Red Creek West Watershed Assessment

2014 – 2015

Wayne County Soil & Water Conservation District

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EXECUTIVE SUMMARY

Red Creek West is a Class C stream with minor impacts caused by habitat modification and, suspectedly, by agriculture. Historic water quality is scarce, but Wayne County Soil & Water Conservation District previously examined it at a single outfall location. For is assessment, water quality samples were collected monthly at sixteen locations from June 2014 to June 2015. The samples were analyzed for total phosphorus, total Kjeldahl nitrogen, nitrate + nitrite, and total suspended solids. Total phosphorus, total Kjeldahl nitrogen, and total suspended solids concentrations observed in Red Creek West were noticeably higher when compared to other streams analyzed in Wayne County. Approximately 75% of the soils in the watershed have low infiltrations rates (higher runoff potential) when saturated, unless proper drainage practices are applied. A significant majority of the land uses in the watershed can be categorized as agricultural land and medium density residential properties. There is approximately 3,689 acres of protected wetlands in the watershed that play an important role in water filtration and nutrient recycling. There are two entities that have SPDES permitted discharges in the watershed that were not observed to have any negative contributions to the creek. Red Creek West's watershed also has four MS4-regulated communities that are required to follow minimum control measures to reduce the amount of pollutants that stormwater can transport. Agricultural livestock operations have been a staple of remediation efforts by SWCD. Water quality impacts to Red Creek West by such operations could be attributed to improper grazing practices and runoff from animal feeding systems. Runoff from cropland was observed as a potential source of nonpoint source pollution. Residential and Commercial properties in the watershed have the potential to implement green infrastructure practices to manage stormwater runoff. Ortho-imagery was used as a tool to identify onsite wastewater treatment systems near waterbodies or that have a number of systems in a concentrated area. Habitat modification in the watershed was observed to be channel modification and the presence of a dam that has changed and continues to alter the rates of erosion and sedimentation in the stream system.

INTRODUCTION AND BACKGROUND

A watershed can be defined as any land area in which water drains to a common point. When beginning to look at how land is managed and the resulting impacts upon water quality, it becomes increasingly clear that what is done on the land will ultimately affect the receiving waterbody. The concept of *Watershed Management* is to look broadly at the multiple land uses (agriculture, development, etc.) to determine their impacts and to find ways to mitigate them to protect these waterbodies.

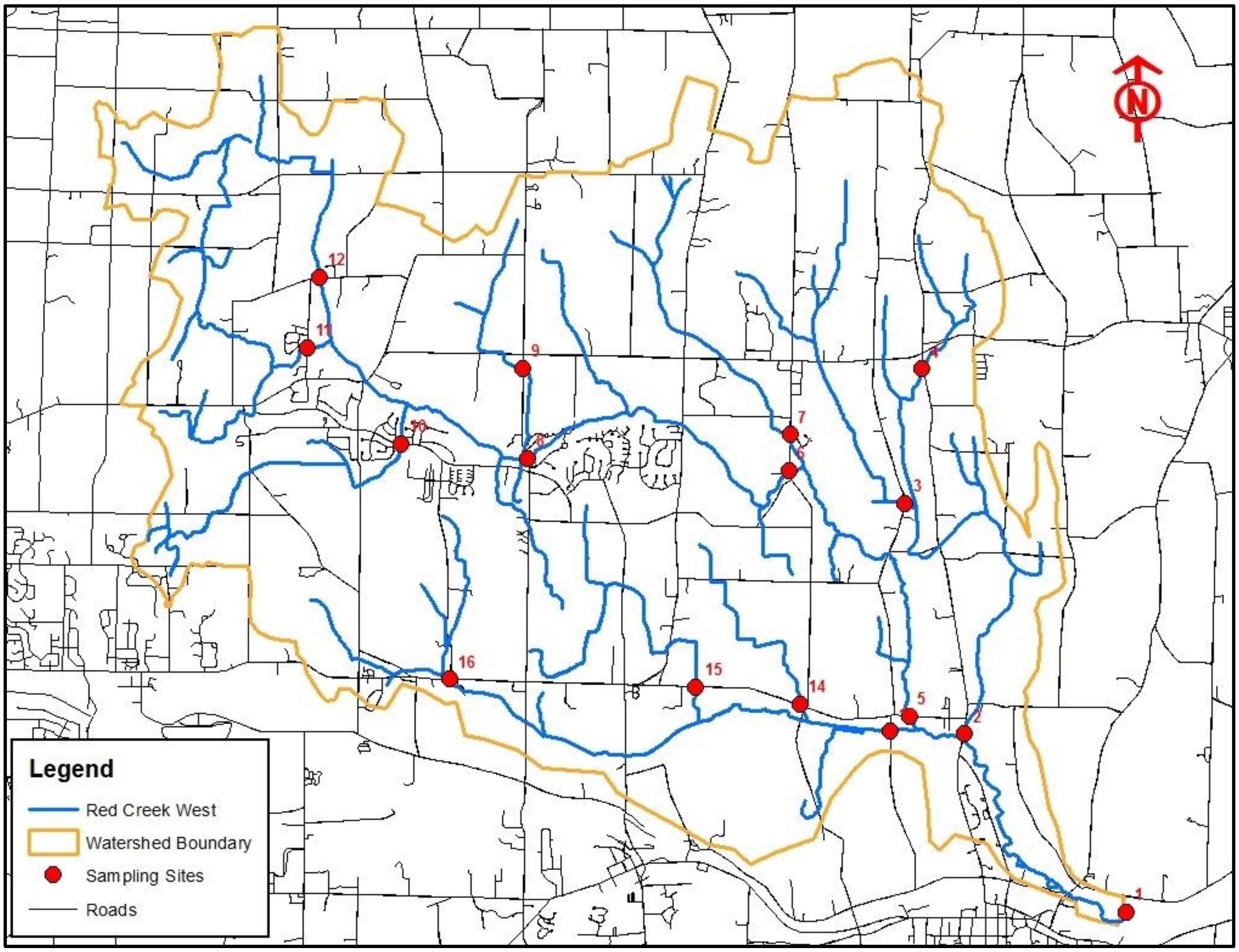
Through a combination of field work, resource evaluation, and mapping, an assessment of the watershed can help determine and outline upland actions that affect water quality. This *Watershed Assessment* then serves as the basis for prioritizing corrective measures and finding appropriate funding opportunities to address sources of pollution within the watershed.

The resulting document will expectantly serve as a guideline for restoration and improvements within the watershed, which will ultimately improve the water quality and ecology.

STREAM AND WATERSHED CHARACTERISTICS

Red Creek West's (0704-0033) headwaters originate along the Wayne-Monroe County line of the Towns of Walworth and Macedon, New York. The stream flows east through Walworth and Macedon into the Town of Palmyra where it outfalls into Lower Ganargua Creek at Swift's Landing Park. The Park is located at 4100 Hogback Hill Rd, Palmyra. Red Creek West and its tributaries are approximately 78.8 miles (416,063 feet) in length. Red Creek West's watershed is approximately 30,750 acres in size.

Red Creek West Watershed



STREAM MORPHOLOGY AND CLASSIFICATION

The section of Red Creek West that lies within the Town of Palmyra is a fourth order stream but the main channel is strongly dominated by third order streams. Red Creek West's main channel has an approximate bankfull width ranging from 15 to 50 feet. Using USGS Quadrant topographic maps, the slope of the main channel of Red Creek West was found to be approximately 0.12 percent. The slopes of the tributaries to this stream range from approximately 0.12 to 0.40 percent.

New York State Department of Environmental Conservation (NYS DEC) *2008 Oswego River/Finger Lakes Basin Waterbody Inventory/Priority Waterbodies List* Report (WI/PWL) classified Red Creek West as a C stream with *MINOR IMPACTS* that stress *AQUATIC LIFE* and *RECREATION* (Appendix I). For class C waters, the best usage is fishing. "These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes"

(Chapter X – Division of Water, Section 701.8). Waterbodies with *MINOR IMPACTS* are waters with "less severe water quality impacts are apparent, but uses are still considered fully supported." The Waterbody Inventory Data Sheet for Red Creek West states that the pollutant type is known to be *ALGAL/WEED GROWTH, NUTRIENTS (PHOSPHORUS),* and *SILT/SEDIMENT*. **The Data Sheet states that the major, known source of the pollutants is *HABITAT MODIFICATION*. This category includes loss of riparian vegetation; loss of buffer zones due to encroachment from incompatible land uses; fragmentation of habitat (loss of connectivity); change in distribution, abundance and/or composition of aquatic flora and fauna; debris removal; channel cover; etc. Agriculture is also a major, suspected source of the pollutants.** The Data Sheet indicates the resolvability of the impairment requires the evaluation of possible solutions and/or the development of management action (*NEEDS VERIFICATION/STUDY*). The Data Sheet continues with the assumption that most details about the problem are known and sufficiently documented and that a management strategy to address the situation and restore the designated use of the waterbody needs to be developed (*SOURCE IDENTIFICATION, STRATEGY NEEDED*). The Resolution Potential noted is *MEDIUM*, meaning the resources necessary to address the problem are beyond what are currently available. The 'Further Details' section of the Data Sheet continues discussing that a macroinvertebrate survey (2001) at the Maple Avenue bridge in Palmyra on Red Creek West indicated slightly impacted water quality conditions. The survey noted that the stream carried an abundance of aquatic weeds, noticeably duckweed (*Lemna sp.*), which indicates that ponding or stagnant flow in the stream. DEC observed specific conductance at the site was 'quite high,' which demonstrates a presence of dissolved solids such as nitrate, chloride, phosphate, sulfate, sodium, magnesium, calcium, and iron. The Data Sheet states that "although aquatic life is supported in the stream, nutrient biotic evaluation indicates the level of eutrophication is sufficient to stress/threaten aquatic life support."

WATER QUALITY

Water Quality

Historical water quality data for Red Creek West is scarce. This stream was included in a watershed characterization projects in 2009 and 2010 (Makerawicz et al. 2010 and 2011) that examined a single sample site located near the outfall of the watershed. The data previously collected by WCSWCD will be compared to the data collect for this project. This watershed assessment was designed to assess and further identify potential sources of pollution that impact the stream. The 16 sampling sites were chosen based on location along the main channel, at the outlet of sub-watersheds, and safety/ease of access (See Map above). Samples were collected once per month at the 16 locations from June 2014 to June 2015. A total of 12 sampling efforts were completed between the previously stated dates. Sampling was completed to reflect random seasonal variations in water quality. No samples were collected during what could be classified as 'Event' conditions i.e. noticeable precipitation runoff. Water samples were not collected in the month of February 2015 due to ice covering the stream sections. Samples were transported, on ice, to the Water Chemistry Laboratory at The College at Brockport, State University of New York, for water chemistry analysis of total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate + nitrite (NOx), and total suspended solids (TSS). Variability existed in the concentrations of nutrients from the 16 sampling sites. This is due to differences in land uses as well as point and nonpoint sources across the watershed.

Table 1. Mean, non-event concentrations of total phosphorus (TP), Nitrate-nitrite (NOx), total suspended solids (TSS), and total Kjeldahl nitrogen (TKN) for Red Creek West from 6/16/14 to 6/22/17 and Mean, non-event concentrations from various Wayne County tributaries.

RED CREEK WEST 2014-15				
	TP (µg/L)	NOx (mg/L)	TSS (mg/L)	TKN (µg/L)
Site 1	76.5	0.19	10.6	949.73
Site 2	74.3	0.17	6	894
Site 3	54.2	0.09	4	1057.73
Site 4	44.9	0.05	7.6	1022.38
Site 5	84.5	0.13	6.6	1019.38
Site 6	223.6	0.12	7.2	1019.3
Site 7	56.0	0.17	4.7	910.05
Site 8	160.9	0.06	5.4	846.8
Site 9	89.6	0.49	11.3	1016
Site 10	238.7	0.1	6.7	1159.68
Site 11	71.2	0.24	7.8	898.34
Site 12	120.6	0.12	6.5	1042.55
Site 13	61.7	0.4	10.3	838.41
Site 14	48.7	1.01	14.6	790.81
Site 15	80.2	0.67	5.6	918.43
Site 16	105.5	0.84	16.3	873.58
WAYNE COUNTY TRIBUTARIES				
	TP (µg/L)	NOx (mg/L)	TSS (mg/L)	TKN (µg/L)
Canandaigua Outlet 09-10	47.75	1.03	2.97	590.18
Glenmark Creek 09-10	39.25	0.77	3.23	535.88
Crusoe Creek 09-10	103.45	0.11	3.39	1201.86
Black Brook 09-10	55.32	0.46	10.96	848.69
Red Creek East 09-10	127.66	0.28	4.44	939.85
Red Creek West 09-10	98.48	0.24	3.16	710.40
Salmon Creek West 10	N/A	N/A	N/A	N/A
Maxwell Creek 10	252.30	0.34	2.00	754.00
Ganargua Creek Lower 12-13	91.09	0.75	13.08	358.00

Total Phosphorus (TP)

Phosphorus as phosphate is one of the major nutrients required for plant growth and is often considered the 'limiting' nutrient in New York freshwaters. Sources of phosphorus include animal wastes, sewage, detergent, fertilizer, disturbed land, and road salts. U.S. Environmental Protection Agency recommended water quality standard for flowing waters entering a lake is 50 µg/L and 100 µg/L for all other streams (USEPA, 2012). Wisconsin Department of Natural Resources established a phosphorus water quality standard for flowing waters entering lakes at 75 µg/L and 100 µg/L for all other streams and rivers (Wisconsin, 2010). The NYS DEC Stream Biomonitoring Team, in conjunction with the University of Albany, Department of Biological Sciences, suggests a phosphorus threshold limit of 65 µg/L between mesotrophic and eutrophic conditions in flowing streams (Smith et al., 2006). Eleven of 16 sampling sites had mean concentrations of total phosphorus exceeding 65 µg/L. Sites 10 and 6 had the highest observed mean TP concentration at 238.7 µg/L and 223.6, respectively (Table 1). Compared to other streams assessed in Wayne County, Red Creek West sites were found to be quite high. From the 2009 and 2010 studies of a single, watershed-outfall site, mean TP concentration was 98.48 µg/L. Site 1 of this study is the closest site to the actual physical outfall of the stream. Mean TP concentrations at this site were 76.5 µg/L.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen is the combination of organically bound nitrogen and ammonia. Sources of these forms of nitrogen include sewage effluent and runoff from land where manure has been applied or stored. U.S. Environmental Protection Agency water quality criteria recommendations for this region provided data that un-impacted waterbodies have a TKN concentration of 200.0 µg/L (USEPA, 2000). For this report, TKN was calculated by finding the difference between the concentrations of Total Nitrogen (TN) and Nitrate + Nitrite (NO_x). Site 10 had the highest mean concentrations of TKN observed for this report (Table 1). Compared to TKN data from other streams within Wayne County (Makerawicz et al. 2010 and 2011), Red Creek West displayed concentrations that were on the higher end, ranging from 790.81 µg/L at Site 14 to 1159.68 µg/L at Site 10. All sites sampled in the study depicted concentrations 3.5 – 5.5 times than the EPA recommended background concentrations for reference rivers or streams.

Nitrate + Nitrite (NO_x)

Nitrate is the form of nitrogen that is most readily available for plant uptake. It is more easily detected as Nitrate + Nitrite, or NO_x (Nitrite is not commonly found in surface waters but is created as nitrate converts to nitrogen gas during denitrification). Nitrate sources include soil, animal wastes (including birds and fish), sewage and septic systems, fertilizers and decaying vegetation. The NYS DEC water quality standard for nitrate in drinking water is 10 mg/L. The United States Geological Survey (USGS) states that background nitrate concentrations for undeveloped watersheds is 0.6 mg/L (USGS, 1999). Site 14, located at Macedon Center Road and Walworth-Palmyra Road, had the highest mean concentration of nitrate, 1.01 mg/L. Sites 15 and 16 also exceeded the background concentration observed by the USGS report. Concentrations observed in Red Creek West were comparable to those observed in other Wayne County streams (Makerawicz et al. 2010 and 2011).

Total Suspended Solids (TSS)

Total suspended solids is a measure of soil particles and other materials suspended in water. Water-borne sediments act as an indicator, facilitator and agent of pollution (Makerawicz et al. 2011). As an indicator, TSS adds hue to water. As a facilitator, sediments transport other pollutants such as nutrients and toxic substances. As an agent, sediments smother organisms and cover habitats used by some species for spawning. Five of the 16 sampling sites had mean concentrations of TSS in excess of 10 mg/L, ranging from 4.0 mg/L at Site 3 to 16.3 mg/L at Site 16. Concentrations of TSS was noticeably higher throughout the spring and summer months.

HYDROLOGIC SOIL GROUPS

Hydrologic soil group (HSG) is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. Wetness characteristics, water transmission after prolonged wetting, and depth to slowly permeable layers are properties that influence runoff potential. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. Hydrologic soil groups are important in the planning watershed-protection and flood-prevention projects as well as for planning or designing structures for the use, control, and disposal of water.

Table 2. Hydrologic soil groups for the Red Creek West.

Hydrologic Soil Groups		Acres	%
	HSG A	2740	9%
	HSG B	4409	14%
	HSG C	5870	20%
	HSG D	679	1%
	HSG A/D	1876	6%
	HSG B/D	8354	28%
	HSG C/D	5919	20%
	No HSG	900	2%
	TOTAL	30750	

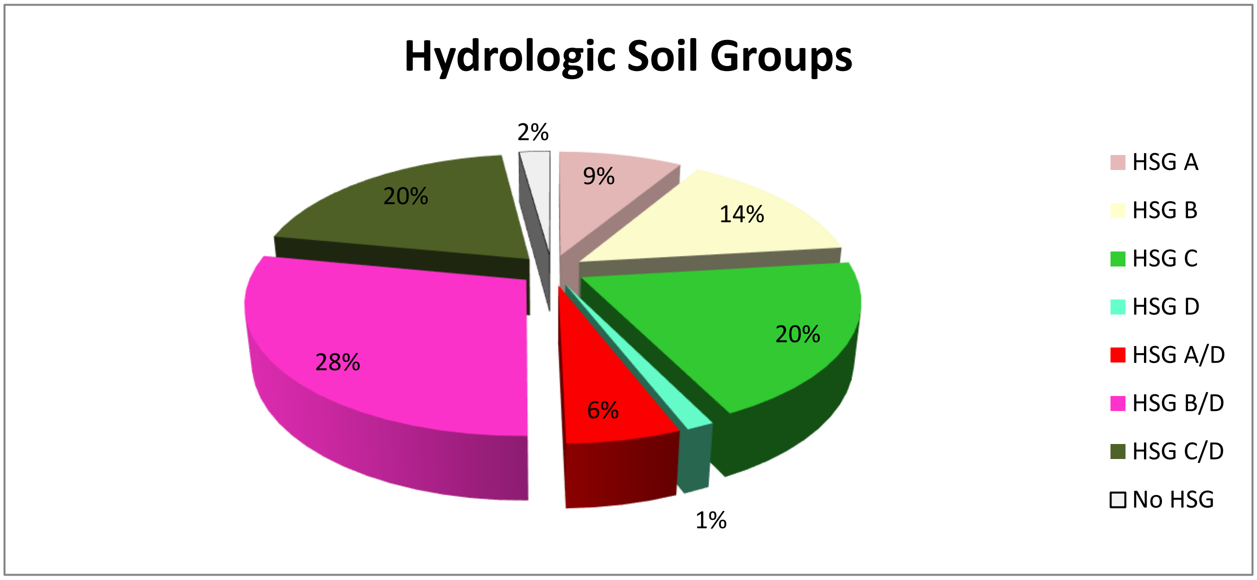
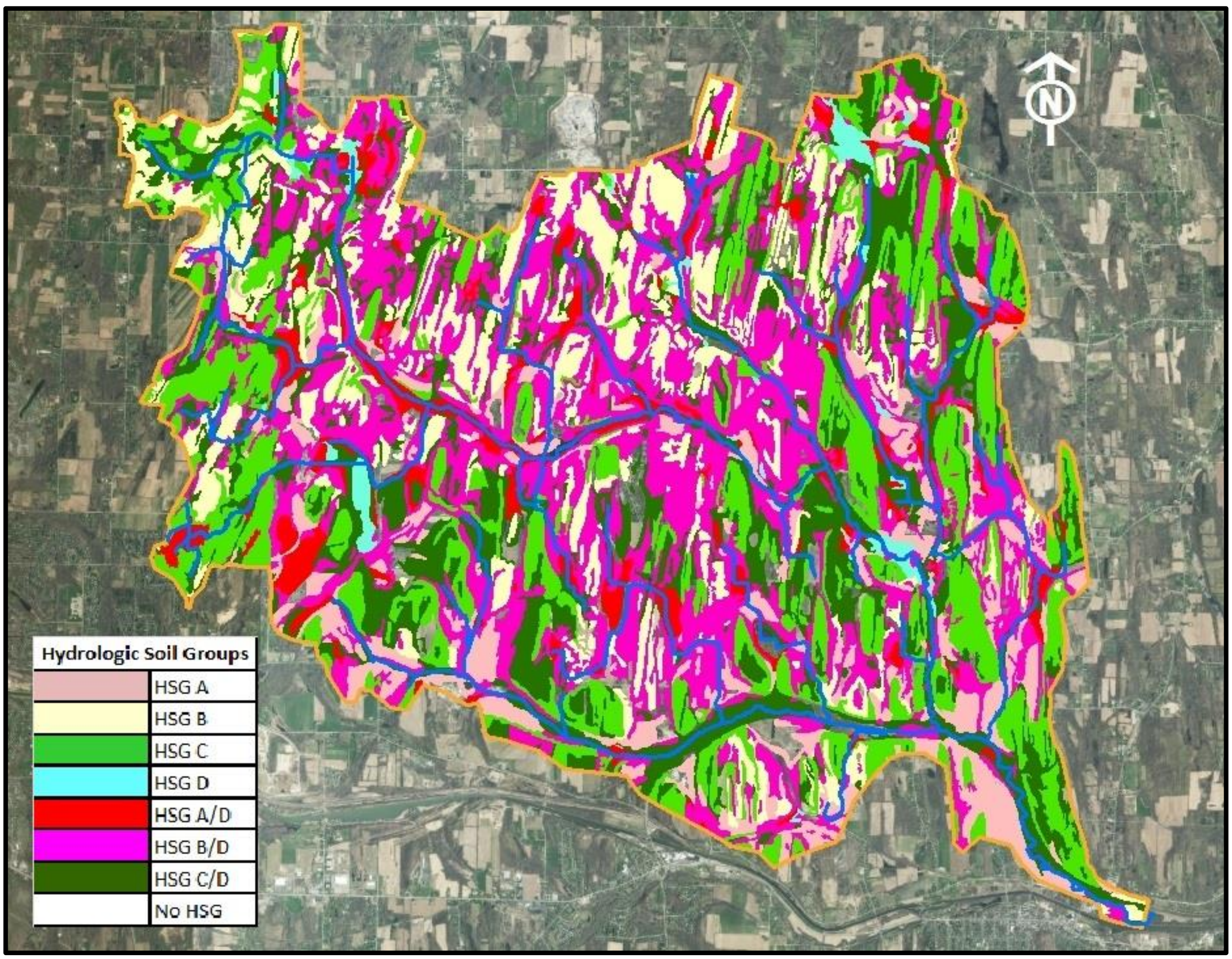


Figure 1. Percent acreage of hydrologic soil groups for the Red Creek West.



Red Creek West – Hydrologic Soil Groups

The four hydrologic soil groups (HSGs) are described as:

Group A—Soils in this group have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hour).

Group B—Soils in this group have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hour).

Group C—Soils in this group have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately-fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hour).

Group D—Soils in this group have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hour).

Dual hydrologic soil groups—Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the ease with which pores of a saturated soil permit water movement may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their ability to allow water movement and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

As evident in Table 2, 75% of the watershed area is soil that has low infiltration rates when saturated and/or has the water table within 24" of the ground surface. Although some of these soils can exhibit lower runoff potentials with the proper drainage practice, they are still susceptible to increased runoff when subjected to prolonged wetting.

Conversely, high infiltration rates can pose an increased risk for groundwater and surface water contamination. Soil straining or filtration usually removes suspended solids and particulate phosphorus, but dissolved phosphorus (phosphates) can remain untreated. Fine- to medium-textured soils have a larger capacity to hold phosphate, while coarse-textured soils do not (Busman et al, 2002). The same can be stated for nitrate-N. Water-soluble nitrate leaches below root zones with excess water. This nitrogen form has the potential to enter ground and surface water in areas of coarse-textured soils (Lamb et al, 2014).

LAND USE

The land use and land cover patterns (permeability) in a watershed have a significant impact on the overall quality of the receiving waterbody. Knowing the extent of development in a watershed and where the development is located can play a key role in the contaminant loading to a waterbody. In general, as land uses occur, stream systems and overall waterbody health can become diminished through changes in runoff and other human impacts.
Land use categories observed in the Red Creek West watershed are categorized as:

- *Water* – includes lakes, ponds, and streams
- *Hay/Pasture* – includes plant and tree nurseries, fruit orchards, livestock grazing areas
- *Cropland* – includes mucklands, field crops, and dairy products
- *Forest* – includes various vacant lands, public parks, and private forests
- *Disturbed (land)* – includes mining and quarry operation
- *Turf/Golf* – includes golf courses and country clubs
- *Open Land* – includes outdoor recreation facilities, skiing center, cemeteries, landfill
- *Low Density Residential* – includes rural, primary residence with acreage including agricultural land
- *Medium Density Residential* – includes multi-family residence, mobile homes, and residence with commercial uses
- *Low Density Mixed Urban* – includes small commercial operations and mobile home parks
- *Medium Density Mixed Urban* – includes commercial operations such as shopping centers, office buildings, downtown row-type structures, apartments buildings, inns and lodging; community services such as schools, hospitals, emergency services, religious and cultural facilities; industry such as light and heavy manufacturing process; and public services such as electric, gas, telephone, and sewages treatment

Table 3. Land uses of the Red Creek West watershed and acrages

Land Use		Acres	%
	Cropland	9822	33%
	Low Density Residential	7602	26%
	Forested	948	3%
	Medium Density Residential	5893	20%
	Disturbed	227	1%
	Open Land	3329	11%
	Turf/Golf	675	2%
	Hay/Pasture	963	3%
	Low Density Mixed Urban	1293	4%

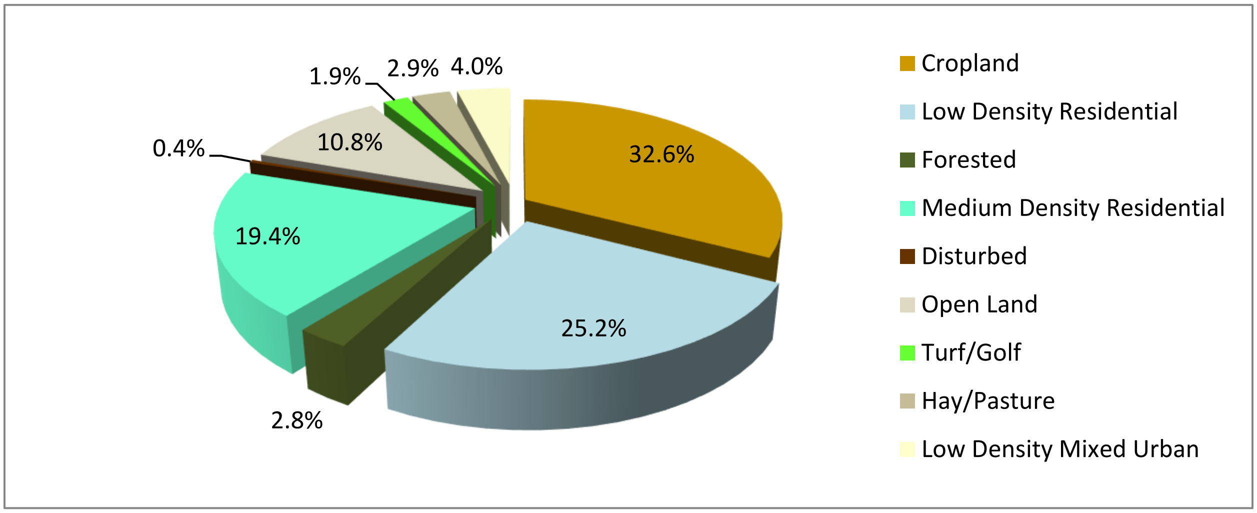
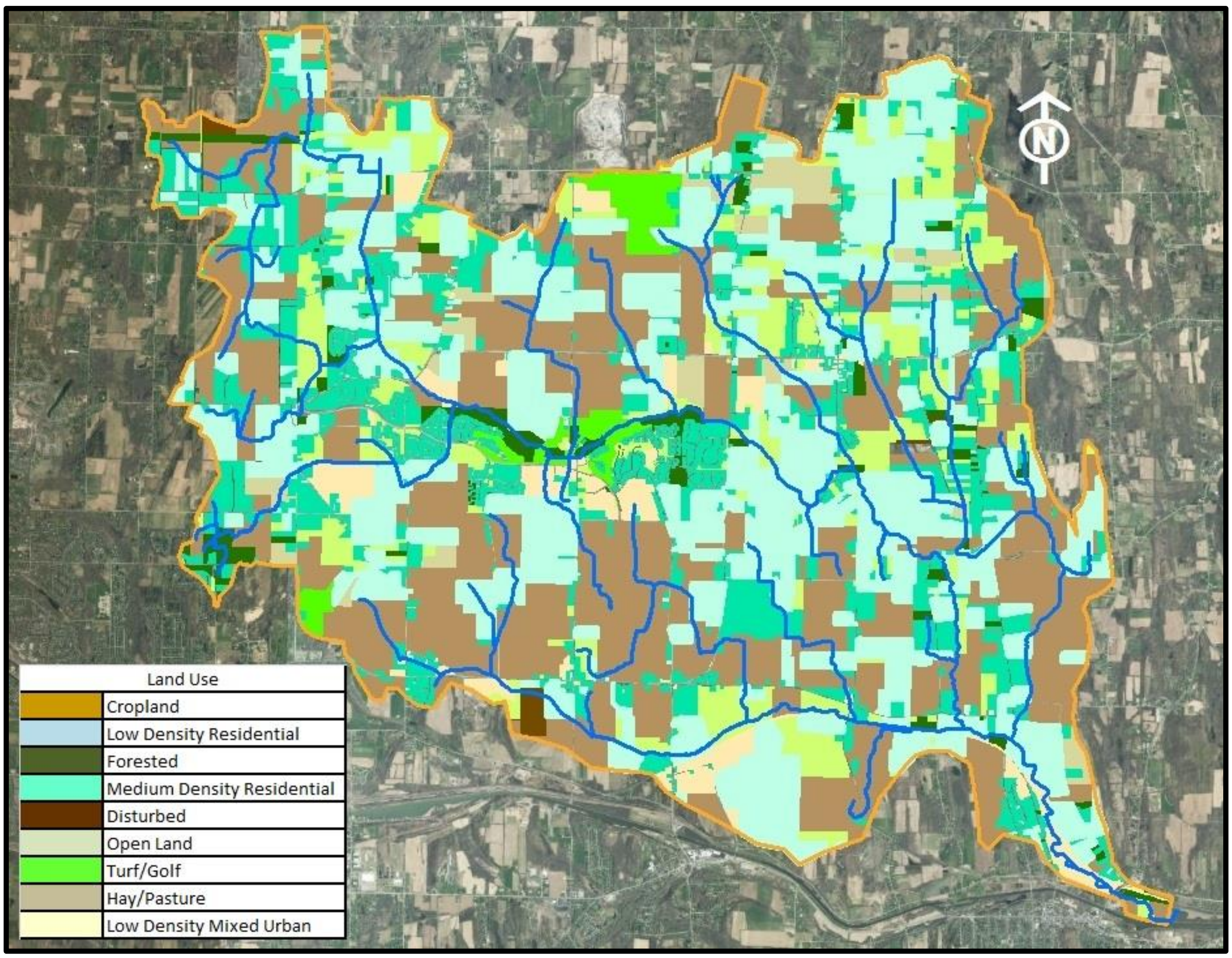


Figure 2. Percent acreage of land uses for Red Creek West watershed.



Red Creek West – Land Uses

Figure 2 provides a fairly accurate representation of current land uses within the Red Creek West watershed. It is important to note that the Low Density Residential category has a high likelihood of containing Agricultural Lands. With that in mind, in combination with Cropland and Hay/Pasture, approximately 60% of the watershed is made up of some form of agricultural land.

Land use information can be used in conjunction with adjacent water quality data to determine potential areas of concern and aide in prioritizing implementation efforts to reduce pollution loading. Using Stressed Stream Analysis, an approach developed by Dr. Joseph Makarewicz, priority subwatersheds can be systematically sampled to locate point and nonpoint sources (Makarewicz, 1993).

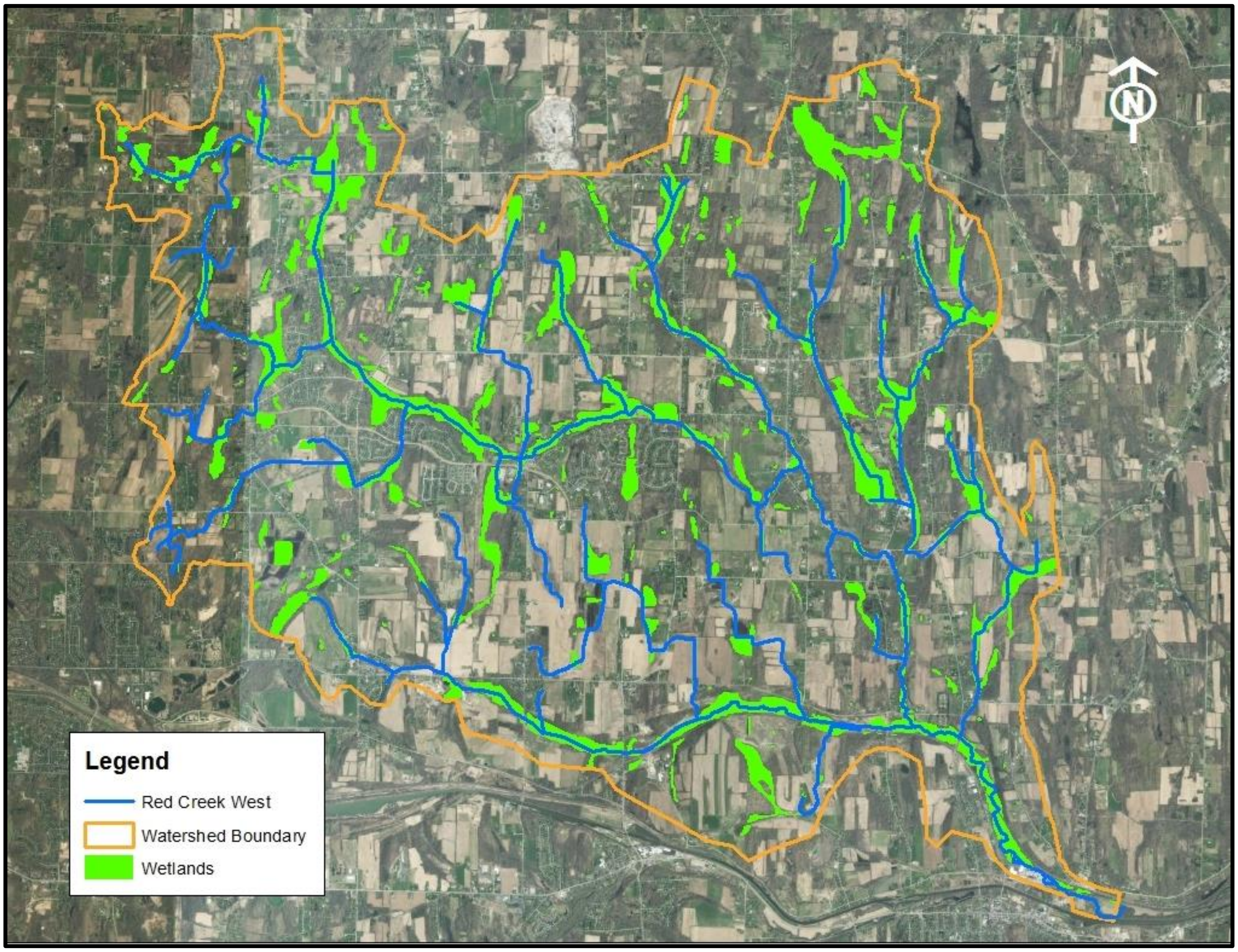
WETLANDS

As per NYS DEC, wetlands "are areas saturated by surface or ground water sufficient to support distinctive vegetation adapted for life in saturated soil conditions." Wetlands provide flood and storm water control by absorbing, storing, and slowing the movement of runoff. They provide erosion control by slowing water velocity, filtering sediment, and by buffering streambanks and shorelines. Wetlands treat pollution and cycle nutrients back into the environment by filtering out natural and manmade pollutants, which are then broken down or immobilized. Wetlands provide important habitat for feeding, nesting, and spawning fish and wildlife including rare and endangered species. Lastly, wetlands give humans areas for recreation, education, and research opportunities.

Wetlands may act as a sink for nutrients and sediment, meaning they act as filters. The biological and chemical process of the nitrogen cycle in wetlands causes up to 90% to be removed.

Phosphorus enters wetlands as dissolved phosphorus or attached to suspended solids. Its removal occurs through uptake by plants and chemical reactions with soil and soil components. However, wetlands can become saturated with phosphorus and may release it from the system. This loss of phosphorus from wetlands occurs in late summer, early fall, and winter as organic matter decomposes causing low oxygen conditions.

Red Creek West – Wetlands



Wetlands filter suspended solids from water that comes into contact with wetland vegetation. The plants also create friction on water flow, slowing movement, thus allowing suspended material to settle.

The Red Creek West watershed has approximately 3,689 acres of NYS DEC regulated wetlands consisting of forest/shrub wetlands, ponds, lakes, emergent wetlands, and riverine wetlands. Wetlands in NYS are protected by the Freshwater Wetlands Act (1975) “with the intent to preserve, protect and conserve freshwater wetlands and their benefits, consistent with the general welfare and beneficial economic, social and agricultural development of the state.”

Red Creek West bordered by forested/shrub wetland and emergent wetland

WATER QUALITY ISSUES AND RECOMMENDATIONS

Point Sources

State Pollution Discharge Elimination System (SDPES) permit is designed to control point source discharges to groundwaters and surface waters.

Wastewater

Town of Walworth operates a SPDES-permitted wastewater treatment plant in the Red Creek West watershed that services 1,650 accounts in Walworth and 500 accounts in Macedon. The plant also takes flow from the pre-treatment plant at Baldwin Richardson Foods located on the road Blue Heron View off the Gananda Parkway. There is a total of 29 miles of sewer lines to service these areas. The plant is designed for a max daily flow of 1.25 million gallons. It currently runs at an annual, daily average of 700,000 gallons. The wastewater treatment plant has not had any recent upgrades nor are any planned for the near future. Taken directly from the Town of Walworth website (www.townofwalworthny.com): "It is the mission of the Town of Walworth Wastewater Treatment Facility to operate a wastewater treatment facility with the best interest of the public, environment and the town; to achieve or exceed all standards set for us by our regulating agencies; and to maintain all facilities and equipment to the best of our capabilities, providing the most cost effective treatment."

Garlock Sealing Technologies in the Town of Palmyra also has a number of SPDES-permitted outfalls to Red Creek West. The facility discharges treated wastewater from eight outfalls. Seven of the eight outfalls discharge only treated manufacturing water, while the other one discharges treated sanitary wastewater along with other manufacturing process water and stormwater from the plant's facilities. As of February 10, 2017, the company and the DEC are in the process of modifying and updating their permit coverage.

The water quality collection component of this study did not have any sampling sites near the treatment facilities. Therefore, the results of this study cannot determine if the plant is negatively affecting the water quality of the creek.

Stormwater

Stormwater runoff is generated when precipitation from rain and snowmelt events flow over land or impervious surfaces and does not seep into the ground (NYS DEC). Polluted stormwater runoff is commonly transported through municipal separate storm sewer systems (MS4s), and then often discharged untreated into local water bodies. EPA's Stormwater Phase II Rule established an MS4 stormwater management program that is intended to improve surface waters by reducing the amount of pollutants that stormwater carries into storm sewer systems during storm events. Phase II regulation requires regulated small MS4s (population less than 100,000) in urbanized areas, as well as small MS4s outside the urbanized areas that are designated by the permitting authority, to obtain National Pollutant Discharge Elimination System (NPDES) permit coverage for stormwater discharges. There are four MS4s in the Red Creek West watershed: the Towns of Macedon, Walworth, Perinton, and Penfield. A small MS4 stormwater management program is comprised of six elements, or minimum control measures, that, when implemented together, result in significant reductions of pollutants discharged into receiving waterbodies. The minimum control measures are:

1. Public education and outreach – Distribution of educational materials and performing outreach to inform citizens about the impacts of polluted stormwater runoff discharges.

2. Public participation/involvement – Provide opportunities for citizens to participate in program development and implementation.

3. Illicit discharge detection and elimination – Develop and implement a plan to detect and eliminate illicit discharges to the storm sewer system.

4. Construction site runoff control – Develop, implement, and enforce an erosion and sediment control program for construction activities that disturb 1 or more acres of land.

5. Post-construction runoff control – Develop, implement, and enforce a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas.

6. Pollution prevention/good housekeeping – Develop and implement a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques.

The MS4 communities in the Red Creek West watershed are also members of organized Stormwater Coalitions. Coalition members are able to work cooperatively to fulfill the federal stormwater regulations and work to improve water quality in a cost-effective manner. The coalitions utilizes their members' expertise, resource, and information to accomplish annual goals and for the benefit of their communities.

The minimum control measures 1 and 2 can be the most effective element of the MS4 program. As the public obtains a greater understanding of the necessity and importance of stormwater management, the public may alter their individual actions to protect or improve the quality of area waters. The public can provide valuable input and assistance to an MS4 community. Public participation can create a feeling of responsibility to protect water resources and play an active role in implementation of the program. The community can be a valuable intellectual resource by providing a broader base of expertise. Those individuals involved in the MS4 program will cross-connect with other community and government programs.

Nonpoint

Agriculture Nonpoint Source Pollution

Livestock

Livestock production is an important component of the agricultural economy of Wayne County, comprising 24% of the county's 179,000 acres of farmland. Depending on management, livestock operations can either degrade or contribute to the quality of natural resources. Livestock situations that can contribute nutrients and sediment to Red Creek West include grazing, animal feeding operation, and animal waste.

Overgrazing of livestock exposes soils, increases erosion, encourages invasive species colonization, destroys aquatic habitat, and destroys streambank and floodplain vegetation. Animals with direct access to streams can degrade water quality by dropping manure directly into the stream and by disturbing streambank stability. Vegetation along a stream corridor is necessary for wildlife habitat and water quality filtration. To reduce the negative impacts of overgrazing on water quality, farmers can adjust grazing intensity, exclude livestock from sensitive areas, provide alternative sources of water and shade, and promote the revegetation of damaged areas.

Confined animal systems for beef and dairy cattle, swine, and poultry have greatly increased farm production efficiency, but this concentration of animals can bring about water resource concerns. Contaminated runoff from these operations can contain excessive amounts of nutrients, pathogens, and sediment. Such operations have to manage manure in the confinement areas and utilize/dispose of manure in an appropriate way.

Pollution of surface waters is not the only concern associated with livestock manure. Manure applied to agricultural land can be beneficial because of its nutrients and soil building characteristics, but over-application may lead to groundwater contamination, especially nitrate and fecal coliform bacteria. This is a significant concern to rural areas where residential drinking water comes from wells.

Farm operations identified during the course of this assessment will not be identified by name or location in this publication to maintain producer privacy.

Managing livestock grazing land to protect water quality and aquatic and riparian habitat should include the following measures:

- Improving and/or maintaining the health of a stable and desired forage plant community that at the same time stabilizes soil and improves water quality;
- Ensure adequate residual vegetative cover;

- Provide adequate regrowth time and rest for plants;
- Excluding livestock from riparian zones and wetlands using fencing and, where necessary, providing stable stream crossings;
- Determining a grazing system for each individual farm;
- Providing water facilities away from streams; and
- Stabilizing heavily used areas.

Animal feeding operations (AFOs) should be managed to minimize impacts on water quality and public health. To meet this goal, management of AFOs should address the following:

- Divert clean water away from feedlots and holding pens, animal manure, and manure storage systems;
- Prevent seepage of contaminated effluent into ground and surface water;
- Provide adequate, safe storage of animal manure;
- Apply manure to farmland in accordance with a nutrient management plan;
- Land receiving manure should be managed to minimize the movement of nutrients and organic material and buffer/treat runoff;
- Operators should document the quantity of waste produced and its utilization/disposal; and
- Deceased animals should be managed so to not adversely affect ground and surface waters.

Vegetated Treatment Area

Cows on new Water Management Barnyard.

Numerous BMPs can be implemented to achieve the management efforts stated above. The most recent practices used by Wayne County SWCD include:

- Roof runoff management;
- Diversions channels;
- Heavy use area protection;
- Waste storage facility; and
- Vegetated filter strips.

The livestock operations observed during this watershed assessment exhibited varying degrees of water resource concerns. These farms could strongly benefit from the management practices stated above.

Cropland

Cropland in the Red Creek West watershed consist of 32.6 percent, or 9,711 acres, of the total watershed (30,750 acres). Two subcategories of cropland are recognized in New York State: cultivated and non-cultivated. Cultivated cropland involve row crops or close-grown crops. Non-cultivated cropland includes permanent hay land and horticultural cropland (fruit, nut, vineyard crops and nurseries).

Cropland activities have the potential to contribute to nonpoint source pollution. Application of commercial fertilizer to cropland can introduce nitrogen and phosphorous to surface or groundwater. When excess nutrients are introduced to natural waterbodies through runoff, they can potentially increase the "productivity" of the water system, referred to as eutrophication.

Pesticides and herbicides can be transported to surface and ground water through runoff and/or soil infiltration. Chemicals that are resistant to degradation can persist in natural waterbodies and can bioaccumulate in aquatic organisms. This can result in chemicals biomagnifying through the food chain. As noted above, the water quality data collected for this report did not include the analysis of pesticide or herbicide components.

The cultivation of croplands destabilizes soils and can lead to excess soil erosion and sedimentation. Soils eroded from cropland often contain nutrients which further impact water quality in the receiving waterbodies. Salts produced from natural weathering of soil can also be transported in runoff, which can negatively affect water quality.

Cropland with minimal riparian buffers and soil erosion.

Where manure is applied to cropland, there is a possibility of excessive concentrations of pathogens and nutrients entering adjacent waterbodies through surface or ground water. Soil characteristics, soil types, crops grown, amount of manure applied, rate of application, and seasonal timing of application determine the potential for adverse impacts to water quality.

To address pollutants caused by cropland activities, BMPs can be designed to initially prevent runoff or to treat polluted runoff before it reaches a waterbody. The simplest BMP to use for cropland activities is sound farm administration and planning. Whole farm planning is the holistic approach to farm management used to identify and prioritize issues on a farm without compromising the farm business.

Often for administrative BMPs to be successful, they require the implementation of structural BMPs. Structural BMPs for cropland have the goal of improving water quality in waterbodies adjacent to cropland by preventing excessive erosion, and intercepting and filtering possibly contaminated runoff. Cropland BMPs that can be used to meet this goal includes:

- Crop rotation;
- Strip cropping;
- Contour farming;
- Cover cropping;
- Residue management;
- Vegetated filter strips;
- Grassed swales;
- Riparian buffers;
- Diversions;
- No-till/conservation tillage;
- Water and sediment control basin; and
- Grade stabilization structures.

Sections of Red Creek West with cropland right to the edge of the stream's bankfull height. **NYS DEC PWL data sheet states that Red Creek West is stressed by habitat modification due to loss of riparian vegetation and the loss of buffer zones due to encroachment.**

In many situations, the use of multiple BMPs may be needed to meet the requirements of reducing nonpoint source pollution on agricultural operations. The appropriate BMP(s) to implement can be dependent on numerous onsite factors (climate, topography, installation costs, etc.) and may require management from a natural resource professional. Management and conservation plans should contain BMPs that are most applicable to the farm location, with each practice functioning with all others to achieve the operation's goals.

NYS Department of Agriculture and Market's *Agricultural Environmental Management* (AEM) program is a specific program that addresses nonpoint source pollution associated with agriculture. AEM is a voluntary, incentive-based program that provides farmers with technical assistance to help plan and implement conservation practices to meet business objectives and that address natural resource concerns. Wayne County SWCD, the local AEM resource professional, has over 300 agricultural operations enrolled in the program since 2005. Seventeen farms within the Red Creek West watershed are enrolled in the AEM 5-tier approach. By participating in AEM, agricultural operations can document environmental stewardship and further improve contributions to the community, economy, and environment.

More detailed information regarding AEM and EQIP can be found at:

http://www.agriculture.ny.gov/SoilWater/aem/index.html

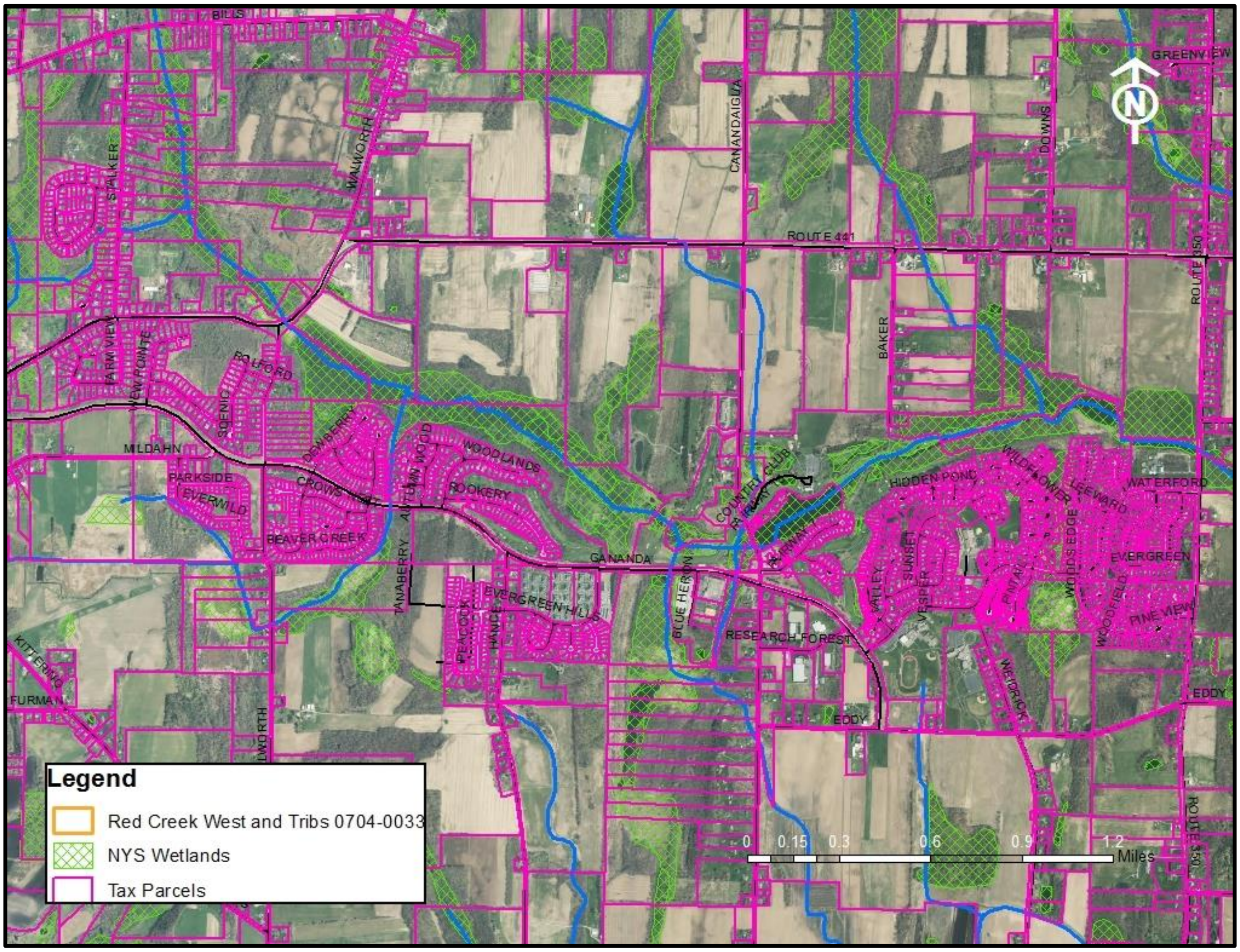
During the preparation of this report, it become apparent the some of the farm operations' information is out of date and/or the farm has changed owners. The SWCD has committed to improving the number of operation enrolled in the AEM program by filling a position that focuses on the program.

Stormwater Runoff

Stormwater runoff associated with population density has already been discussed in the report, section **Point Source – Stormwater**. This section of stormwater runoff as a nonpoint source pertains to opportunities for Green Infrastructure (GI). As more and more natural areas are developed for commercial or residential uses, natural stormwater conveyance systems are disrupted therefore affecting the receiving waterbody. GI uses practices that mimic natural systems to manage stormwater. Examples of GI practices include:

- Rain gardens;
- Green roofs;
- Vegetative swales;
- Bioretention areas;
- Rain barrels; and
- Pervious pavement

There are a number of locations in the Red Creek West watershed where GI would prove to be very beneficial to the water quality of the stream. The master planned community of Gananda consist of approximately 9,000 – 10,000 residents in neighborhoods along the Gananda Parkway and Route 350 in the Town of Walworth. This community is within the Walworth MS4 where the town has to meet the six minimum control measures stated above. For the residential and commercial properties currently present, minimum control measure #1 and #2 become the most valuable to protecting the water quality of Red Creek West.



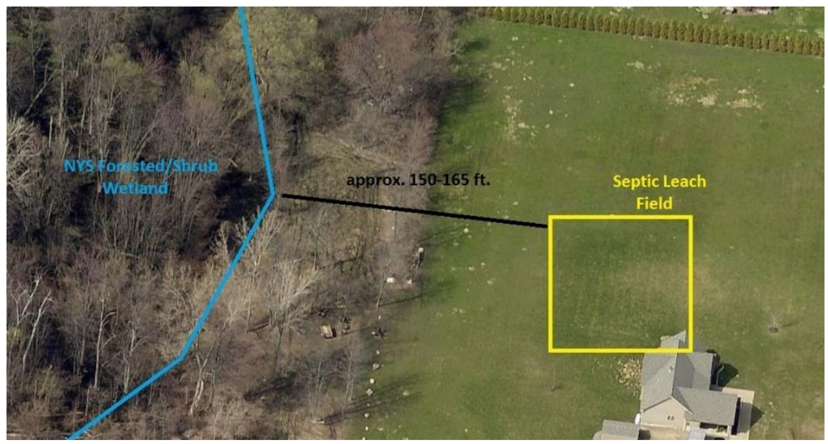
The master planned community of Gananda in Walworth, NY

Educating the public on the importance of GI and how they can use certain practices for their own benefit will improve to overall appeal of the community, while also protecting water resources. For example: A rain garden can be installed to collect and absorb runoff from rooftops, sidewalks, and streets, while increase the 'curb appeal' of a home. The water-tolerant plants of the rain garden also act as habitat and food for birds and pollinators. Neighborhood associations

Rain garden that collects stormwater from the house and from the street. Photo from US EPA.

and community groups could be used to promote, coordinate, and implement GI practice in the residential neighborhoods of the Gananda community. Potential stormwater runoff from the commercial properties in the Gananda community and the Gananda Central School District would result from impervious land cover (parking lots, roofs). Those location with close proximity to surface waterbodies should provide adequate buffer space. Potentially contaminated runoff could also be rerouted away from sensitive areas to locations where it could be absorbed and filtered into the ground. The school district could offer many opportunities for student-led, GI projects as part of a curriculum or as a ‘capstone’ project.

Onsite Wastewater Systems (Septic)



As illustrated in the Land Use section of this report, more than half of the Red Creek West watershed can be considered rural. This may depict that the household residences of the area have onsite wastewater treatment systems, or septic systems. The concentrations of TKN observed in the stream can be considered excessive, and sewage being a possible source, the importance of septic management should not be overlooked.

Septic system failure can be attributed to a number of causes including damaged distribution pipes, saturated soils, improper location, and poor design/installation. A system could be perfectly designed but still contribute excess nutrients to a waterbody simply by being in close a proximity to said waterbody. NYS regulations require that septic leach/absorption fields have to be a minimum of 100 feet away from a waterbodies mean high water mark. These septic systems would pose the immediate attention in identifying contributing sewage sources. Researchers at SUNY College of Brockport and Cornell University have evaluated the use of aerial imagery in identifying and mapping septic fields in NYS watersheds (Richards et al. 2016). Under optimal conditions (no canopy cover or shadows), the researchers were able to identify over 80% of the systems in an observed watershed. They were able to identify systems that were located less than 100 feet from surface waters and produced maps of septic field “hotspots”, or areas of high septic system concentration. As a second component of the experiment, the researchers introduced a DNA-based groundwater tracer into systems where the owner permitted it. The tracers would identify the movement of the effluent towards a waterbody. Results of the second part of this experiment were inconclusive.

Using aerial imagery could be very useful when the conditions are appropriate. A few systems within the Red Creek West watershed were identified using this technique, but further evaluation is needed. In addition, more use of this practice will improve the user's ability and confidence with it.

The lack of an adequate system, lack of routine maintenance, increased density of homes served by septic systems, undersized/overused systems, and the installation on unacceptable land conditions can lead to onsite system failure and water quality impacts.

A typical septic system consists of a septic tank and a drainfield, or soil absorption field. The following are signs that a septic system is failing:

- Wastewater backing up into household drains;
- Bright green, spongy grass on the drainfield, even during dry weather;
- Pooling water or muddy soil around your septic system or in your basement; and
- A strong odor around the septic tank and drainfield.

Successful upkeep of a septic system should include:

- Inspect and pump frequently: The average household septic system should be inspected at least every three years by a septic service professional and is typically pumped every three to five years.
- Water efficiency: Efficient water use can improve the operation of a septic system and reduce the risk of failure.
- Proper waste disposal: Septic systems are designed to process only human waste and bath tissue. Disposing of chemicals and/or pharmaceuticals via toilets or drains can damage the living organisms that digest and treat septic system waste.
- Drainfield maintenance: Avoid driving across or parking on the drainfield. Avoid planting trees near the leach lines. Keep roof drains, sump pumps, and other rainwater drainage systems away from the drainfield area.

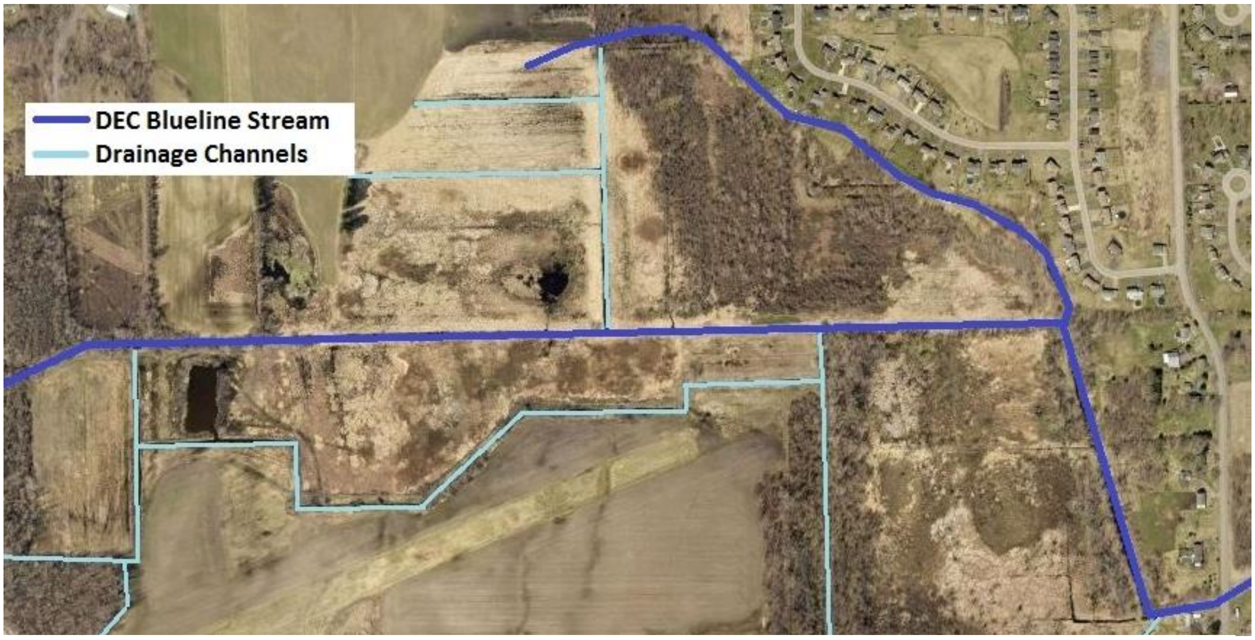
Hydrologic Modification

Hydrologic Modification is the alteration of natural flow of water through a landscape. NYS DEC includes habitat modification in its description of hydrologic modification. Forms of hydrologic modification observed in the Red Creek watershed are channel modification and dams.

Channel modification, sometime referred to as channelization, is stream channel engineering done for the purpose of flood control, navigation, drainage improvement, and reduction of channel migration potential (EPA, 2007). This includes activities such as straightening, widening, deepening, or relocating stream channels and clearing or snagging operations. These types of hydrologic modification typically result in a more uniform channel cross sections, steeper stream gradients, and reduced average pool depths (EPA, 1993). Hydrologic modification also reduces groundwater recharge (EPA, 2007).

Channel modification changes the ability of a natural systems to both absorb hydraulic energy and filter pollutants from surface waters (EPA, 2007). It also alters the rate and pathway of sediment erosion, transport, and deposition (EPA, 1993). Channel modification often results in diminished instream and riparian habitat for fish and wildlife. Channelization accelerates the movement of NPS pollutants to the receiving waterbody. **As stated in the DEC PWL data sheet, this debris (habitat) removal and the removal of channel cover impacts Red Creek West's ecology.**

A typical longitudinal profile of a stream is curved with steep slopes near the headwaters and a gentle slope near the mouth. In the headwaters, the smaller streams are steeper to transport its naturally eroding sediment. As often observed in the headwater and intermediate streams of Wayne County, the slope is altered by drainage practices to make the land more usable. The velocity of the stream then changes, causing significant changes in erosion and sedimentation throughout the stream.



Stream channel has been straightened and drainages ditches are increasing the stream's discharge.

Physical and chemical characteristics of surface waters that may be influenced by channel modification include sedimentation, turbidity, temperature, nutrients, dissolved oxygen, oxygen demand, and contaminants. Sites 14 and 16 both had increase concentration of TSS (14.6 and 16.3 mg/L) and showed signs of channel modification and channelization.

Dams are the most visible form of hydrologic modification. Red Creek West has one dam adjacent to Garlock Sealing Technologies in the Town of Palmyra. The dam is approximately 20 feet wide and made of concrete. The wing walls of the dam extend into the adjacent area approximately 50 feet. Dams were generally built to store and provide water for generating mechanical power, industrial cooling, generating hydroelectric power, irrigation supply, municipal water supply, and impoundment-based recreation (EPA, 2007).

The effects of dams include changes to:

- Hydrology;
- Water quality;
- Habitat; and
- River morphology.

The impoundments created by dams incur what their watershed contributes, including sediment, nutrients, and toxins. Over time, this may cause the impoundment to experience eutrophication. It is believed that the dam structure at Garlock Sealing Technologies has been in place for some time due to the expansion and diversity of wetland plants. As stated above, wetlands can become saturated with nutrients and sediment, causing them to lose the ability to filter and process water. Nonpoint source pollution controls above a dam become very important.

CONCLUSION

Water is one of our most precious natural resources. As populations increase and development expands, it puts a negative strain on our waterbodies. It is imperative that these natural systems are maintained in a way where it can continue to support the ecosystem that it has developed. Watershed management is a tool to evaluate and address how a waterbody responds to human activities.

Development and agricultural practices within the Red Creek West watershed are not likely to end in the near future. Therefore it is extremely important to manage the land uses in the best interest of the stream. Irresponsible management of lands can further degrade the water quality and aquatic ecosystem of Red Creek West and its tributaries. Protection of water resources is dependent on not just a single entity but an entire watershed community. It is vital that the residents and visitors of this watershed be vigilant in protecting this stream for the future. This assessment is intended to summarize water resource issues within the watershed and to improve awareness of them. It is the duty of landowners within the watershed to be stewards of this stream so that future generations may enjoy it.

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APPENDIX I. NYS DEC PRIORITY WATERBODY LIST DATA SHEET

Red Creek and tribs (0704-0033) — MinorImpacts

Waterbody Location Information

Revised: 08/09/2007

Water Index No: Ont 66-12-52-23-24
Hydro Unit Code: 04140201/230 **Str Class:** C
Waterbody Type: River
Waterbody Size: 78.3 Miles
Seg Description: entire stream and tribs

Drain Basin: Oswego-Seneca-Oneida
Seneca/Clyde Rivers
Reg/County: 8/Wayne Co. (59)
Quad Map: PALMYRA (I-12-4)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Aquatic Life	Stressed	Known
Recreation	Stressed	Known

Type of Pollutant(s)
Known: ALGAL/WEED GROWTH, NUTRIENTS (phosphorus), Silt/Sediment
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: HABITAT MODIFICATION
Suspected: AGRICULTURE
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 4 (Source Identified, Strategy Needed)
Lead Agency/Office: ext/WQCC
TMDL/303d Status: n/a

Resolution Potential: Medium

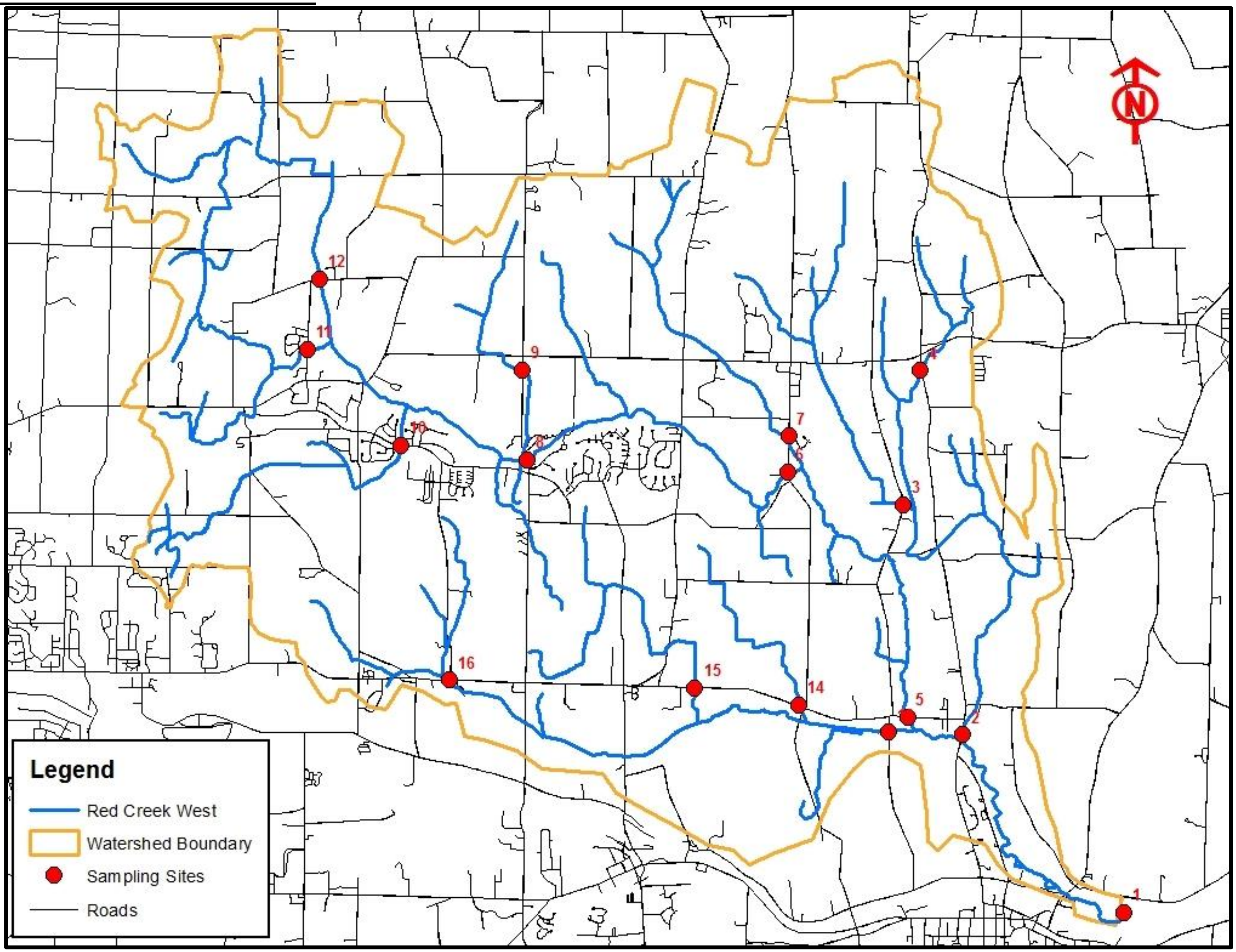
Further Details

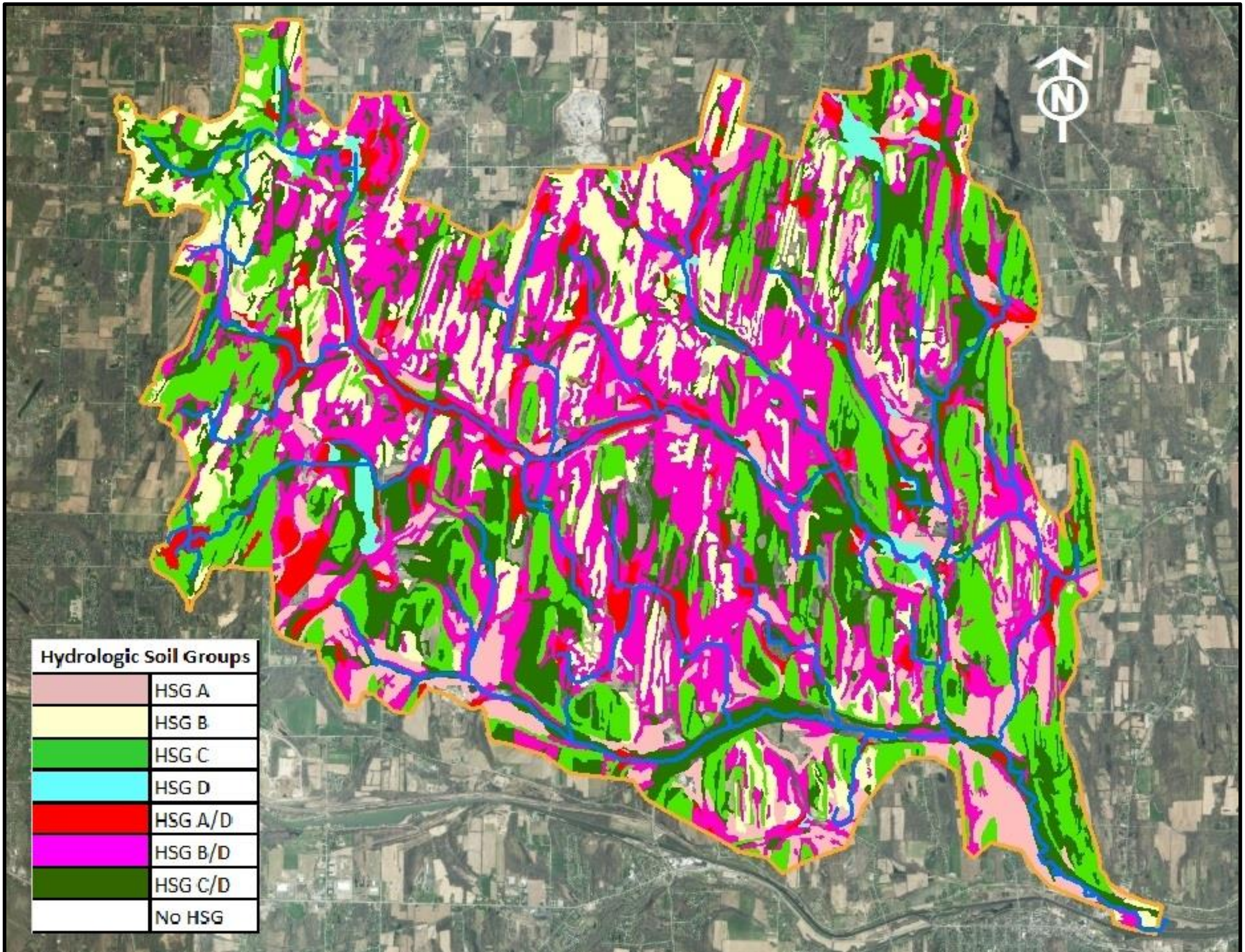
Aquatic life support and recreational uses in Red Creek are known to experience minor impacts due to nonpoint nutrients and silt/sediment. Aquatic weed growth also contributes to the impacts.

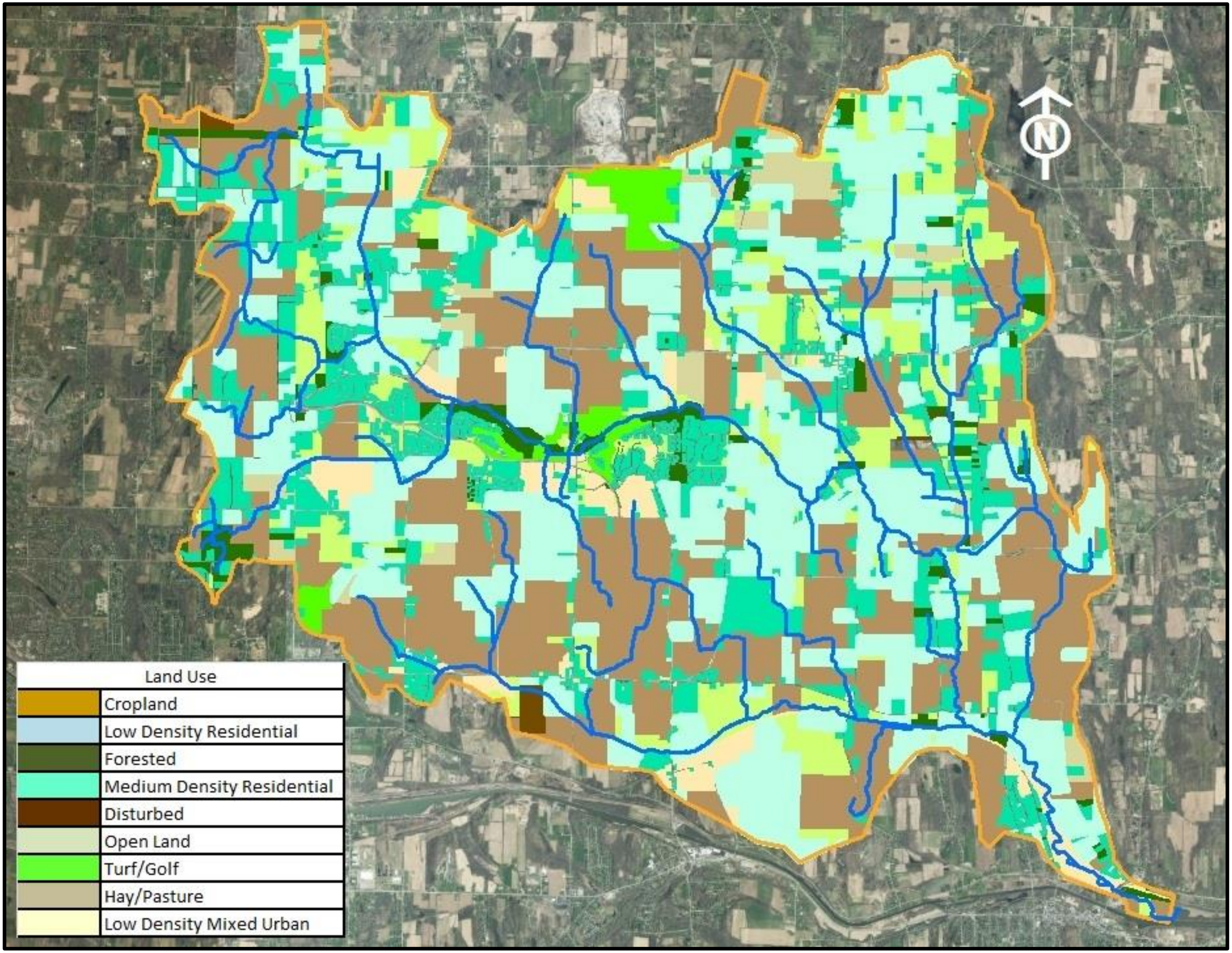
A biological (macroinvertebrate) assessment of Red Creek in Palmyra (at Maple Avenue) was conducted in 2001. Sampling results indicated slightly impacted water quality conditions. The stream carried an abundance of aquatic weeds (duckweed) indicating ponded waters upstream. The ponded water likely influenced the sample. Specific conductance at the site was quite high also. Although aquatic life is supported in the stream, nutrient biotic evaluation indicates/suggests the level of eutrophication is sufficient to stress/threaten aquatic life support. (DEC/DOW, BWAM/SBU, June 2005)

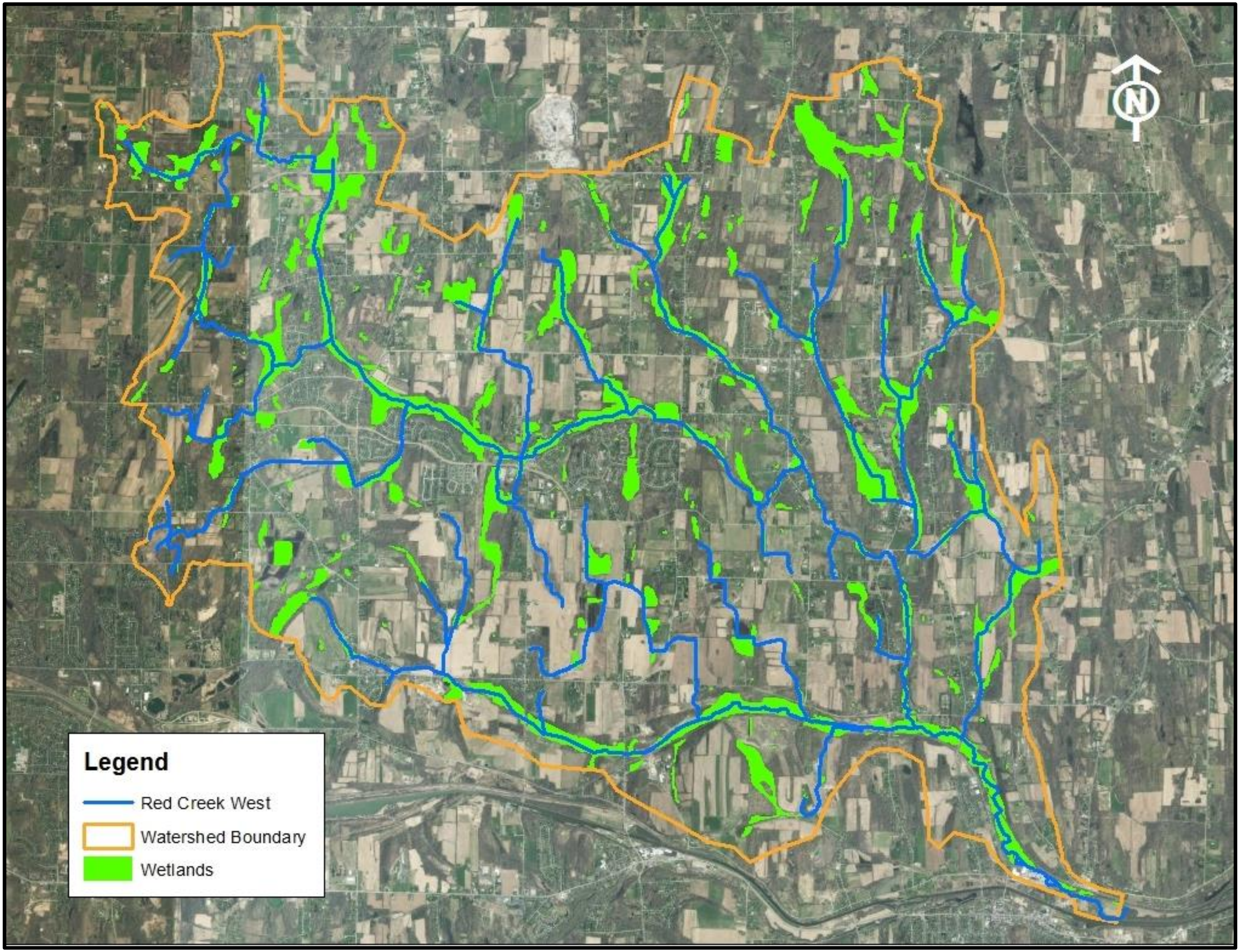
This segment includes the entire stream and all tribs. The waters of the stream are Class C. Tribs to this reach/segment, including Black Creek (-9) are Class C,C(T).

APPENDIX II. DETAILED MAPS




N
Hydrologic Soil Groups
HSG A
HSG B
HSG C
HSG D
HSG A/D
HSG B/D
HSG C/D
No HSG


N
Land Use
Cropland
Low Density Residential
Forested
Medium Density Residential
Disturbed
Open Land
Turf/Golf
Hay/Pasture
Low Density Mixed Urban


Legend
Red Creek West
Watershed Boundary
Wetlands
N

APPENDIX III. RED CREEK WEST WATER QUALITY DATA

RCW 1

Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	56.1	1.28	0.35	0.93	929.10	9.5
7/14/2014	45.0	0.25	0.25	0.00	0.00	24.3
8/18/2014	54.4	0.58	0.26	0.32	322.60	17.3
9/18/2014	93.6	0.10	0.10	0.00	0.00	6.7
10/8/2014	89.5	0.04	0.04	0.00	0.00	4.3
11/17/2014	52.1	1.82	0.11	1.70	1704.10	2.0
12/15/2014	96.5	1.75	0.17	1.58	1583.30	3.7
1/21/2015	75.1	1.82	0.27	1.55	1549.20	4.8
3/16/2015	65.1	1.87	0.21	1.66	1658.30	7.0
4/13/2015	49.0	0.98	0.19	0.79	792.20	17.0
5/12/2015	130.1	1.64	0.07	1.57	1568.40	18.0
6/22/2015	111.3	1.58	0.29	1.29	1289.50	12.2
MEAN	76.5	1.14	0.19	0.95	949.73	10.6

RCW 2

Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	72.7	1.32	0.56	0.76	763.20	11.0
7/14/2014	51.9	0.30	0.30	0.00	0.00	4.3
8/18/2014	46.3	0.69	0.07	0.62	619.00	8.0
9/18/2014	71.9	0.05	0.05	0.00	0.00	2.3
10/8/2014	56.1	0.08	0.08	0.00	0.00	6.0
11/17/2014	37.3	2.02	0.13	1.90	1895.10	1.7
12/15/2014	113.1	1.99	0.13	1.86	1860.50	5.8
1/21/2015	79.7	1.54	0.12	1.42	1417.60	3.7
3/16/2015	80.6	1.96	0.10	1.86	1855.60	3.3
4/13/2015	15.7	0.27	< 0.02	0.25	250.00	3.7
5/12/2015	138.2	1.31	ND	1.31	1310.00	14.5
6/22/2015	128.5	1.22	0.14	1.08	1079.00	8.0
MEAN	74.3	1.06	0.17	0.89	894.00	6.0

RCW 3

Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	53.7	1.19	0.19	1.00	1000.90	8.8
7/14/2014	33.0	0.18	0.18	0.00	0.00	1.5
8/18/2014	14.9	0.59	0.07	0.52	520.20	6.8
9/18/2014	141.4	0.04	0.04	0.00	0.00	6.0
10/8/2014	28.6	< 0.02	ND	< 0.02	< 20.00	2.0
11/17/2014	40.2	1.69	ND	1.69	1690.00	2.5
12/15/2014	35.9	1.91	0.03	1.88	1879.70	1.8
1/21/2015	25.8	1.62	0.08	1.54	1542.40	2.5
3/16/2015	30.0	1.70	0.06	1.64	1642.60	3.7
4/13/2015	18.9	0.45	ND	0.45	450.00	3.0
5/12/2015	115.3	1.57	ND	1.57	1570.00	5.7
6/22/2015	112.3	1.68	0.07	1.61	1612.60	4.0
MEAN	54.2	1.15	0.09	1.06	1057.73	4.0

RCW 4

Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	44.4	1.18	0.09	1.09	1094.60	13.0
7/14/2014	25.6	0.05	0.05	0.00	0.00	4.0
8/18/2014	59.0	0.58	0.04	0.54	535.00	5.5
9/18/2014	70.1	< 0.02	< 0.02	0.00	0.00	11.0
10/8/2014	114.6	< 0.02	< 0.02	0.00	0.00	20.3
11/17/2014	31.2	1.69	ND	1.69	1690.00	6.0
12/15/2014	23.7	1.62	ND	1.62	1620.00	3.3
1/21/2015	13.9	1.68	ND	1.68	1680.00	4.1
3/16/2015	34.6	1.48	0.01	1.47	1465.20	3.5
4/13/2015	2.4	0.19	ND	0.19	190.00	2.2
5/12/2015	51.9	1.16	ND	1.16	1160.00	6.2
6/22/2015	67.0	1.05	0.04	1.01	1010.20	12.0
MEAN	44.9	1.07	0.05	1.02	1022.38	7.6

RCW 5						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	95.5	1.38	0.23	1.15	1149.90	5.3
7/14/2014	41.8	0.28	0.28	0.00	0.00	2.5
8/18/2014	59.2	0.78	0.21	0.57	570.20	5.7
9/18/2014	93.0	0.13	0.13	0.00	0.00	5.7
10/8/2014	97.0	0.04	0.04	0.00	0.00	3.3
11/17/2014	97.2	1.93	0.09	1.83	1834.50	1.5
12/15/2014	41.8	2.01	0.10	1.91	1914.60	0.8
1/21/2015	32.1	1.54	0.14	1.40	1403.60	5.5
3/16/2015	92.6	1.80	0.11	1.68	1684.10	12.0
4/13/2015	41.9	0.62	0.04	0.59	586.00	7.0
5/12/2015	183.2	1.76	0.05	1.71	1710.70	23.8
6/22/2015	139.0	1.52	0.14	1.38	1379.00	5.8
MEAN	84.5	1.15	0.13	1.02	1019.38	6.6

RCW 6						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	94.5	1.33	0.18	1.15	1149.50	5.3
7/14/2014	88.0	0.28	0.28	0.00	0.00	3.0
8/18/2014	65.9	0.60	0.20	0.40	397.80	5.2
9/18/2014	51.1	0.08	0.08	0.00	0.00	0.0
10/8/2014	54.2	0.05	0.05	0.00	0.00	5.0
11/17/2014	244.0	2.24	0.10	2.14	2143.10	1.2
12/15/2014	809.9	1.97	0.10	1.87	1874.60	5.0
1/21/2015	654.6	1.77	0.09	1.68	1684.00	9.1
3/16/2015	108.9	1.83	0.12	1.71	1708.50	11.8
4/13/2015	90.4	0.83	0.03	0.80	801.80	9.5
5/12/2015	220.7	1.36	ND	1.36	1360.00	26.5
6/22/2015	200.8	1.33	0.10	1.23	1232.70	5.4
MEAN	223.6	1.14	0.12	1.02	1019.30	7.2

RCW 7						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	40.4	1.13	0.15	0.98	977.90	5.8
7/14/2014	38.5	0.14	0.14	0.00	0.00	4.0
8/18/2014	21.6	0.55	0.09	0.46	462.20	8.0
9/18/2014	45.2	< 0.02	< 0.02	0.00	0.00	1.3
10/8/2014	97.0	0.54	0.54	0.00	0.00	3.3
11/17/2014	25.8	1.78	0.07	1.72	1716.10	2.5
12/15/2014	30.0	1.66	0.11	1.55	1546.00	4.0
1/21/2015	21.1	1.79	0.15	1.64	1636.80	4.5
3/16/2015	38.6	1.55	0.15	1.40	1403.00	4.5
4/13/2015	10.8	0.37	< 0.02	0.35	350.00	3.7
5/12/2015	226.8	1.38	ND	1.38	1380.00	11.0
6/22/2015	76.3	0.97	0.12	0.85	852.00	4.4
MEAN	56.0	1.08	0.17	0.91	910.05	4.7

RCW 8						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	113.6	1.07	0.10	0.97	971.20	2.8
7/14/2014	233.5	0.03	0.03	0.00	0.00	2.0
8/18/2014	134.3	0.83	0.11	0.72	723.40	5.3
9/18/2014	39.5	0.04	0.04	0.00	0.00	5.3
10/8/2014	57.1	0.08	0.08	0.00	0.00	7.7
11/17/2014	98.1	1.81	ND	1.81	1810.00	2.7
12/15/2014	201.2	1.52	0.02	1.50	1499.00	6.7
1/21/2015	178.5	1.31	ND	1.31	1310.00	7.4
3/16/2015	272.8	1.55	0.10	1.45	1447.80	5.8
4/13/2015	107.8	0.42	ND	0.42	420.00	3.7
5/12/2015	145.7	1.29	ND	1.29	1290.00	11.5
6/22/2015	348.7	0.95	0.02	0.93	930.90	4.4
MEAN	160.9	0.91	0.06	0.85	846.80	5.4

RCW 9						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	37.6	1.38	1.17	0.21	209.90	7.5
7/14/2014	116.6	0.82	0.82	0.00	0.00	< 0.2
8/18/2014	148.2	0.83	0.59	0.24	235.80	14.5
9/18/2014	114.8	0.57	0.57	0.00	0.00	8.3
10/8/2014	117.5	0.44	0.44	0.00	0.00	33.0
11/17/2014	62.6	2.50	0.47	2.04	2036.10	3.2
12/15/2014	41.4	2.11	0.22	1.89	1887.50	2.5
1/21/2015	29.3	1.85	0.39	1.46	1456.00	4.2
3/16/2015	86.2	2.10	0.02	2.08	2079.30	3.7
4/13/2015	51.9	1.57	0.12	1.45	1449.80	12.8
5/12/2015	126.4	1.87	0.17	1.70	1699.30	21.2
6/22/2015	143.0	1.99	0.85	1.14	1138.30	14.0
MEAN	89.6	1.50	0.49	1.02	1016.00	11.3

RCW 10						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	365.3	1.37	0.05	1.32	1323.60	6.0
7/14/2014	664.3	0.09	0.09	0.00	0.00	10.0
8/18/2014	429.7	0.77	0.09	0.68	682.60	10.8
9/18/2014	120.0	0.10	0.10	0.00	0.00	NA
10/8/2014	127.1	0.02	0.02	0.00	0.00	16.3
11/17/2014	109.7	2.08	0.09	1.98	1984.30	1.3
12/15/2014	42.6	2.09	0.08	2.01	2013.20	0.7
1/21/2015	38.8	1.89	0.22	1.67	1666.80	4.1
3/16/2015	182.5	2.17	0.21	1.96	1956.40	4.2
4/13/2015	86.2	0.86	0.04	0.81	814.10	4.0
5/12/2015	181.2	1.77	ND	1.77	1770.00	6.5
6/22/2015	517.6	1.87	0.07	1.80	1798.00	9.4
MEAN	238.7	1.26	0.10	1.16	1159.68	6.7

RCW 11						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	62.5	1.51	0.68	0.83	825.90	5.0
7/14/2014	126.0	0.33	0.33	0.00	0.00	7.8
8/18/2014	70.2	0.50	0.27	0.23	229.00	7.5
9/18/2014	27.9	0.44	0.44	0.00	0.00	12.3
10/8/2014	94.6	< 0.02	ND	< 0.02	#VALUE!	17.3
11/17/2014	30.8	1.85	0.04	1.82	1816.90	1.7
12/15/2014	43.1	1.77	0.10	1.67	1665.30	2.5
1/21/2015	32.4	1.77	0.08	1.69	1686.80	3.2
3/16/2015	57.2	1.47	0.18	1.28	1284.10	4.0
4/13/2015	15.7	0.38	0.01	0.37	370.60	4.2
5/12/2015	162.0	1.33	ND	1.33	1330.00	18.5
6/22/2015	132.4	1.22	0.30	0.92	920.30	9.4
MEAN	71.2	1.14	0.24	0.90	898.34	7.8

RCW 12						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	152.9	1.34	0.11	1.23	1232.10	7.3
7/14/2014	79.2	0.26	0.26	0.00	0.00	2.0
8/18/2014	88.2	0.58	0.03	0.55	545.00	9.5
9/18/2014	20.1	0.23	0.23	0.00	0.00	4.7
10/8/2014	144.1	< 0.02	ND	< 0.02	#VALUE!	13.0
11/17/2014	54.7	2.03	0.05	1.99	1987.30	1.2
12/15/2014	107.5	1.84	0.13	1.71	1710.50	2.3
1/21/2015	88.4	1.56	0.13	1.43	1426.40	4.1
3/16/2015	134.7	1.88	0.20	1.68	1682.60	4.2
4/13/2015	82.0	0.49	0.04	0.45	446.60	2.7
5/12/2015	106.9	1.44	0.05	1.39	1386.50	19.5
6/22/2015	388.0	1.10	0.05	1.05	1051.00	7.4
MEAN	120.6	1.16	0.12	1.04	1042.55	6.5

RCW 13						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	41.5	1.27	0.70	0.57	572.80	5.3
7/14/2014	19.8	0.47	0.44	0.03	34.90	2.0
8/18/2014	45.8	0.51	0.45	0.06	64.20	17.3
9/18/2014	37.5	0.23	0.23	0.00	0.00	4.7
10/8/2014	48.5	0.17	0.17	0.00	0.00	3.3
11/17/2014	32.3	2.12	0.33	1.79	1789.30	2.8
12/15/2014	122.9	1.86	0.42	1.44	1436.00	13.7
1/21/2015	98.9	2.17	0.52	1.65	1652.80	10.2
3/16/2015	63.4	2.56	0.48	2.07	2074.80	16.0
4/13/2015	27.0	1.08	0.42	0.65	654.70	9.5
5/12/2015	104.6	1.38	0.09	1.30	1295.60	27.5
6/22/2015	98.2	1.05	0.56	0.49	485.80	11.8
MEAN	61.7	1.24	0.40	0.84	838.41	10.3

RCW 14						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	47.1	2.42	2.21	0.21	209.60	6.0
7/14/2014	15.9	2.22	2.22	0.00	0.00	3.3
8/18/2014	16.4	0.96	0.96	0.00	0.00	15.8
9/18/2014	7.3	0.85	0.85	0.00	0.00	4.3
10/8/2014	123.6	0.59	0.59	0.00	0.00	11.0
11/17/2014	64.1	2.53	0.70	1.83	1829.50	17.2
12/15/2014	38.8	1.74	0.34	1.40	1402.80	12.5
1/21/2015	26.7	2.00	0.77	1.23	1225.20	25.9
3/16/2015	63.8	2.17	0.41	1.77	1765.10	22.8
4/13/2015	28.9	1.97	1.13	0.83	833.80	12.0
5/12/2015	126.3	2.26	0.70	1.56	1562.50	32.0
6/22/2015	25.9	1.92	1.26	0.66	661.20	12.0
MEAN	48.7	1.80	1.01	0.79	790.81	14.6

RCW 15						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	44.7	1.19	0.77	0.42	420.90	< 0.2
7/14/2014	61.6	0.31	0.31	0.00	0.00	1.5
8/18/2014	61.6	0.96	0.94	0.02	22.60	6.8
9/18/2014	90.5	0.19	0.19	0.00	0.00	2.7
10/8/2014	130.8	0.06	0.06	0.00	0.00	3.7
11/17/2014	32.1	2.44	0.70	1.74	1736.30	1.2
12/15/2014	49.7	2.20	0.91	1.29	1292.40	2.2
1/21/2015	43.9	2.97	0.83	2.14	2139.20	7.7
3/16/2015	85.9	3.40	0.96	2.44	2436.00	12.0
4/13/2015	45.1	1.78	0.78	1.00	995.70	7.0
5/12/2015	236.9	1.98	0.45	1.53	1531.10	14.0
6/22/2015	79.9	1.57	1.12	0.45	446.90	2.6
MEAN	80.2	1.59	0.67	0.92	918.43	5.6

RCW 16						
Date	TP (µg/L)	TN (mg/L)	NOx (mg/L)	TKN (mg/L)	TKN (µg/L)	TSS (mg/L)
6/16/2014	161.0	2.22	1.97	0.25	254.10	10.8
7/14/2014	115.1	1.37	1.37	0.00	0.00	6.8
8/18/2014	61.8	1.22	1.22	0.00	0.00	10.0
9/18/2014	18.8	0.46	0.46	0.00	0.00	6.0
10/8/2014	157.4	0.19	0.19	0.00	0.00	18.7
11/17/2014	61.5	3.10	0.70	2.40	2402.30	9.3
12/15/2014	105.2	2.61	0.61	2.00	2003.10	12.0
1/21/2015	99.2	2.17	0.88	1.29	1288.80	22.4
3/16/2015	76.1	2.68	0.66	2.02	2020.30	64.8
4/13/2015	48.0	1.58	0.79	0.79	793.30	5.8
5/12/2015	114.3	1.74	0.30	1.44	1436.90	23.7
6/22/2015	248.2	1.26	0.98	0.28	284.10	5.0
MEAN	105.5	1.72	0.84	0.87	873.58	16.3