO sampling locations (yellow dots) along AUID-645. The larger, green dot is the location of 15RN021.

Temperature

Water temperatures were quite cool at all visits. Elevated temperature as a direct stressor on the fish community is not a concern in AUID-645.

Biological response

Fish

Only two species of fish were collected at 15RN021, primarily central mudminnow, and a few white sucker. These are extremely ubiquitous stream species. With so few species, it is not very useful to

calculate community metrics. Central mudminnow is classified by MPCA as "Very Tolerant" of low-DO conditions.

Macroinvertebrates

The macroinvertebrate community was heavily weighted toward wetland taxa, which are able to live in low DO environments. Two of the top four most-abundant taxa present were snails, which is extremely uncommon for a stream community. Hirudinea (Leeches) were the second-most abundant taxa. There were also numerous beetle (*Haliplus*, *Hydraena*, *Limnoporus*, Gyrinidae, *Hydrobaenus*, *Liodessus*, *Peltodytes*) and Hemiptera (Corixidae, *Notonecta*, *Microvelia*) taxa, both of which collect atmospheric oxygen at the water surface, and thus are not affected by low DO. The midge *Chironomus*, notorious for being able to live in low-DO waters was also present. A total of four Gastropod (snails) taxa were present, along with the fingernail clam (Pisidiidae). The presence and dominance of these taxa are very strong evidence that low-DO conditions are prevalent in this stream. No "Intolerant" taxa were found in the sample, while 64.4 % of the individuals are classed as "Very Tolerant".

Though the taxa list speaks for itself, macroinvertebrate metric scores were examined to confirm that DO levels are problem for the aquatic biological community. The macroinvertebrate community scored extremely poorly for the DO Index metric in 2015 (at the 6th percentile), but better in 2016, a bit above the class average (Table 7). There were many more low-DO Tolerant taxa than low-DO Intolerant ones, especially in the 2015 sample (Table 8). The TSS Index score was exceptionally good in 2015 and a bit higher (worse) than average in 2016. The number of TSS Tolerant taxa was quite a bit higher that TSS Intolerant ones in both samples. This analysis suggests that low DO is influencing the macroinvertebrate community and adds to evidence that DO is problematically low for the fish community. The community was skewed toward TSS-Tolerant taxa, both in numbers of species and percent of individuals. Only one TSS sample has been collected, which was below the regional standard and 68% of that TSS was organic particulates. The low gradient nature of the stream (i.e., low sheer stress within the channel) suggests that higher mineral TSS levels (from erosion) are not likely common.

Table 7. Macroinvertebrate metrics related to DO and TSS for 15RN021 utilizing MPCA tolerance values. The percentile rank (2018 version) is based on the Community DO Index score. "Prob" is the probability of a community with this TIV score coming from a site that meets the parameter standard.

Year		TIV Score	Class Avg/Median	Percentile within class	Prob.		TIV Score	Class Avg/Median	Percentile within class	Prob.
2015	Low-DO	4.56	6.30/6.49	6	13	TSS	10.72	13.63/13.76	94	--
2016	Low-DO	6.71	6.30/6.49	64	61	TSS	13.95	13.63/13.76	45	--

Table 8. Macroinvertebrate metrics related to DO and TSS for 15RN021 using MPCA parameter-specific tolerance values.

TIV Parameter	# Intolerant Taxa	# Very Intolerant Taxa	# Tolerant Taxa	# Very Tolerant Taxa	% Intolerant Individuals	% Tolerant Individuals
Low-DO (2015)	1	0	12	8	0.63	46.88
Low-DO (2016)	2	1	7	3	0.96	7.64
TSS (2015)	1	0	10	4	0.31	6.88
TSS (2016)	3	2	7	3	1.27	28.66

Connectivity

Fish in smaller streams migrate to find suitable habitat for various parts of the year. In fall, they generally migrate downstream to larger water bodies to overwinter. There are no human infrastructure barriers between the biological site and the Sand River downstream. Beaver are active in this subwatershed (Figures 12 and 13) and have created numerous dams, particularly upstream of the biological site, though also downstream of it, though it is not as clear (by viewing aerial photos) whether the downstream dams were fully functional, or breached in 2015.

Figure 12. Beaver dams upstream of the biological site.

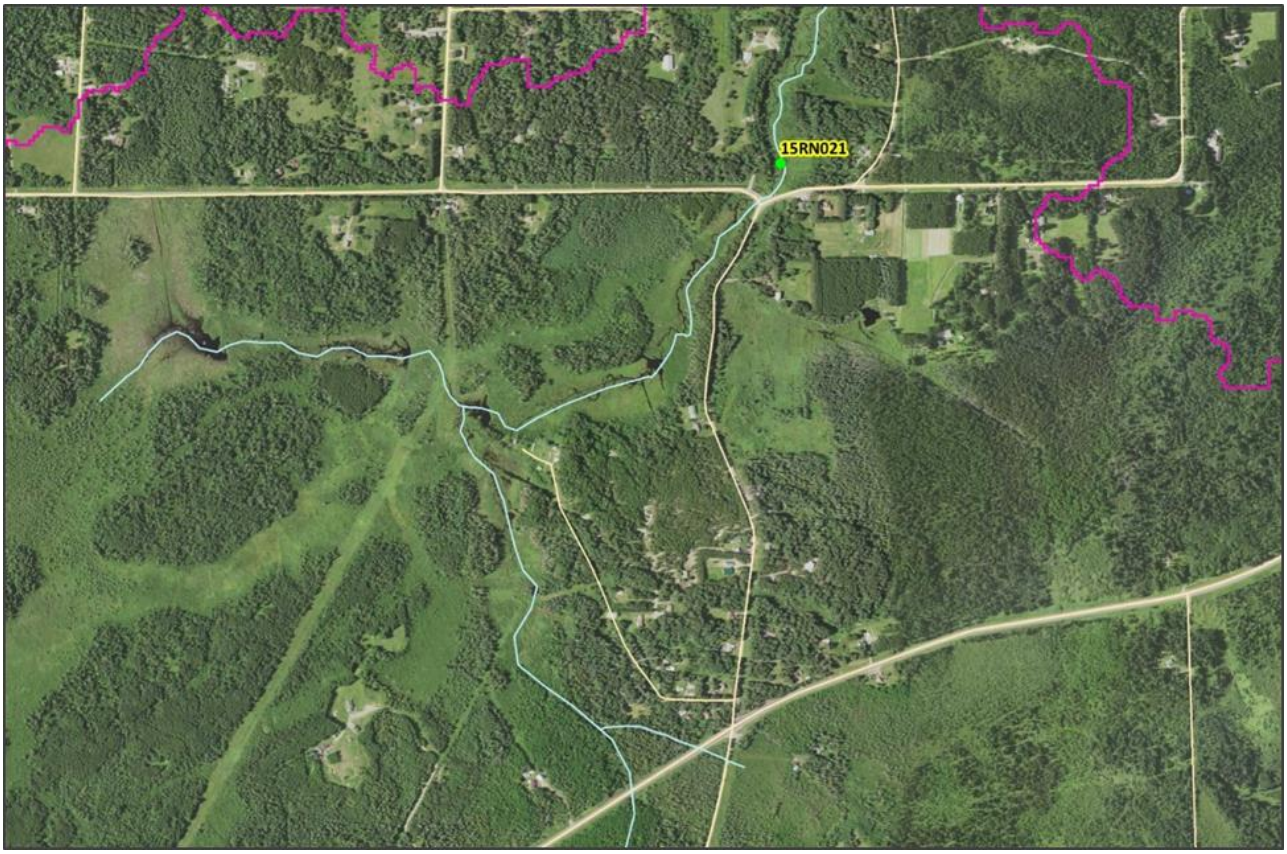


Figure 13. Aerial photo on 8/13/2015. Yellow arrows point to apparent dams downstream of the biological site, near the mouth of the AUID at Sand River.

The Wouri Road crossing at the time of biological sampling in 2015 was perched, sitting at too high an elevation. It was backing up water into the upstream wetland and may have exacerbated the low DO conditions. There is a new road crossing culvert on Wuori Road (Photo 1), installed in 2016, which is well-sized and placed, and is now very passible for fish, and also no longer backs up water into the upstream wetland.

Photo 1. The new culvert on Wouri Road.

Hydrology and geomorphology

No specific investigations into altered hydrology or unstable geomorphology were done for AUID-645. Aerial photography did not suggest that significant hydrologic alteration would be occurring due to relatively low human landscape alteration. In addition, there were no signs of stream channel instability upon general observation by staff familiar with symptoms of instability.

Habitat

The MSHA score for 15RN021 was 44.5, right at the border of "Poor" and "Fair" habitat categories. The "Substrate" and "Channel Morphology" MSHA component scores were very low. Substrate was predominantly clay and detritus, with scant amounts of larger hard substrate. Wood was also scarce. Channel features (riffles and pools) were not well developed, and flow was only "slow". The limited habitat here is probably mostly natural, a result of the local geology, soils, and topography.

Conclusions

The water chemistry, fish, and macroinvertebrate community statistics point to low DO concentrations as a primary cause of stress resulting in the fish community impairment. Low gradient streams bordered by riparian wetland habitat often have poor levels of DO. Many of these also have groundwater seepage emerging in these wetlands, eventually entering the streams, and this contributes to lower stream DO, as groundwater typically is low in DO. These low gradient streams do not have the turbulence to increase DO by interaction with the atmosphere. They also typically have more organic particulate material on the stream bed, which bacteria are acting on and which utilize dissolved oxygen in the water column. Exacerbating all of these are beavers, and the impoundments they create. These impoundments flood the organic riparian soils, and also create more-stagnant water that warms due to greater sun exposure. All of these natural factors are occurring in AUID-645.

In addition to the low DO that was found, the above-noted habitat characteristics point to homogeneous habitat in the stream channel, which typically results in low species diversity as numerous important microhabitats required by certain species are missing. This habitat condition is likely natural in this case, due to the relatively natural landscape conditions described above. The lack of habitat diversity coupled with quite low DO concentrations are responsible for the fish impairment in AUID-645.

Recommendations

As beaver are a natural component of forested landscapes, it is not warranted to remove beavers from AUID-645 as a means to address the fish impairment. Such removal is sometimes done when beavers are interfering with trout habitat needs, but this is not a trout stream.

Overall conclusions for the VRW Streams

The Stressor Identification process identified one likely stressor, low-DO, for the lone stream reach (AUID-645) with a biological community impairment (Table 9). Wetlands are prevalent along this stream and its smaller tributaries. Beaver activity is high in the VRW, as it is in many other northern Minnesota watersheds. Their dams can cause water temperature rise, lower downstream DO concentrations, and be immigration barriers for fish. All of these effects from beaver activity are plausibly acting in AUID-645. The Pelican River also has low DO, but was not assessed as impaired due to its landscape setting. It is not uncommon for lower gradient streams and rivers in northern Minnesota to exhibit DO levels below the state standard. These often occur when riparian wetlands are abundant along a stream or river, and can be exacerbated by the activity of beavers creating impoundments. The substandard

biological communities found in the two AUIDs reported on in this report were deemed to be caused by natural factors.

Table 9. Summary of stressors causing biological impairment in VRW streams by location (AUID).

Stream	AUID Last 3 digits	Reach Description	Biological Impairment	Stressor					
				Dissolved Oxygen	Phosphorus	Sediment/Turbidi	Connectivity	Altered *	Channel
Trib. to Sand River	645	At Wouri Road, two miles southeast of Britt	Fish and MI	•			o		

*Includes intermittency and/or geomorphology/physical channel issues

- • Determined to be a direct stressor.

o A stressor, but determined to have very little to no anthropogenic cause. Includes natural wetland and/or groundwater inputs, and beaver dams as natural stressors.

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