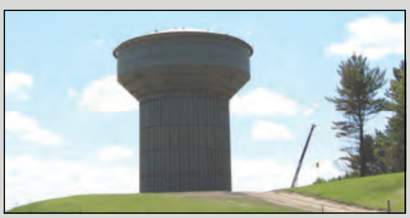
Rochester Water Primer

An Introduction to our Water Resources

Natural Water Features

Rochester's Water History

Local Geology



Groundwater Resources

Storm Water Management

Wastewater Treatment

Constructed Water Features

CITY OF ROCHESTER MINNESOTA

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Dear Water Users:

Each day, we turn on our faucets and we have plenty of clean water for drinking, showering, cooking, and cleaning. We flush the toilet and wastewater goes away. When it rains, storm water is carried away in pipes and channels to protect our property. Since 1985, treating dirty storm water has been part of every new development in Rochester. During major storms, several reservoirs store water to prevent flooding. Because these City-provided services are so reliable, they almost seem invisible and we have come to take clean water, in just the right amount, for granted.

Water is the basis for life and it is needed for most of life's activities. It is a limited resource that continuously recycles both locally and globally. Did you know that most of earth's water is salt water? Only about 2.5% is freshwater and about two-thirds of that (or 2% of all water) is unavailable because it is stored as solid ice in glaciers! That means only 1% of all water is available from surface and groundwater sources as fresh, liquid water. Unfortunately, some of that water is polluted to the point where it does not meet water quality standards. To keep the water resources that we need clean and plentiful, each of us needs to make choices that protect the quality and availability of water.

The Rochester Water Primer will help us understand the many ways we use and impact water – right here in Rochester, today and in the future. Learning about water will help us become citizens that take action to protect the City's surface and groundwater resources each and every day.

Welcome to the world of water in Rochester, Minnesota!

Rochester Mayor Ardell Brede

Sincerely,

Ardell Brede,

Mayor, City of Rochester

Introduction

What is this document?

A primer, by definition, is a book that covers the basic elements of a subject. This is the "Rochester Water Primer". It provides **locally relevant information** about most water topics that impact people and the environment in Rochester. It was designed to complement "Minnesota Water Ways – A Minnesota Water Primer and Project WET Companion" (www.dnr.state.mn.us/projectwet/waterways).

As you use this reference document, you will learn basic, and sometimes surprising, information about the many facets of water in Rochester. Hopefully, you will be inspired to responsibly use and protect our water resources as a result of your new knowledge. Discover what you can and should be doing to make sure Rochester has clean and plentiful water today and in the future. Join the ranks of Rochester citizens who are "Keeping it Clean" in Rochester.

Who should use it?

Everyone that uses water in Rochester can benefit from this information, but particular audiences that will be drawn to use it include:

- **teachers**, of all grade levels, needing local water data to incorporate in their existing curricula
- **students** developing environmental service learning, science fair, or extra credit projects
- **scouts** completing requirements for environmental badges or planning community projects
- **volunteers** who want to improve Rochester's environment
- **parents** that homeschool their children
- **naturalists** and educators at local nature and science centers
- **citizens** that want to know more about storm water management, wastewater treatment, and water supply protection
- **elected officials** that want to make informed decisions about water infrastructure projects
- **water management agency staff** who need Rochester-specific water facts in their work
- **visitors** who are curious about Rochester's surroundings

How can I provide feedback?

Water issues and data are not static, they are continuously evolving. This Primer is not all inclusive. Individuals and groups are encouraged to keep this document alive and interesting by making suggestions like these:

- identify factual errors
- fill data gaps
- update data so it is current
- add ideas for classroom activities
- suggest service learning projects for students
- describe what you like or don't like about it

Suggestions should be shared with Megan Moeller, Rochester Storm Water Educator, at mmoeller@rochestermn.gov for consideration during the preparation of the next edition.

Rochester's Water Facts

- **Drinking Water:**
  - Municipal Wells – 33
  - Pumping Capacity - 35,882,000 gallons per day
  - Pumping Daily Average (2012) – 13,183,000 gallons per day
  - Highest Use Record– 30,229,000 gallons in one day on August 1, 2007
  - Water Customers – 37,919
  - Water Storage: Capacity 15.2 million gallons
  - Water Storage: Facilities – 20
  - Length of Water Pipes – 573.6 miles
  - Volume of Water Pipes – 9,800,000 gallons
  - Fire Hydrants – 6,799
  - Values – 14,903

- **Wastewater Treatment:**
  - Treatment Capacity – 23.85 million gallons per day
    - High Purity Oxygen Plant – 19.1 million gallons per day
    - Aeration Basin Complex Plant – 4.75 million gallons per day
  - Average Treatment - 13 million gallons per day
  - Time to Treat – 24 hours
  - Time to Travel From Downtown to the treatment plant – about 2 hours
  - Length of Sanitary Sewer Pipes – 505.8 miles or 2,670,520 feet
  - Length of Trunk (12" or larger pipe) – 488,320 feet
  - Range of Pipe Diameters – 8 to 84 inches in diameter (4" and 6" older pipes are still in service in a few areas)
  - Energy Production from Biogas – meets 40 % of the treatment plant's requirements, saving about $500,000 annually
  - Annual Quantity of 6% Biosolids Produced – 12,000,000 gallons or 3000 dry tons
  - Permitted Acreage for Biosolids Dispersal – 6,000 acres
  - Biosolids Dispersal 2012 – 2,000 acres
  - Fertilizer Value of Biosolids - $300 per acre

- **Storm Water:**
  - Catch Basins: 15,692
  - Additional Storm Sewer Structures 14,857
  - Length of Storm Sewer – 417.3 miles or 2,203,263 feet
  - Water quality treatment ponds -77
  - Raingardens - 53

- **Flood Control**
  - Number of storage reservoirs – 7
  - Length of channel modifications – 6.9 miles
  - Length of levees - 1.3 miles
  - Level of protection – 160 year storm event for most of the City, 100 year storm event for Cascade Creek

Rochester's 1929 Water System Versus Today's System:

	Year 1929	Year 2012
City Population	21,523	108,992 (estimated)
Water Main	38.75 miles	573.6 miles
# of Water Meters	3,650	37,919
Sanitary Sewer	38.19 miles	505.8 miles
Storm Sewer	9.2 miles	417.3 miles

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Acknowledgements: Special thanks go to the following people and organizations for their help in creating this document:

Barb Huberty - Rochester Public Works Department, editor

Craig Bloomer – Minnesota Department of Natural Resources

David Lane – Rochester Water Reclamation Plant

Deb Las – Rochester Public Works Department and ISD 535, primary author

Gary Neumann – City of Rochester, Assistant Administrator

History Center of Olmsted County

Jeff Green - Minnesota Department of Natural Resources

Jeff Morton – Rochester Park and Recreation Department

Jim Loehr - Rochester Public Works Department

Katherine Logan – Minnesota Pollution Control Agency

Kevin Strauss – Zumbro Watershed Partnership

Matt Crawford – Rochester Public Works Department

Megan Moeller - Rochester Public Works Department

Mike Easley – Rochester Public Works Department

Mike Kraszewski – Rochester Public Works Department

Nels Rasmussen – Rochester Public Works Department

Pam Meyer - Quarry Hill Nature Center

Skip Langer –Olmsted County Soil & Water Conservation District

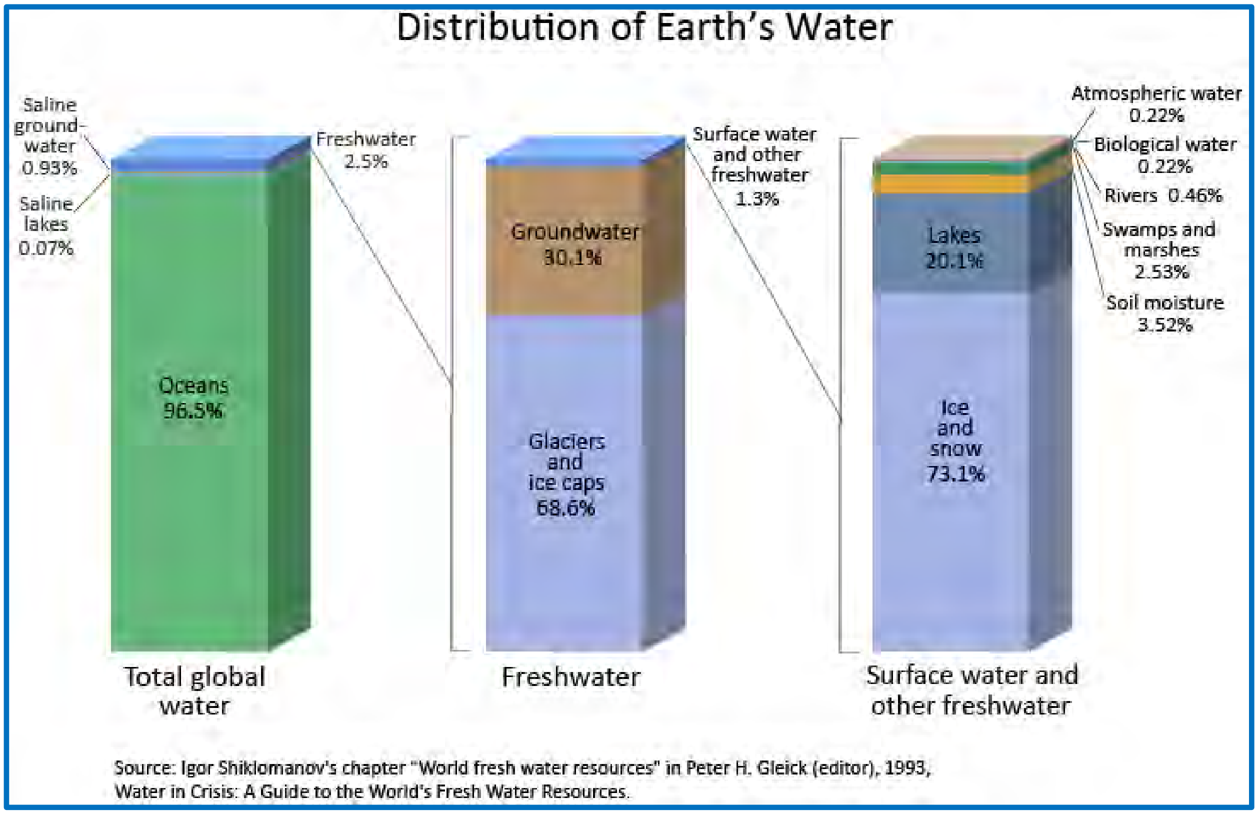
Stefan Theimer – Cascade Meadows & Environmental Learning Center

Terry Lee – Olmsted County Environmental Resources Department

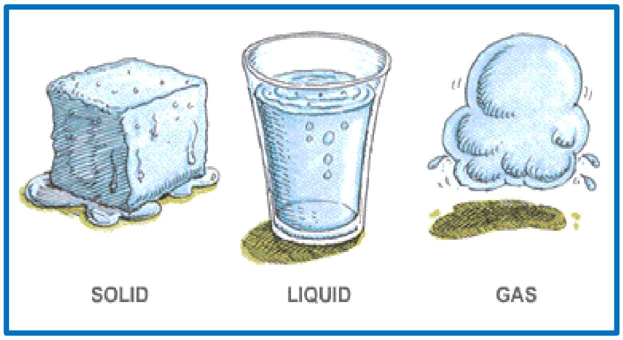
Todd Osweiler – Rochester Public Utilities

Chapter 1 - Rochester's Water Cycle

Water is the basis for life. Water is a limited resource that recycles both locally and globally. Most of the water on earth is salt water, with less than 3% being fresh. About two thirds of fresh water (about 2% of all water) is stored as a solid in ice and glaciers. That leaves only about 1% of the total water on earth as fresh, liquid water. Contamination of fresh water impacts human and aquatic life. Pollution prevention and water conservation are needed to protect our limited freshwater resources.



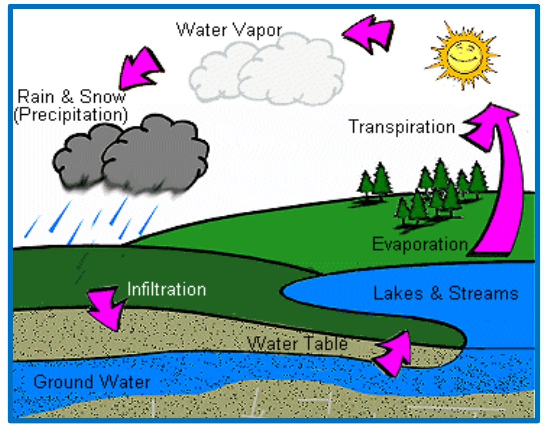
Water is found in three phases, or states, of matter: solid, liquid, or gas. Water may change from state to state depending on seasonal temperatures and where water is found within the water cycle. Another name for the water cycle is the hydrologic cycle. Hydro refers to the Greek word for water. Hydro also relates to the two hydrogen atoms that bond with a single oxygen atom to create a molecule of water. Cycle refers to a series of reoccurring events.



Source: Fairfax, VA

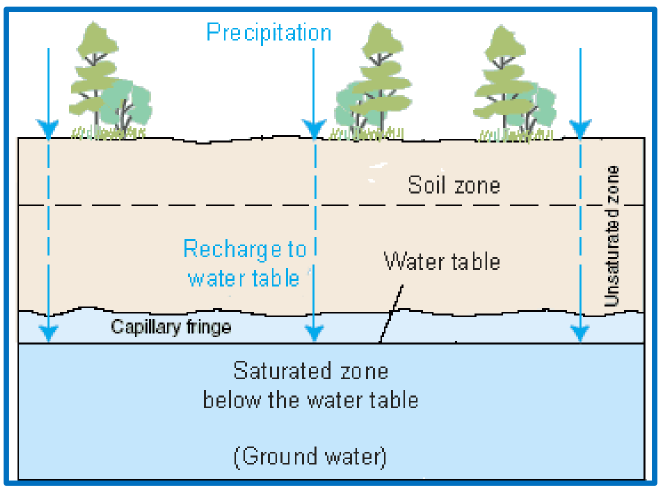
In general, the hydrologic cycle involves water moving through a series of events:

- liquid water evaporating to water vapor(in winter, snow and lake ice can change to water vapor by a process called sublimation)
- liquid water being converted to water vapor by plants and released, or transpired, to the air
- water vapor condensing to form liquid rain or solid snow or ice
- rain, snow or ice falling as precipitation
- rain or snowmelt running across the land to join water bodies, like lakes and streams runoff or lake and stream water infiltrating into the soil to become groundwater



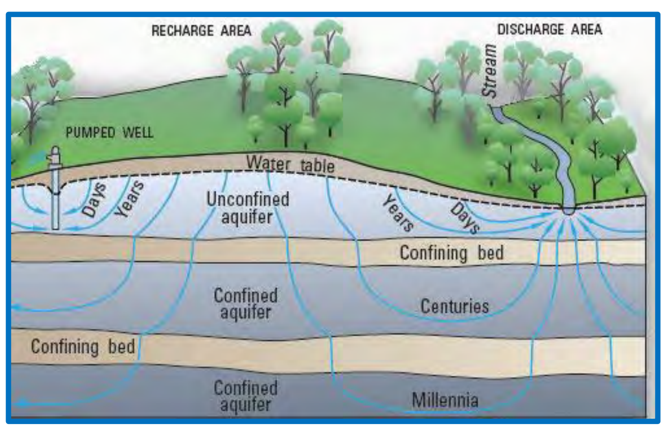
Source: Environmental Education for Kids

Water may not flow through the water cycle in the order listed above. Think of the variable routes water can take in the cycle. Water that falls to the ground may evaporate quickly to return to the atmosphere before infiltrating or reaching a lake. The water vapor may condense on small particles to form clouds and travel long distances before falling back to the Earth as precipitation. Some water will filter into the ground and cling to particles of soil where plant roots may capture it through osmosis and use it for photosynthesis and growth. Some water may travel deeper through the cracks and spaces of the soil and rock. The water-filled zone is called the zone of saturation, or groundwater. The water table is the name given to the top of this zone, with the unsaturated zone lying above it. The water table is not fixed, but rises as water fills the spaces between rock particles or lowers as water leaves the rock to fill a stream or lake or when it is pumped out at a well. Sometimes the surface of a lake or stream is also the top of the groundwater table. In these cases, the water table is at the land surface, not underground!



Source: US Geological Survey

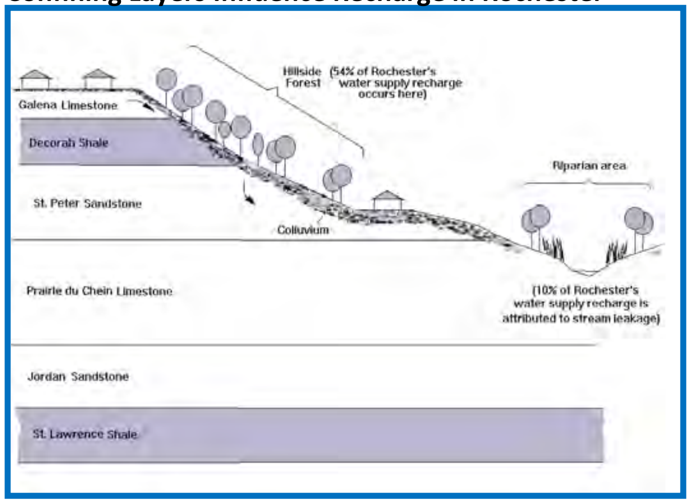
Water can move through the fractures and pores of bedrock, like the limestone and sandstone formations found underneath Rochester. Rock formations that hold water are called aquifers. If a rock type does not allow water to pass easily through it, it is said to be impermeable and is called a confining bed.



Source: US Geological Survey

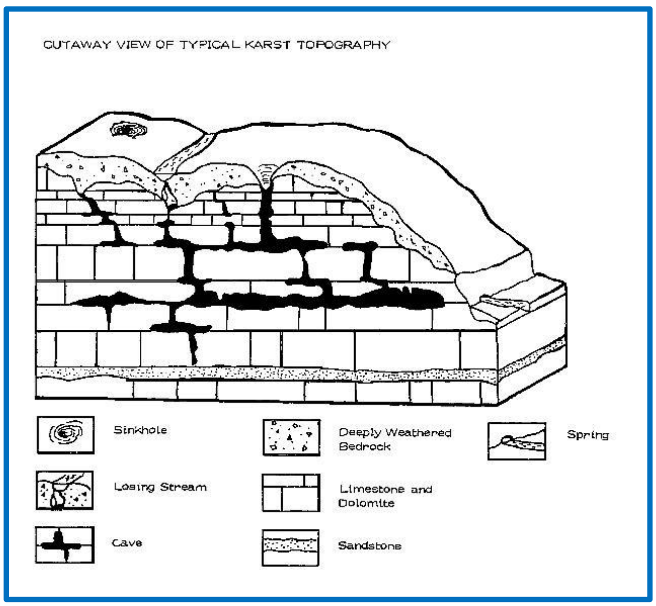
In Rochester, the uppermost confining bed is the Decorah shale. Water can sometimes leak very slowly down through a confining layer, but will be more likely to move along its top until it can seep out at a hillside edge or road cut. The process of water infiltrating from the land surface to form groundwater is known as recharge. Groundwater can be recharged from rain, snowmelt, or surface water features like streams and lakes. When groundwater returns to the land surface to supply rivers, streams, lakes and wetlands, the process is called discharge. A spring is an example of a discharge focused in one area and a seep is groundwater oozing out over a larger area.

Confining Layers Influence Recharge in Rochester



Source: Hydrogeology adapted from Delin, USGS, 1991

Rochester's geology is known as "karst", which has distinctive landforms and hydrology. It is characterized by disappearing streams, springs, caves, and sinkholes that form in limestone bedrock. These karst features form because limestone, a carbonate rock, is easily dissolved by rainwater that mixes with carbon dioxide in the air to form a weak carbonic acid. Although the limestone rock itself is fairly impermeable, water can pass through it quickly via interconnected fissures, fractures, and joints. These spaces are great for water storage and movement, which makes limestone a highly productive aquifer. But those spaces are also conduits for contaminants to travel quickly between the land surface and groundwater. Topsoil that might otherwise filter surface impurities is thin in karst areas, thus compounding the vulnerability of groundwater contamination.



Source: Missouri Speleological Survey

Recharge - Water moving from the surface to groundwater

Discharge - Water moving from the groundwater to the surface

KEY TERMS:

- **Evapotranspiration or Transpiration** – Water turns into a gas as it returns to the atmosphere as a result of evaporation from plants. This process requires energy.
- **Evaporation** – Water changes from a liquid into a solid. This process requires energy.
- **Condensation** – Water changes from a gas to a solid. This process releases energy.
- **Precipitation** – Water falls to the Earth, most commonly as rain or snow.
- **Infiltration** – Water soaks into the underlying soil and bedrock.
- **Groundwater** – Water below the Earth's surface, where all the spaces are filled with water.
- **Run-Off** – Water that travels on the land surface.
- **Surface Water** – Water that is not underground. It includes run-off and water bodies like rivers, wetlands, and lakes.

Water travels all around planet Earth as part of the water cycle. Some water moves quickly and other water can get stuck somewhere for thousands of years. Think about how long water may be trapped in the polar ice caps. If the climate warms and the ice caps melt, that water will be released back into the water cycle for the first time in thousands of centuries.

Rochester has tested the age of its ground water and found that some wells extract young water that is only a few decades old, while others pump out ancient water that was probably left here by the glaciers over 10,000 years ago. To age date water, scientists analyze water to see how much tritium (^3H or hydrogen-3) is in it. Tritium is a radioactive isotope of hydrogen that forms during the nuclear decay process. Naturally occurring tritium is very rare on Earth. Atmospheric level of tritium started rising in 1945 when the United States began testing nuclear bombs. Nuclear testing peaked in 1963. Tritium from the atmosphere can replace H_2 in water, joining the water cycle as precipitation. Higher tritium levels in water are an indication of younger water. Rochester's young water is recharged within about a 20 mile radius. Ancient water recharges from much farther distances.

While the process is generally the same, the water cycle may look different at other places on the globe. For example, rain forests receive a lot of precipitation and deserts hardly get any. The amount of transpiration from plants will differ depending on temperature and humidity.

The water cycle in Rochester has its own unique characteristics. According to the National Oceanic and Atmospheric Administration, Rochester's average monthly precipitation is almost 32 inches of rain and nearly 53 inches of snow.

NORMALS, MEANS, AND EXTREMES

ROCHESTER, MN (RST)

LATITUDE: 43° 54′ 15″ N LONGITUDE: 92° 29′ 30″ W ELEVATION (FT): GRND: 1323 BARO: 1326 TIME ZONE: CENTRAL (UTC + 6) WBAN: 14925

	ELEMENT	POR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	NORMAL (IN)	30	0.94	0.75	1.88	3.01	3.53	4.00	4.61	4.33	3.12	2.20	2.01	1.02	31.40
	MAXIMUM MONTHLY (IN)	46	2.53	2.21	3.58	7.30	8.41	12.51	12.33	9.52	10.50	6.08	5.90	2.83	12.51
	YEAR OF OCCURRENCE		1967	1971	1990	2001	1982	2000	1978	1979	1986	1970	1991	1982	JUN 2000
	MINIMUM MONTHLY (IN)	46	0.07	0.04	0.32	0.94	1.17	0.94	1.02	0.34	0.38	0.27	0.06	0.22	0.04
	YEAR OF OCCURRENCE		1961	1964	1994	2000	1963	1985	1975	2003	1975	1965	1967	1967	FEB 1964
	MAXIMUM IN 24 HOURS (IN)	46	1.42	1.05	2.04	3.97	5.23	4.80	7.47	3.89	6.01	2.81	2.64	1.35	7.47
	YEAR OF OCCURRENCE		1967	1984	1966	1990	2000	2000	1981	1991	1978	1966	1991	1982	JUL 1981
	NORMAL NO. DAYS WITH:														
	PRECIPITATION ≥ 0.01	30	9.6	7.8	10.7	11.7	11.6	11.4	10.7	10.1	9.8	8.6	9.6	9.3	120.9
	PRECIPITATION ≥ 1.00	30	*	0.0	0.2	0.5	0.8	0.8	1.3	1.0	0.8	0.3	0.4	*	6.1
SNOWFALL	NORMAL (IN)	30	11.9	7.8	9.0	4.3	0.*	0.0	0.0	0.0	0.*	1.0	7.1	11.6	52.7
	MAXIMUM MONTHLY (IN)	42	30.2	19.1	25.2	16.4	0.3	T	T	T	0.8	5.4	22.5	35.3	35.3
	YEAR OF OCCURRENCE		1996	1962	1985	1983	1967	1993	1994	1989	1961	1979	1985	2000	DEC 2000
	MAXIMUM IN 24 HOURS (IN)	42	15.4	9.3	19.8	13.7	0.3	T	T	T	0.8	5.4	9.2	9.0	19.8
	YEAR OF OCCURRENCE		1982	1983	2005	1988	1967	1993	1994	1989	1961	1979	1991	1985	MAR 2005
	MAXIMUM SNOW DEPTH (IN)	53	29	21	20	11	1	0	0	0	0	4	11	20	29
	YEAR OF OCCURRENCE		1982	1979	1951	1988	1954					1979	1983	1969	JAN 1982
	NORMAL NO. DAYS WITH:														
	SNOWFALL ≥ 1.0	30	3.1	2.5	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.2	2.4	3.3	15.6

published by: NCDC Asheville, NC 3 30 yr Normals (1971-2000)

Of course, averages only tell part of the story. NOAA tracks weather extremes too, like theses shown below.

Highest One-Day Amount of Moisture for Rochester

1.	7.47"	July 11, 1981
2.	6.22"	July 5, 1978
3.	5.98"	September 12, 1978
4.	5.24"	July 26, 1949
5.	5.16"	August 18th, 2007
6.	4.80"	June 1, 2000
7.	4.34"	September 23, 2010
8.	4.18"	June 25, 1993
9.	4.10"	June 23, 1908
10.	4.06"	June 9, 2004

http://www.crh.noaa.gov/arx/?n=pcpn.rst

Highest Snowfall for One Month			Record One-Day Snowfall		
1.	41.3"	December 2010	1.	19.8"	March 18, 2005
2.	35.3"	December 2000	2.	15.4"	January 22, 1982
3.	35.1"	March 1951	3.	15.0"	December 11, 2010
4.	30.6"	December 1969	4.	14.0"	March 30, 1934
5.	30.2"	January 1996	5.	(NA)	April 20, 1893
6.	29.4"	January 1999	6.	13.5"	February 27, 1893
7.	28.6"	December 2008	7.	13.0"	April 26, 1988
8.	27.3"	January 1982	8.	12.0"	November 30, 1934
9.	27.0"	January 1932	9.	10.8"	March 10, 1956
10.	26.3"	December 2009	10.	10.6"	November 25, 1952

Source: http://www.crh.noaa.gov/arx/?n=snow.rst

Seasonal Snowfall for Rochester
(Measured from July through June)

Highest			Lowest		
1.	84.7"	1996-97	1.	9.1"	1967-68
2.	77.5"	1950-51	2.	10.5"	1913-14
3.	74.5"	1961-62	3.	17.5"	1924-25
4.	73.6"	1951-52	4.	19.4"	1930-31
5.	73.3"	1978-79	5.	20.5"	1910-11
6.	70.5"	2010-11	6.	21.2"	1919-20
7.	68.6"	1984-85	7.	21.6"	1957-58
8.	68.0"	1881-82	8.	24.4"	1956-57
9.	66.3"	1887-88	9.	24.6"	1937-38
10.	66.0"	1983-84	10.	24.8"	1953-54

Source: http://www.crh.noaa.gov/arx/?n=snow.rst

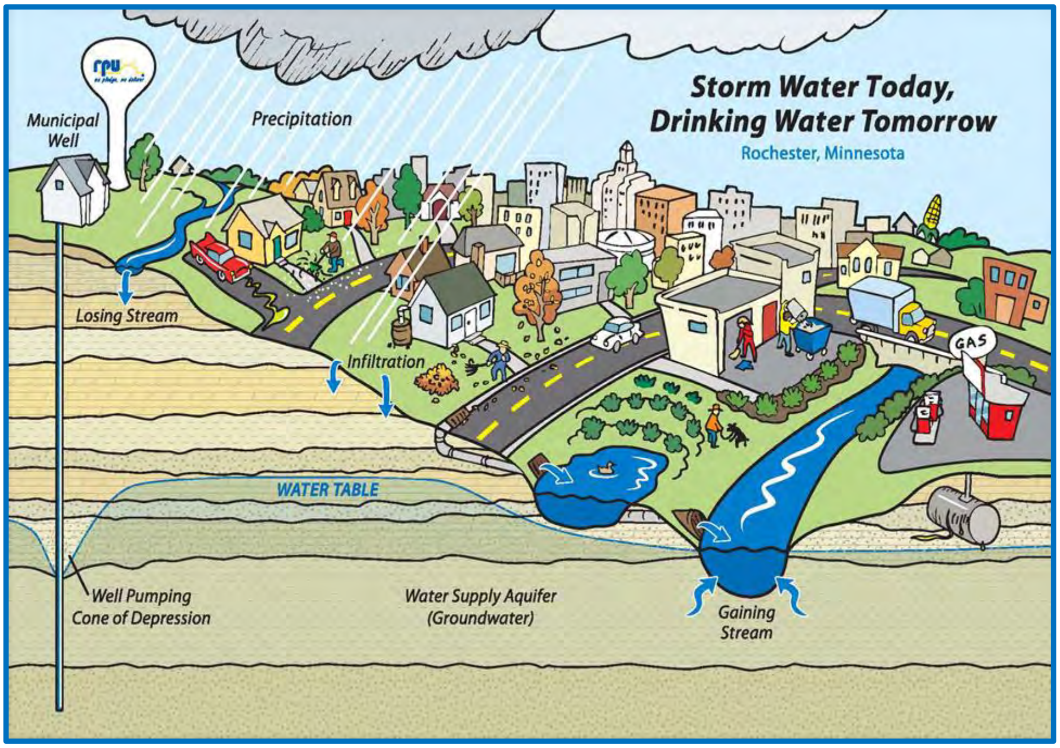
The US Geological Survey has an interactive website about water resources of Minnesota. It includes current stream flow data for Rochester and water-quality and groundwater data for other parts of Minnesota. Check it out at: http://mn.water.usgs.gov/

In Minnesota, snowmelt is an important part of the water cycle!

The Advanced Hydrologic Prediction Service of the National Weather Service has an interactive website that displays Rochester's river levels in comparison to flood stage. Check it out at: http://water.weather.gov/ahps2/index.php?wfo=arx

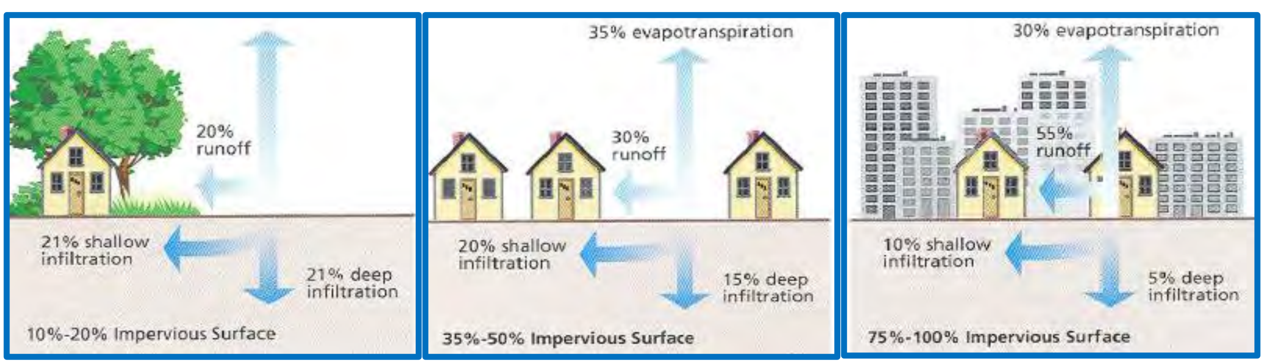
As an urban area, Rochester interrupts the natural water cycle. The groundwater is pumped out of the ground so we can use it at our businesses and homes. At this time, the amount of groundwater used in Rochester is about equal to one inch of precipitation. When we are done using it, it flows down drains and into sanitary sewers as wastewater. After it is treated at the Water Reclamation Plant, it is discharged back to the river. Plus, precipitation and snowmelt travel across a lot of constructed surfaces like: roofs, sidewalks, driveways, roads and parking lots. This storm water is directed into storm sewers that eventually discharge back into our lakes and rivers. Can you see how closely groundwater and surface water are connected in Rochester's water cycle?

Rochester's Urban Water Cycle



Source: Rochester Public Works

It is obvious that urbanization has affected water flow, but how much have hard surfaces changed the water cycle? Before settlement, about 50% of rainwater and snowmelt could soak into the ground because it moved slowly across the landscape. The remainder moves back into the air or runs off the land to fill lakes and rivers. As cities grow, more hard surfaces and compacted soils are added and they prevent water from infiltrating below. They are impervious surfaces. It is estimated that as impervious surface area increases to 20%, infiltration is reduced by 8%. As it reaches 50%, 15% of infiltration has been lost. If a City's entire landscape is nothing but buildings, roads and parking lots, then 35% of the infiltration is gone. If the water can't soak into the ground, where does it go? It runs off the surface, so the more pavement, the more storm water, the faster it flows, and the more urban pollution it collects.



Source: Center for Watershed Protection

Even agriculture has changed the water cycle. Farmers have drained wetlands that used to hold water on the landscape. They have installed field tile to quickly move water away from their fields. Most of their crops cover the soil only for a part of the year, exposing loosened soil to wind and water erosion. If plants do not take up all the fertilizers and pesticides, then the excess can run off as pollution.

The Minnesota State Climatology Office, a DNR Division of Ecological and Water Resources, maintains the "Wetland Delineation Precipitation Data Retrieval Gridded Database". This tool was created to help people delineate wetlands, but it is also useful for other research. Highlight a specific location in Rochester and click on the button to create a precipitation data table for that site. Check it out here: http://climate.umn.edu/gridded_data/precip/wetland/wetland.asp

Case Study: Water and Rocks

Hydrology and geology interact with each other. We extract our water supply from bedrock aquifers. In karst regions, water affects rock by dissolving limestone to form fractures, joints, caves, and sinkholes. In Rochester, shale is exposed by the river valley to form the Decorah Edge, releasing water from the upper aquifer so it can flow into, or recharge, the lower aquifer. Much can be inferred about the interaction of water and rocks by comparing data.

By looking at each of the following pictures of the Century High School area, make inferences about how hydrology and geology relate to each other.

Picture A

1. Find Century High School. What do you already know about the area around Century?
2. Make an inference about the relationship between springs and the area known as the Decorah Edge, which is comprised of the Decorah, Plattville, and Glewood shale formations.

Picture B

1. What color represents the highest elevation?
2. What color represents the lowest elevation?
3. Make an inference about the relationship between springs and elevation.

Picture C

1. What color represents the highest vulnerability to pollution?
2. What color represents the lowest vulnerability to pollution?
3. Make an inference about the relationship between springs and vulnerability to pollution.

Picture D

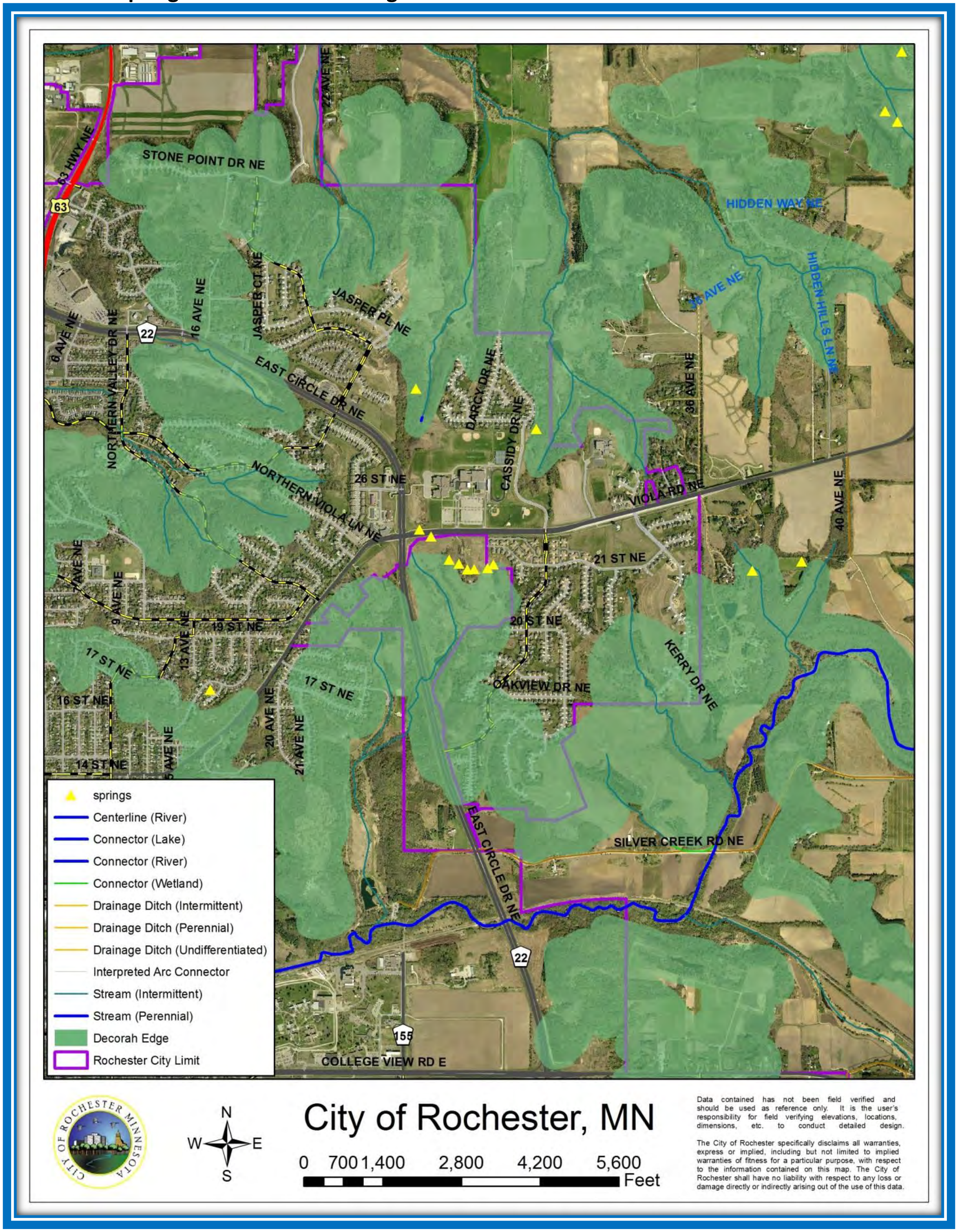
1. Which rock layer has the highest elevation?
2. Which rock layer has the lowest elevation?
3. Make an inference about the relationship between springs and rock layers.

Putting It Together

1. Write a short paragraph that summarizes the relationship between the geology and hydrology shown in these pictures.
2. How do you think this area would compare to the rest of Rochester?

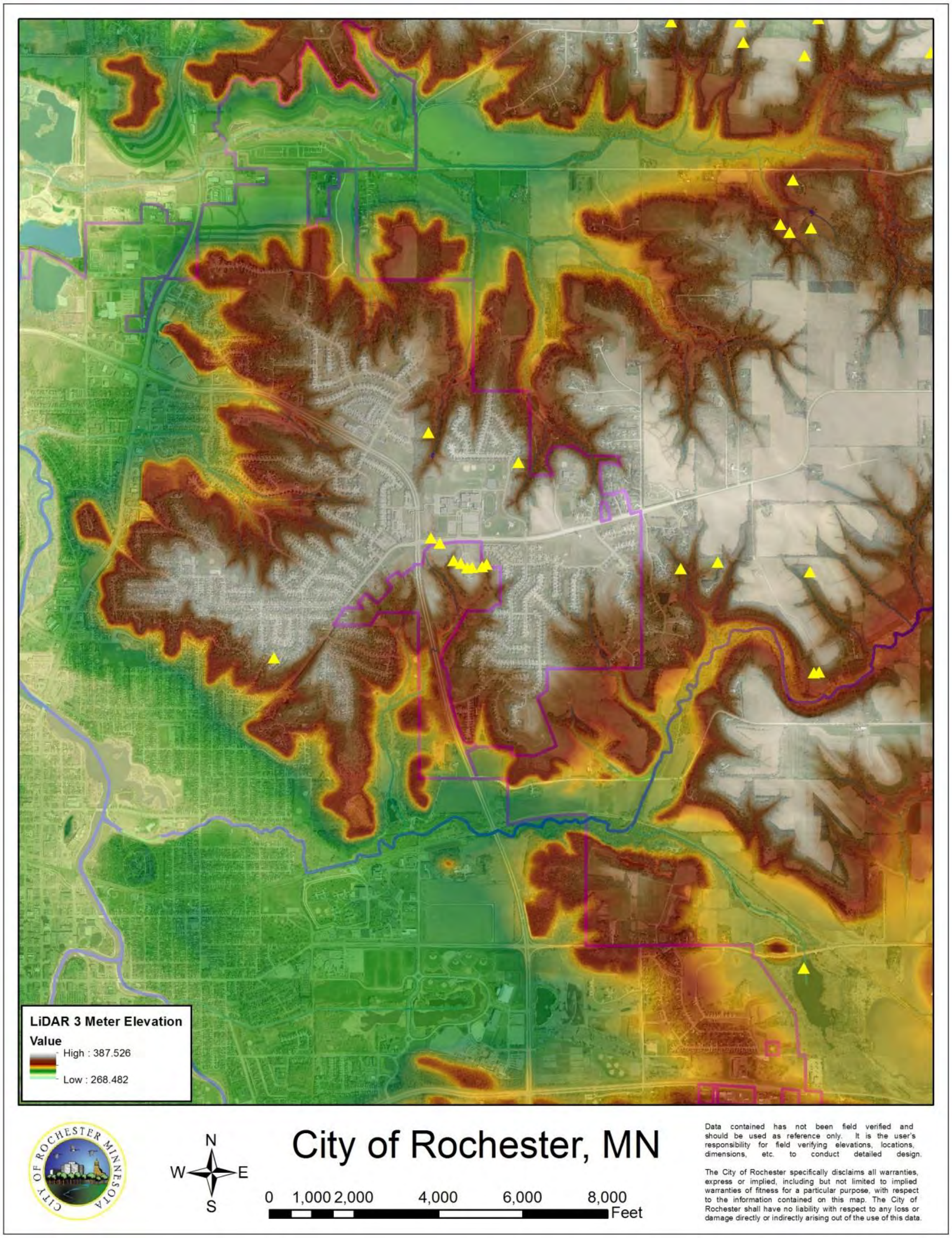
To find out more about the relationship between springs and rocks, check out USGS's website at http://ga.water.usgs.gov/edu/watercyclesprings.html.

Picture A – Springs and the Decorah Edge



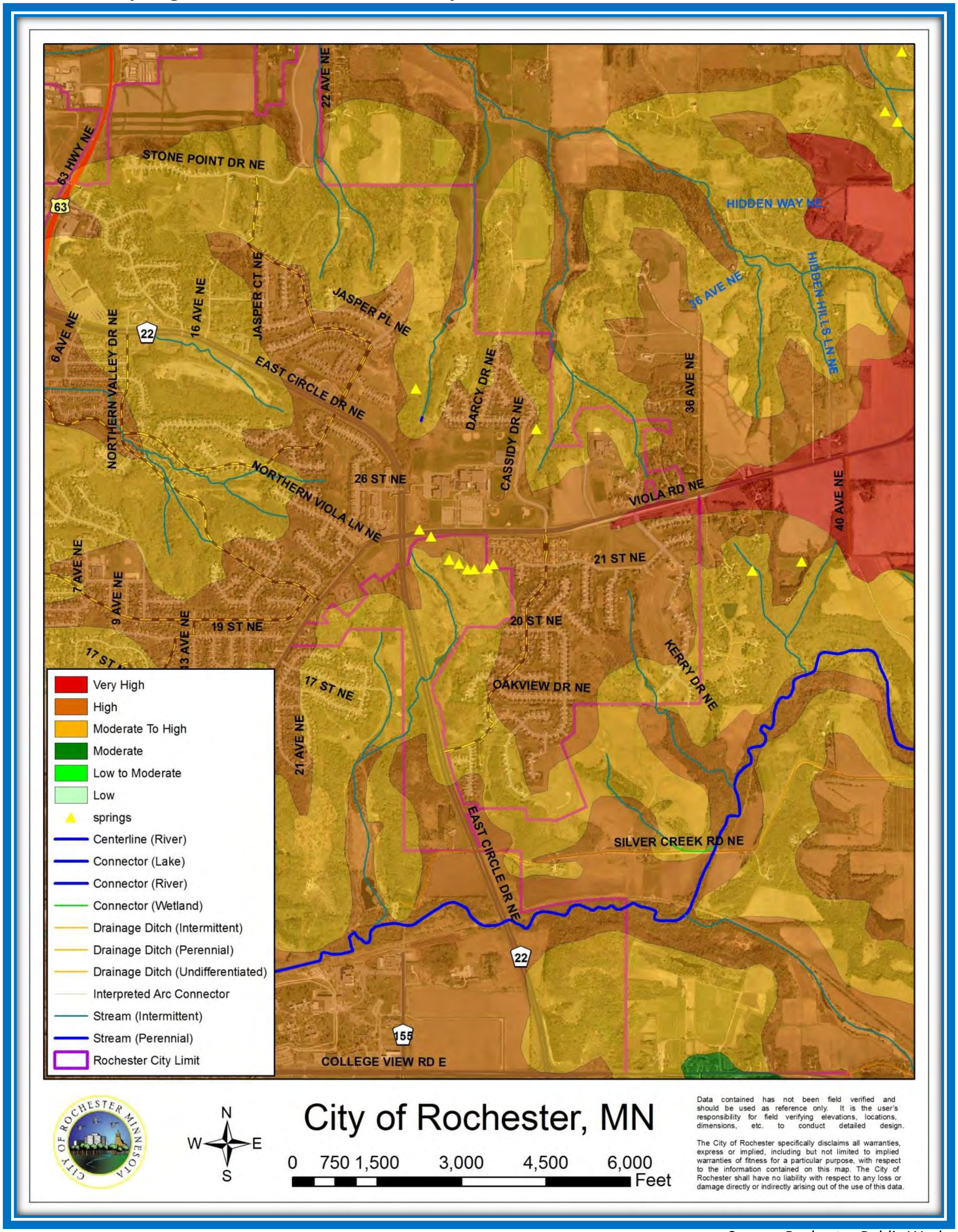
Source: Rochester Public Works

Picture B – Springs and Elevation



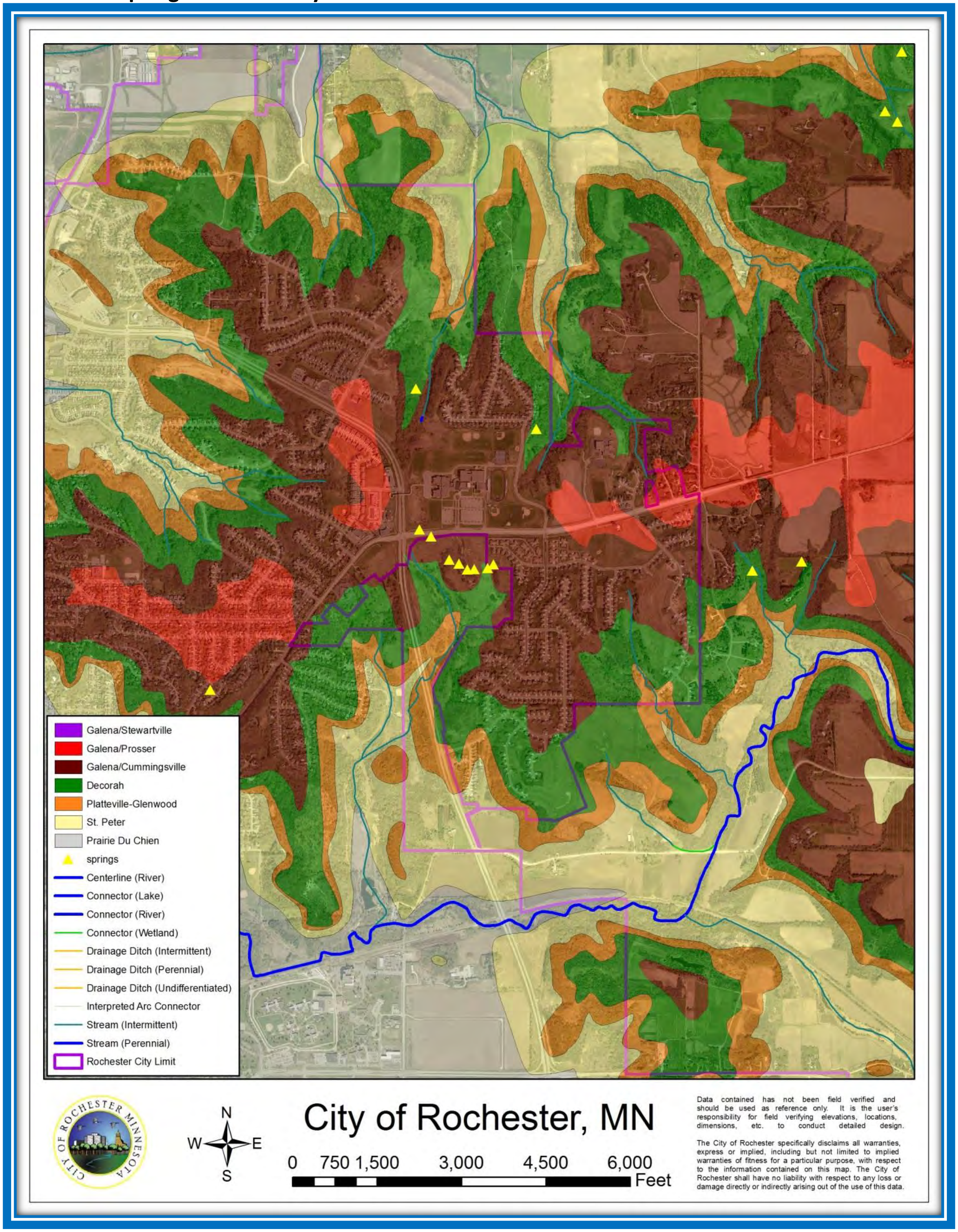
Source: Rochester Public Works

Picture C – Springs and Pollution Vulnerability



Source: Rochester Public Works

Picture D – Springs and Rock Layers

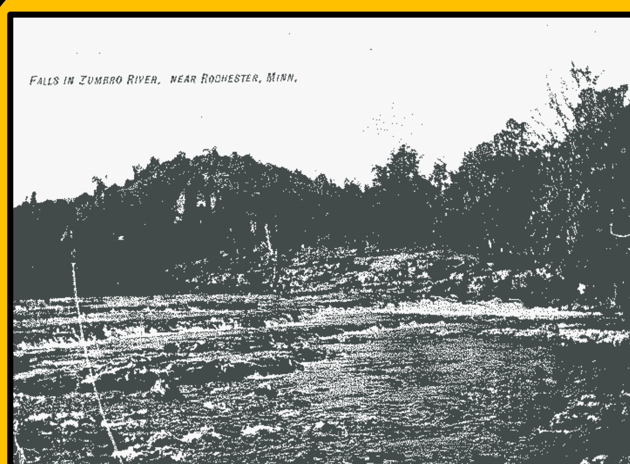


Source: Rochester Public Works

Chapter 2 - Rochester's Water History

The City of Rochester's history is intertwined with that of water. Limited archeological and historical evidence records the presence of Native Americans along the banks of the Zumbro River before Rochester became a City. After the Treaty of Traverse des Sioux was signed in 1851, white settlers began moving here, as well. Minnesota became a territory on March 3, 1849. Five year later, John Head and his two sons, George and Jonathan, built a log house on the west shore of the Zumbro River near 4th Street SE. Rochester was official founded by George Head in 1854, although incorporation as a City with a formal government, would not occur until 1858. Head named the new settlement Rochester because the waterfalls in the river reminded him of his native Rochester, New York. Some early sources refer to the water feature as the "Falls of Wasioja"; others sources note it as the "Falls of Wazionja". The waterfalls were located close to what is now 4th Street SE.

The history behind the river name Zumbro is a bit of a mystery as well. The Minnesota Territory was part of President Jefferson's Louisiana Purchase from France that greatly expanded the boundaries of the United States in 1803. An early map, dated 1805 -1806, by famous cartographer Zebulon M. Pike, called the river "Riviere des embarrass". When this name is said out loud in the French dialect, it might sound a lot like "Riveer dezembra" to English speaking ears, which then became Zumbro. Riviere des embarrass means "river of difficulties" as it had many snags and dead trees at the mouth on the Mississippi so it was never a great river for hauling supplies or furs in canoes during the fur trade era. Another map, dated 1836 by Major Stephen H. Long and Lieutenant Albert M. Lea, called the river "Embarrass". Joseph Nicolas Nicollet and his team were commissioned to map the upper regions of the Mississippi River. On their 1843 map, the river where the Head family built their home in Rochester is labeled as "Wazi Oju", meaning "place of pines", as it was called by members of the Dacotah Nation. (Today, the town of Wasioja is on the Middle Fork of the Zumbro River, northwest of Rochester.) A July 21, 1854 plat from the United States Surveyor General's Office uses the name "Embarrassa River". J.A. Leonard, in Last History of Olmsted County (1910), referred to the fact that newcomers in the Rochester area had difficulty with the pronunciations of local geographical names. Documents seem to support the metamorphosis of the name through the slurring of language. An 1856 map by J.H. Young uses the name "Zumbrea" for the river. A September 14, 1858 document refers to County Commissioners of Wabasha County building a



Source: History Center of Olmsted County bridge over the “Zombro River”. Another suggestion about the origin of the river’s name is that it may have been related to a French-Canadian explorer, Edward Zumbro, who travelled through the area in the latter part of the 18th century, although documentation is lacking.

The Zumbro River has been a part of life in Rochester since the City’s founding. In 1856, gold was discovered in the Zumbro from Rochester to Oronoco and further down river. On February 7, 1858, the First Baptist Church, Rochester’s first house of worship, held its first baptismal service in the Zumbro River. Holes had to be chopped through the ice to allow for the believer’s immersion into the cold water. Ice harvesting on the river during the winter provided ice for the people of Rochester during the summer months. George Head built another cabin on the river that would turn into Rochester’s first hotel. After a tornado ripped through Rochester in 1883, new concerns for safety arose within the community. A system that provided safe drinking water and could be used for putting out fires was needed and built.

> Rochester Daily Bulletin
>
> Thursday January 7, 1915
>
> THE ICE HARVEST IS BEING GATHERED IN ROCHESTER
>
> No Need For Worry in 1915
>
> The ice harvest in Rochester has started in earnest. The Zumbro river below Fifth street bridge has been attacked by the icemen in regular formations and on all sides the ice king has been flanked. One portion is being utilized by George DeWitt while the State hospital has a crew of employes busy gathering the season's harvest. The ice is of a good quality and escaped injury at the hands of the warm weather which the country experienced during the past two days.
>
> Just as soon as occasion permits, Mr. DeWitt will start another crew of men on the upper Zumbro, south of Rommel's Dam and efforts will then be directed toward filling the new ice house recently completed by Mr. DeWitt. With the interior of the big ice houses taxed to their capacity and the distribution of manufactured ice by The Rochester Artificial Ice Company there is no need for worry over the ice crop supply during the hot days of nineteen hundred and fifteen.

Source: History Center of Olmsted County – Original Source: Rochester Daily Bulletin

Water Supply

The issue of a private versus a public water supply system was the center of much debate, petition, and apparent fraud. Finally in 1887, the City decided to contract with the firm Hodgkins, Moffet, and Clark from Waterville, New York to operate a water system. It was a franchise contract with a 30 year lease, whereby Rochester would rent the water structures, but the water itself would be free. Rochester was charged $3,900 per year for the water system that included 120 hydrants for fire protection and 8 miles of water main. A standpipe that held 225,000 gallons of water was built in 1887 on College Hill, where St. Mary's Park is currently located. The standpipe remained in service until it was taken down in 1995, 108 years after it was built! Pumps to distribute the water and other operations were in a "Water Works" building that was located where Bear Creek joined the Zumbro River, close to where the Mayo Civic Center is now located. The water company had difficulty turning a profit, however, and declared bankruptcy in March of 1896. Burt W. Eaton, the Rochester City Clerk, was appointed president to run the company while new buyers were being sought. At that time, the company name was changed to the Rochester Water Company. Money was tight. The system was aging and floods in 1903 and 1908 caused damage. Financial matters stabilized enough in 1910 for the company to drill its first Rochester well into the Jordan sandstone. When the City's lease with the company ended in 1916, the City decided to purchase the company instead of renting the water structures, thus forming the Public Utilities Water Department. Funds for the purchase needed voter approval, however, and the bond issue for $175,000 passed on May 25, 1916, by a vote of 612 to 17. The first municipal system included 1,700 customers, 17.5 miles of main with hydrants, and the Water Works (pumping station, wells, workshop, and a bay horse named, Dick.) Part of the bond, $50,000, was set aside for needed improvements. The "Saint Mary's" water tower was constructed in 1924 and was functional until 2000. It is now being preserved as a historic landmark. (See Chapter 5 – Rochester's Water Supply, for information on the City's current system.)

Hydroelectric Generating Plant

As the village grew into a town and then a city, so did the population's needs. To decrease their dependence on burning coal for electricity, the citizens of Rochester voted to construct a municipal electrical power dam 12 miles upstream at the cost of about a million dollars. The contract to build the dam was signed on April 6, 1917, the same day that the United States declared war with Germany (World War I). Hugh Lincoln Cooper was hired to design and oversee the construction of the dam. Cooper later earned worldwide recognition for his engineering of dam structures. The Toronto Power Plant at Niagara Falls was designed by Cooper and he was the first foreigner to be awarded the Order of

Homes Powered by the Lake Zumbro Hydroelectric Generating Plant:

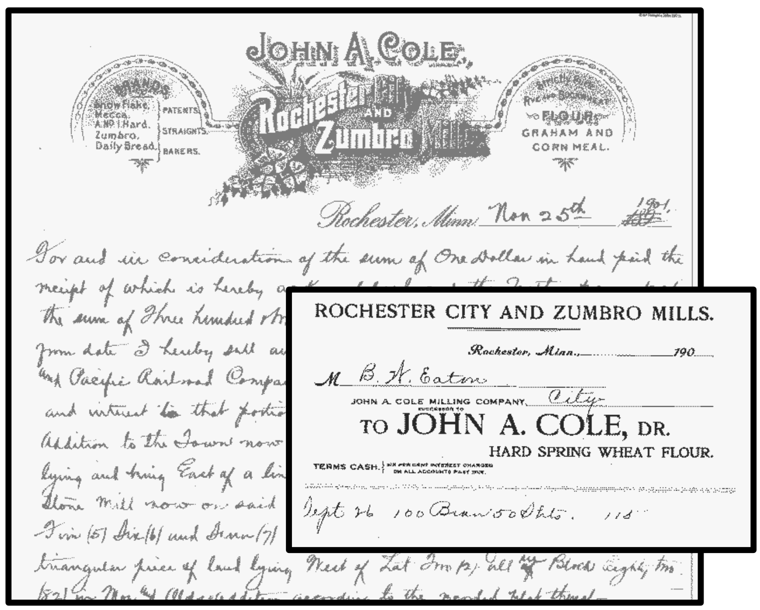
- 2012 = 7,549 MWH
  - 968 homes (lowest water year since 1989)
- 2011 = 15,797 MWH
  - 2,025 homes
- 2010 = 13,241 MWH
  - 1,698 homes

NOTE: Each home uses about 7.8 megawatts per hour of electricity produced by renewable water energy.

the Red Star, the highest honor given by the Soviet government. The Lake Zumbro Hydroelectric Generating Plant began operation on November 7, 1919 to supply the electrical needs of the growing City. It could only operate cost-effectively during the spring months when water levels were the highest. The system is still owned and operated by Rochester Public Utilizes and water levels still affect the amount of electricity produced by the plant.

Industrial Mills

The rapid drop in elevation at the Falls of Wasioja attracted the attention of mill owners. Throughout the 1950's an assortment of flour mills dotted the banks of the Zumbro in Rochester. Rochester Milling Company was Rochester's oldest industry, having been opened by Mr. F. A. Olds in 1854. It produced 250 barrels of flour a day and was located on 3rd Street by the Zumbro River. The Rochester City and Zumbro Mill (Cole's flour mill) operated at 7th Street NE, near today's location of the Silver Lake Fire Station. Tondro Mills was built in 1863 on Cascade Creek. Canals or "mill runs" or "mill races" were created to direct water from the rivers to the mill foundations, where the current would turn large wheels that would then turn the milling stones to grind flour. At one time, there were four mill runs in Rochester, with the largest running near Broadway Avenue. Electrical power gradually replaced the need for running water and the mill runs were filled with dirt.



Source: History Center of Olmsted County

Milling was not limited to just flour. The first saw mill in Rochester was owned by Joseph Alexander and produced 500 foot-boards of lumber per day. In 1857, the Steam Millwork and Sash Factory open on the east side of the Zumbro River.

Just as the former mills depended on water flowing from higher elevations to lower elevations, the delivery of sanitary sewage to today's water treatment plant also relies on the topography of Rochester's river valleys again. Sanitary sewers also use gravity to do the work (see Chapter 6 – Rochester's Wastewater Treatment System).

Rochester Post Bulletin Friday June 7, 1929

Old Mill Race is Filled Up

Part of that which made Rochester in the beginning has begun to disappear, the old mill race, north of Fourth Street SE. Workmen this week began filling the trench which for many years carried water for power to operate the flour mill. This is part of the program of development now under way in that vicinity, including the laying out of a public alley between Fourth and Third streets.

Dirt from the alley excavation is being dumped into the mill race and it is the ultimate intention to close it entirely so as to add land to the holding of the milling company.

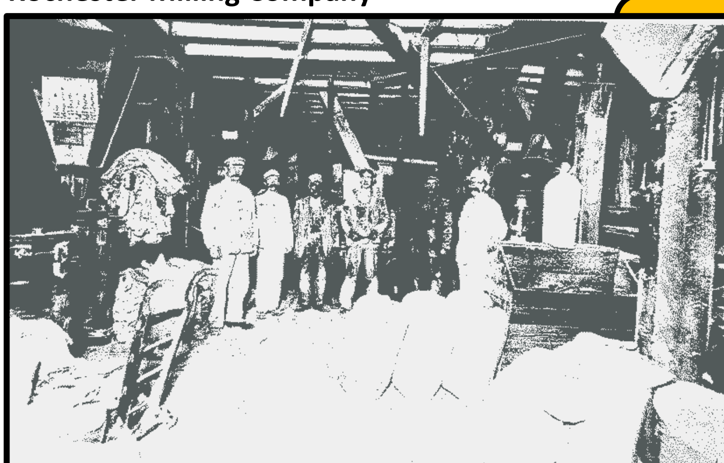
This land and the old private roadway, which led to the mill and which served as a semi-public road during the entire history of Rochester, may be later used for a parking space, Spencer Knapp of the milling company, has intimated.

The Falls of Wasioja at the bridge caused Rochester to be established because it showed that there was water power here. The mill was built because of the power. The race was dug so as to provide a flowage of water for the turning of the old mill wheels.

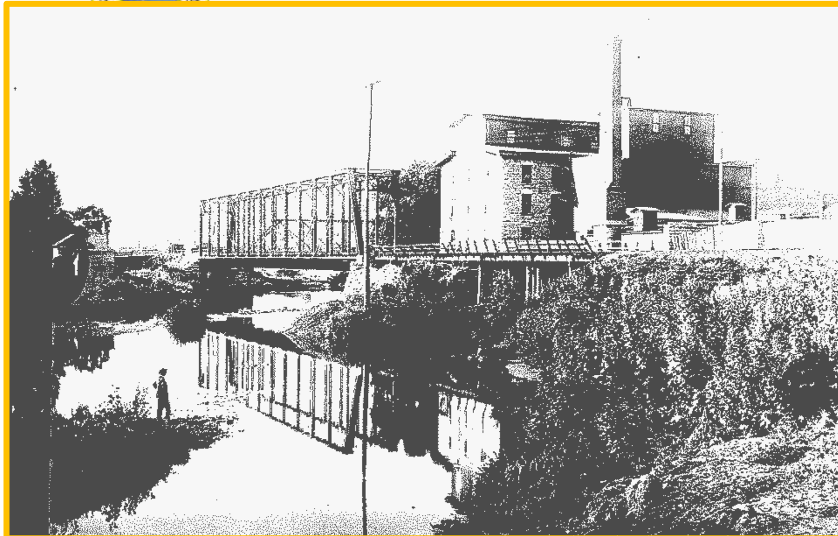
Today the mill is operated by electricity. The water power has not been needed for a long time. The mill race is being abandoned and obliterated.

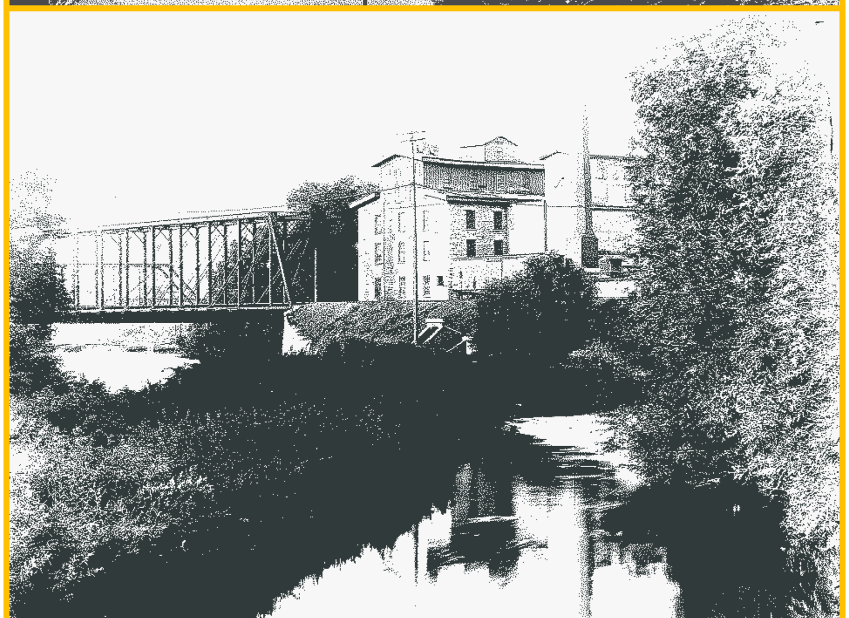
Source: History Center of Olmsted County

Rochester Milling Company



Source: History Center of Olmsted County





Source: *History Center of Olmsted County (All)*

The two photos on the top left are of the Rochester Milling Company (Olds and Fishback) Mill. The others are the Rochester and Zumbro (Cole) Mill. The stone bridge was the foundation of the Cole Mill. Find the Zumbron River, the mill run and the railroad bridge.

As the land uses changed, the Highway Department was called upon to straighten the river channel and improve Highway 63 (also known as Broadway Avenue). Two mill dams within the Zumbro, Rommel and Strawberry, were removed and the channel of the Zumbro was straightened. The riverbed along Highway 63 was also blasted to add depth and, in doing so, the original Wasioja Falls of Rochester were destroyed. The Highway 63/Broadway Avenue bridge over the Zumbro River was dedicated in 1932.

Recreation/Dams

In addition to its industrial uses, the river was also important for recreation. While many people would travel north of Rochester to Lake Shady and Cedar Beach on Lake Zumbro to cool off during the summer months, the residents of Rochester wanted a nearby City park on the river. Mayo Park, formed in 1904 where the Civic Center stands today, was the City's first park along the Zumbro River. Later, an architect, Hugh Vincent Feehan, was hired by the City to design another park with an artificial lake that came to be known as Silver Lake Park, which housed a municipal zoon until 1940. This lake was formed by digging a basin and installing a dam. (See Chapter 4 – Rochester's Constructed Water Bodies for more information on its construction.)

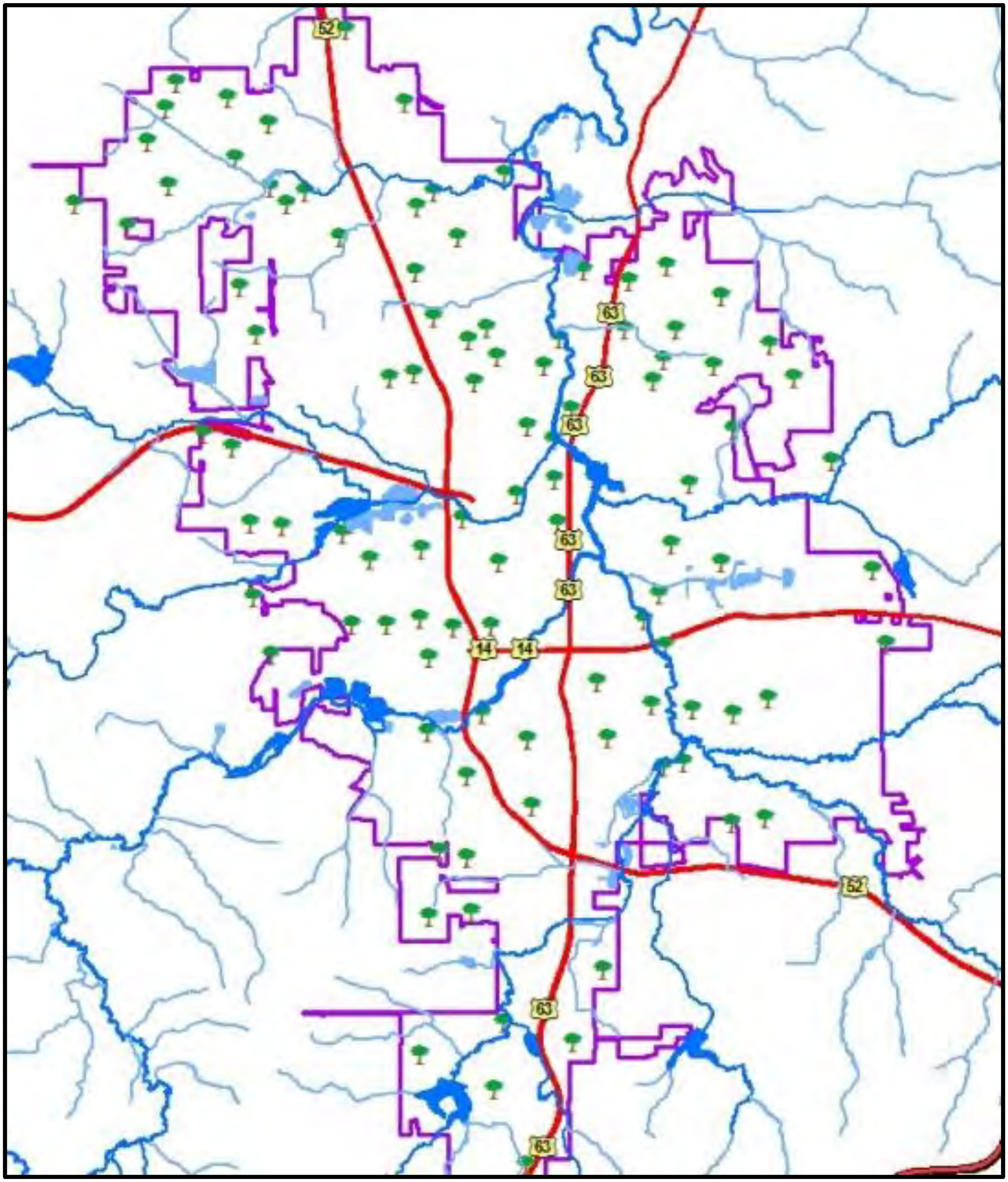
Even today, Rochester has many parks located on creeks and rivers (see the next page). Silver Lake is still part of the Zumbro River. Silver Creek runs through Quarry Hill Park. Cook and Kutzky Parks are located along Cascade Creek. Bear Creek has a park named after it. Slatterly Park is also on the banks of Bear Creek. On Sunday evenings in July and August, thousands of people enjoy "Down by the Riverside" free concerts in Mayo Park.

Canoeing the Zumbro River in Rochester

Source: Deb Las

While the Silver Lake dam is perhaps the most well-known dam in Rochester, other dams have had an important part in Rochester's water history. In 1911, Dr. Charles Mayo added a dam to his Mayowood Estate, creating Mayowood Lake. It had a tailrace to operate a generator. Twenty years later it became obstructed with silt and a new dam was needed. The second dam did not have a generator.

Rochester City Parks: How many are located along rivers?



Source: Rochester Public Works

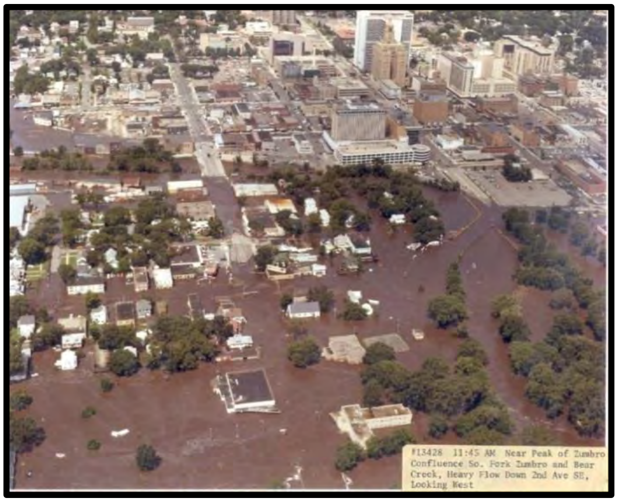
Flooding

The need for controlling the flow of water through Rochester went beyond industry and recreation, however. Controls were also installed along the rivers for flood protection. Rochester was built on the floodplain created by the South Fork of the Zumbro River and its tributaries. Since early settlers depended on water for many of their daily needs, the City's location next to the rivers seemed perfect for a growing community. But all the new construction was ignored by naturally flooding rivers. The conflict between a river's need to flood into its floodplain and people's desire to be next to water became a battle that is still fought today.

The first recorded flood in Rochester was either in 1855 or 1859 (records conflict); it destroyed bridges with its crest 15 feet above normal water levels. A prominent Rochester publisher perished in the flood waters. In August of 1866, three homes were destroyed and three families were rescued by boat. On June 23, 1882, another noted Rochester flood resulted in the loss of livestock and property. Parks were flooded and destroyed in 1908. Flooding in Rochester continued through the subsequent years. The U.S. Army Corps of Engineers, in cooperation with the City of Rochester and Olmsted County, began taking a serious look at trying to prevent flooding in Rochester in 1962, long before the historic 1978 flood.

The 1978 flood was Rochester's worst flood disaster since its founding. The rains started on July 5, 1978 and by July 6th the flood waters were rising. At the time, over one-third of the City,

Rochester's 1978 Flood



Source: City of Rochester

including 2,000 homes and businesses, lay in the flood plain. Evacuation of 5,000 residents, some by boat, took place during the rainy night and continued the next day. Damage was over $58 million ($250 million in today's economy). Five people lost their lives.

Volunteer Joins Rescue 'Navy'

Boater Helps Stranded Victims

By STEVE SCHULTZE
Post-Bulletin Staff Writer

Gordon Holmes was listening to his police scanner radio Wednesday night as Zumbro River and Bear Creek waters kept rising, forcing Rochester residents out of their homes.

A message crackled over the scanner that sent Holmes out into the stormy night: Officials handling the emergency effort needed boats.

Holmes

Holmes, who lives on higher ground at 521 19th St. NW, hitched his 16-foot Alumacraft boat and trailer to his car and drove down to the banks of the swollen Zumbro in southeast Rochester.

He was immediately pressed into service, assisting two city policemen in a rescue at the Tropic Bowl at 400 Fifth Ave. S.E., where five persons were stranded. Approaching the building, one of the policemen threw the boat's anchor through a window to provide an escape route. The marooned persons were then ferried to safety.

Holmes had helped with four rescues, dodging floating debris in the murky, swift waters, when his 25-horsepower outboard motor became a flood casualty. He was transporting a cargo of nine near Slatterly Park when the motor hit a submerged obstruction and conked out.

But Holmes, a Post-Bulletin circulation department employee, was not deterred.

He and his policemen comrades hopped into the waist-high water and towed the boatload of rescued persons to land.

He and the officers continued to rescue people by this means until dawn Thursday.

"Oh boy, they really worked," Holmes said of the policemen, whose names he never had time to learn.

"We were in water most of the time up to our hips."

Holmes wasn't the only volunteer boatman offering ... assistance.

"There were ... there: inboards, ... small boats." ... really responded...

Some peopl... want to be r... erroneously ... reached its ... and refused ... entire south... power or ... dents had ... crest wa... said.

City Sewer Plant To Be Bypassed With Raw Sewage

Raw sewage will be dumped into the Zumbro River for about a month because of flood damage to the Rochester municipal sewage treatment plant, it was reported today.

Plant Supt. Marvin Skodje said he doesn't see how all repairs can be made and the plant restored to operation for at least 30 days, even if work starts now.

Skodje, who estimated damage to the plant at half-a-million dollars, said sewage will be bypassed raw into the river, but will be first heavily chlorinated.

Public health officials here said the chlorinated sewage poses no health hazard to city drinking water.

Flood waters submerged the plant, severaly damaging electrical equipment, including pumps, motors and meters, Skodje said.

Mayor Alex Smekta is expected to order immediate repairs without going through normal bidding or price quoting, a delay he can avoid through his executive emergency powers of office.

"We couldn't ask for estimates," Skodje said, "because no one could tell how much will need repair or replacement until instrument panels and such are removed."

He said, ironically, the plant is even without water today to was wash down mud left by floodwaters. He said water would be trucked in to get the job done.

4 Nursing Home Deaths Confirmed As Drownings

By MARY VITCENDA
Post-Bulletin Staff Writer

The four women trapped in an elevator at ... Health Enterprises ... southeast ... flood ... con-...

A city inspector said the elevator automatically descends to the basement when there is a malfunction or short circuit. Nothing the four trapped persons could have done would have saved them, he said.

State officials who handle elevator inspection and licensing could not be reached for comment this morning.

Authorities said the four were trapped about 1:15 a.m. and their bodies recovered about 6 a.m. Rochester firemen reached the four by prying their way through a hatch at the top of the elevator shaft, authorities said.

Nursing home employees continued their cleanup of the building today.

They returned late Thursday morning to find their offices on the basement floor filled with mud. "We ...n't even get to them," said Marilyn ...des, one of the aides.

"When it started raining, the fire ... went off and scared every-..., said nursing home resident ... Gorath.

...ey dashed to get everybody to ...nd floor. The power went on ... was unable to walk, but he

Source: History Center of Olmsted County, Rochester Post Bulletin

Flood Control

The historic 1978 flood happened while a flood control bill for Rochester was waiting in Congress for approval. The flood control plan had two distinctive parts: the river project by the U.S. Army Corps of Engineers (the Corps) and the reservoir project by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service. Congress approved the NRCS project in 1983 and it was completed in 1996.The Corps project was approved in 1986 by Congress and it was completed in 1995. The plan was for six NRCS flood reservoirs plus one flood reservoir that would also become a recreational area (Chester Lake). The Corps was to widen and deepen the river channel to add more water capacity in and improve flows through the City. The flood control project cost $114 million dollars: $96 million for the Corps portion and $18 million for the NRCS part. The City was responsible for 25% of the Corps project cost ($24 million) and 92.8% of the NRCS costs ($16.704 million), for a total City bill of $40.704 million. The funds were raised through a voter-approved, 1% addition to the local sale tax that was collected between 1983 and 1992.

The flood control project used a multiple faceted approach that combined water storage in reservoirs located in the upper portions of the watershed, stream bank stabilization, channel improvements, and levees. Together, these structures control the amount of water moving through the City and the rate it is discharged. The engineered design protects most of the flood prone lands within the flood control project area from significant flooding, up to a 220 year storm event (that is, a large rainfall event whose probability that is will occur is once every 220 years). Basically, that means that the flood risk has been lowered to less than 0.5% in any given year. In addition to managing floods, the structures were built to provide recreational uses with a pleasing community aesthetic. Pedestrian bridges and bike trails were included along with distinctive railings and lighting throughout the flood control corridor.

Key Flood Control Components:

- Over 7 miles of channel modifications and bank stabilization
- Rehabilitation of a low-head dam
- 1.3 miles of flood levees
- 4 grade control structures
- 13 pedestrian bridges
- Relocation of 1 railroad and 2 roadway bridges
- Minor modifications of 13 additional bridges
- Relocation and removal of 19 homes from the floodplain
- Visual innovations such as riprap covered with topsoil and sod

Source: Deb Las

Because Rochester's flood control project uses seven upstream reservoirs, water is held back instead of flowing immediately through the watershed after a large rain event. Not only does this protect the City of Rochester, the upstream water storage helps downstream property to some degree, as well.

100 Year Flow Rate Comparison*
(in cubic feet per second, or cfs)

Waterway in Rochester	Before Flood Control	After Flood Control
Cascade Creek	6,500 cfs	4,400 cfs
Bear Creek	13,500 cfs	8,900 cfs
Silver Creek	5,200 cfs	3,400 cfs
Zumbro River (37th St. NW)	23,900 cfs	20,900 cfs

*Currently, a 100-year rainfall event is defined as 6.15" of rainfall in a 24 hour period.

The first true test of Rochester's flood control project came in 2007. On August 18-19, a heavy rainstorm in the South Zumbro Watershed was greater than a 500 year rainfall event, far higher than the designed flood protection level of the flood control project. Total measurements varied from 6 to 12 inches across the landscape that flows into Rochester; the City itself received a record rainfall of 7.05 inches. There were problems reported with storm system flooding, basement flooding caused by surface and groundwater, and some slope failures. Significant sanitary sewer back-up problems were also noted, particularly in the Slatterly Park and Kutzky Park neighborhoods. (See Chapter 6 case study.) Despite these localized impacts, Rochester was largely protected from surface flooding, proving the effectiveness of flood control project.

In 2010, Rochester experienced another major flood event. That year, the City received a record 6.22 inches of rain in a 48 hour (September 22nd -23rd) period. Other locations in the watershed received even higher rainfall amounts. The South Fork of the Zumbro River crested 3 feet above flood stage at 17.16 feet. Each major storm event proves that the City's investment in the flood control project was a good one.

A local resident recorded the 2010 flooding in Rochester and shared the event on YouTube:
http://www.youtube.com/watch?v=4otPn9Xk0Y8

Rochester Flood Severity

Date	River Level (Zumbro River Flood Stage at 37^{th} St is 14 feet)
July 6, 1978	23.00 ft.
September 21, 1986	20.77 ft.
March 1, 1965	19.12 ft.
March 29, 1962	18.46 ft.
October 18, 1955	18.00 ft.
June 23, 1908	18.00 ft.
July 21, 1951	17.50 ft.
September 23, 2010	17.08 ft.
June 21, 1974	16.86 ft.
August 19, 2007	16.68 ft.
September 15, 2004	15.57 ft.
March 26, 1952	15.43 ft.
March 11, 1973	15.34 ft.
March 4, 1906	14.64 ft.
April 6, 2001	~14.00 ft
February 9, 1966	13.93 ft.
April 6, 1965	13.55 ft.
June 4, 1958	13.54 ft.
May 1, 1973	13.36 ft.
March 31, 1952	13.26 ft.
March 11, 1967	12.45 ft.
June 24, 1952	11.60 ft.
March 27, 1967	11.45 ft.
	Source: USGS

Cascade Confluence 2001

Source: Rochester Public Works

Silver Lake Dam 2007

Source : Rochester Public Works

As the flood control reservoirs were constructed, the stored and slowly released floodwaters lessened river level heights during flood events. Therefore, post-1986 flood levels cannot be compared equally to pre-1986 rainfall events. So, when about 7 inches of rain fell one day in April 2001, it was hardly noticed in comparison to the 7+ inch rainfall event of July 1978. High waters still flowed, but their extent was mostly limited to undeveloped or smaller, localized areas. Today, climate changes are creating more significant snowmelt and rainfall events that cause flooding. However, because of the flood control project, impacts of even larger events are minimized.

Rochester is connected to its waterways even through its City logo, which features a river and the Giant Canada Goose. At one time these birds were thought to have disappeared from the United States. Harold C. Hanson of the Illinois Natural History Survey discovered a remnant flock at Silver Lake in 1962. The geese were attracted by the open water caused by discharge of warm water used to cool the Silver Lake Power Plant's boiler. After the discovery, governmental agencies began monitoring and protecting the species. In the 1960's the fall/winter population of the giant Canada geese rose to about 6,000. By the 1970's, around 19,500 geese were calling Rochester home during the winter months.

GEESE: AN ASSET OR A LIABILITY? Did you know that too many geese in one area can cause water quality problems? Each goose produces about 3 pounds of droppings per day that are rich in bacteria and nutrients. When excess phosphorus and nitrogen reach surface water, unwanted algae growth can result. If large algae mats form, they use up the water's oxygen when they decompose, robbing fish and insects of the oxygen they need to live.

Source: Deb Las

Looking to the Future

For many years, gravel pits have been turned into recreational water bodies or aesthetic features in Rochester. (See Chapter 4 – Rochester's Constructed Water Bodies.) The City of Rochester is following that practice with the eventual formation of Cascade Lake in NW Rochester by merging several pits that have been mined for sand and gravel. The City has already begun park improvements, the most important of which was relocating Cascade Creek so it now flows around the lake instead of through it. This will help keep pollutants found in surface water out of the lake. A weir structure controls flow rates into the creek. The northern part of the park will be a natural area containing the creek and wetlands, along with a trail through a restored prairie area. Once mining is finished in 2015, the City will be able to begin development of the southern portion of the lake. That area will have trails, fishing and non-motorized boating access, and a swimming beach.

Source: Rochester Park Department Cascade Lake Master Plan

The surface elevation of Cascade Lake represents the top of the groundwater table. Since the lake water will consist primarily of groundwater, its clarity will be much better than with surface water.

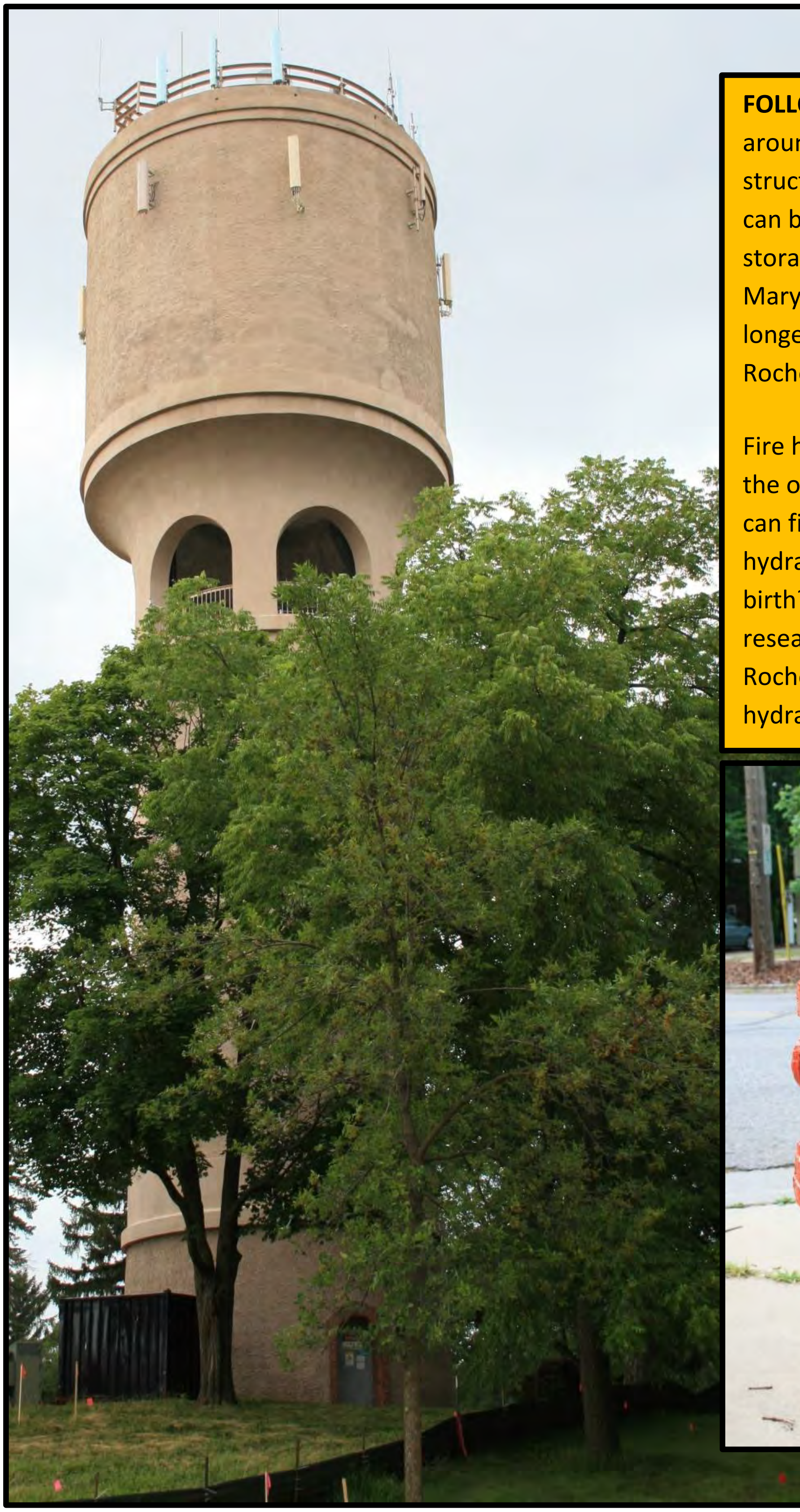
Mine Pit Filled Primarily with Groundwater (7/03)

Mine Pit Filled Primarily with Surface Water (7/03)

Source: Rochester Park and Recreation Department, Cascade Lake Master Plan

Aerial View of the Cascade Lake Area – April 2012

Source: Rochester Public Works



FOLLOWING HISTORY: All around Rochester water structures from the City's past can be found. The water storage facility behind St. Mary's hospital, although no longer in service, was part of Rochester's early water system.

Fire hydrants are dated. What is the oldest fire hydrant that you can find? Can you find a fire hydrant from the year of your birth? Select a fire hydrant and research what was happening in Rochester the year the fire hydrant was installed.

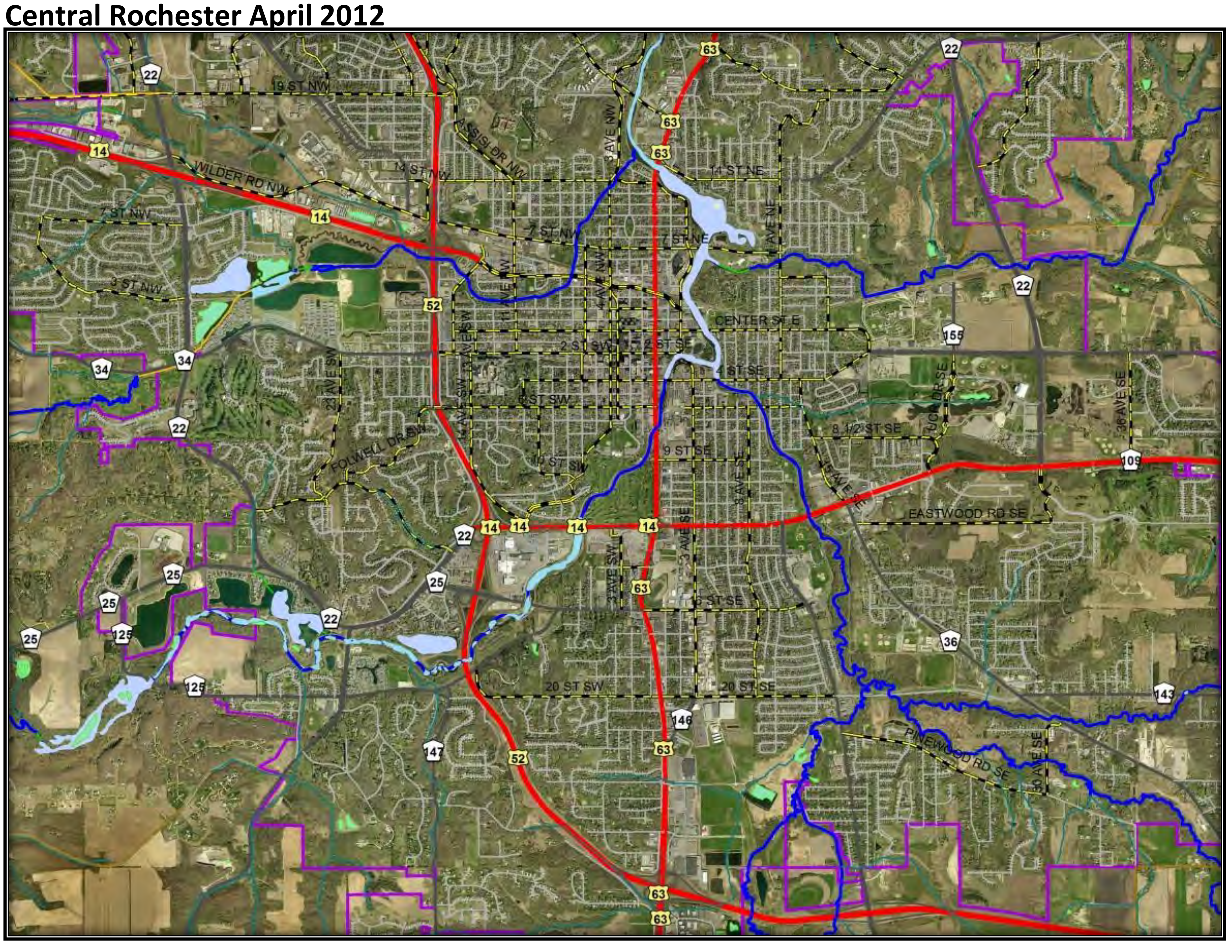
Source: Deb Las

Case Study: Rochester's Mill History

Rochester's first businesses, the flour and saw mills, were powered by running water supplied by the Zumbro River and its tributaries. Mill runs were built to redirect water to the mill foundations where large wheels could then be turned by the water currents. These wheels provided the mechanical energy needed to grind grains into flour or move saws to produce lumber. The mill runs are no longer present, but evidence of their locations still exists.

Below you will find a series of maps from different periods in Rochester's history, along with photos of Rochester's current street scene near 4th Street SE and the Zumbro River. These are arranged from current years to oldest years, so you will be going back in time as you proceed. When you look at them, make inferences about Rochester's mill run history. Where has the path of the Zumbro River changed? Why were the changes made? When were the runs active? What is now located where the runs were once located? State the evidence upon which the inferences are based.

Central Rochester April 2012



Source: Rochester Public Works

The yellow line on the aerial photo below shows the approximate location of a former mill run. The number on each of the eight labels matches a photo number on the following pages. By following the numbers and the photos, you will see what exists today along the former mill run alignment. Why would the mill run end in the middle of an intersection? (Hint: Look at the 1920 Sanborn map.)

Former Mill Run

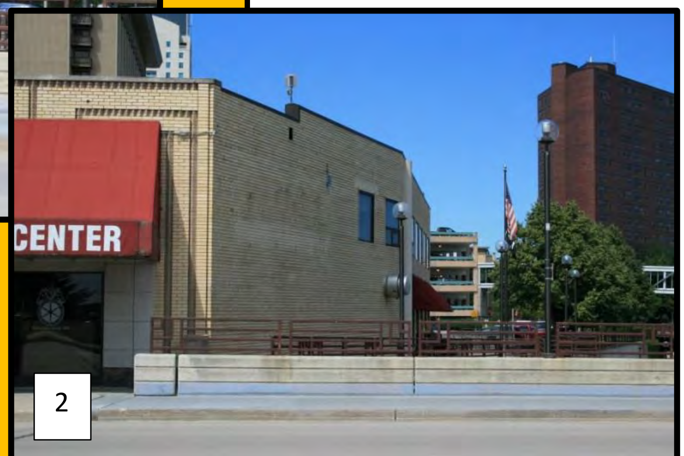
Source: Rochester Public Works

2013 Photos Taken Along the Path of the Former Mill Run

(See map on previous page)

Source: Deb Las


1



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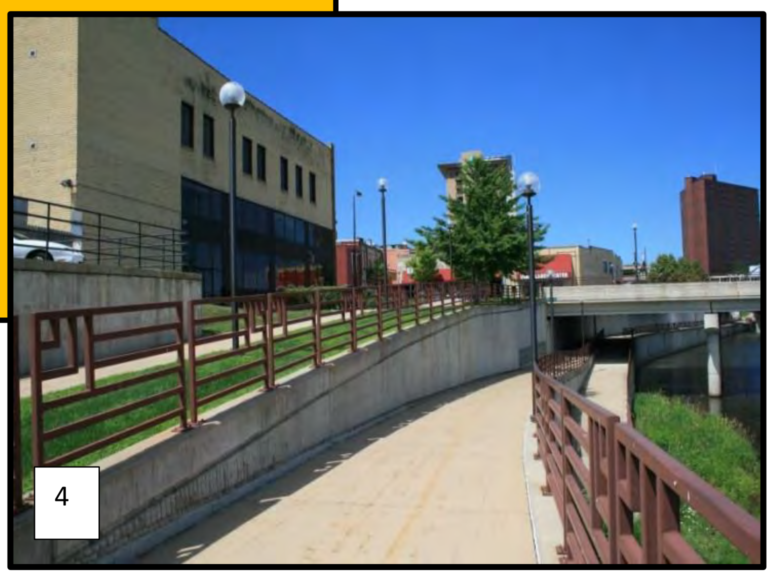
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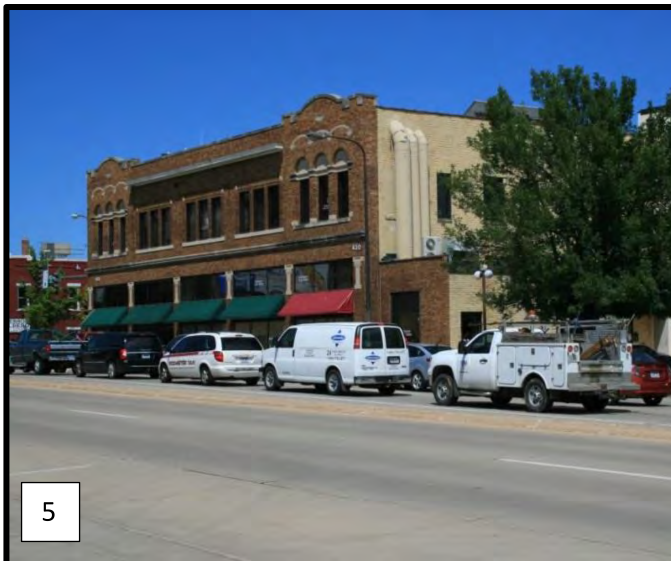

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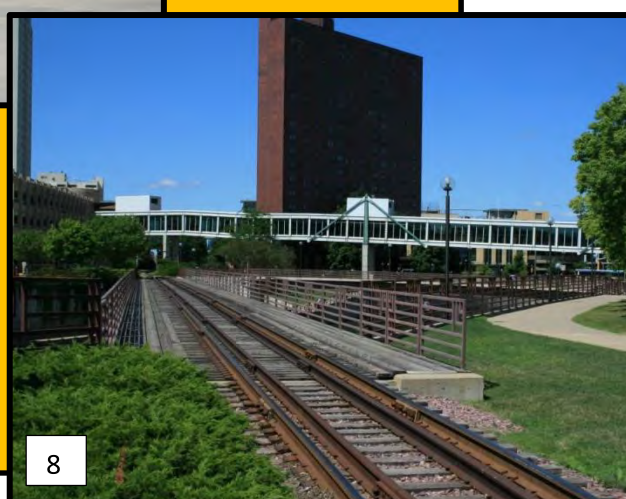
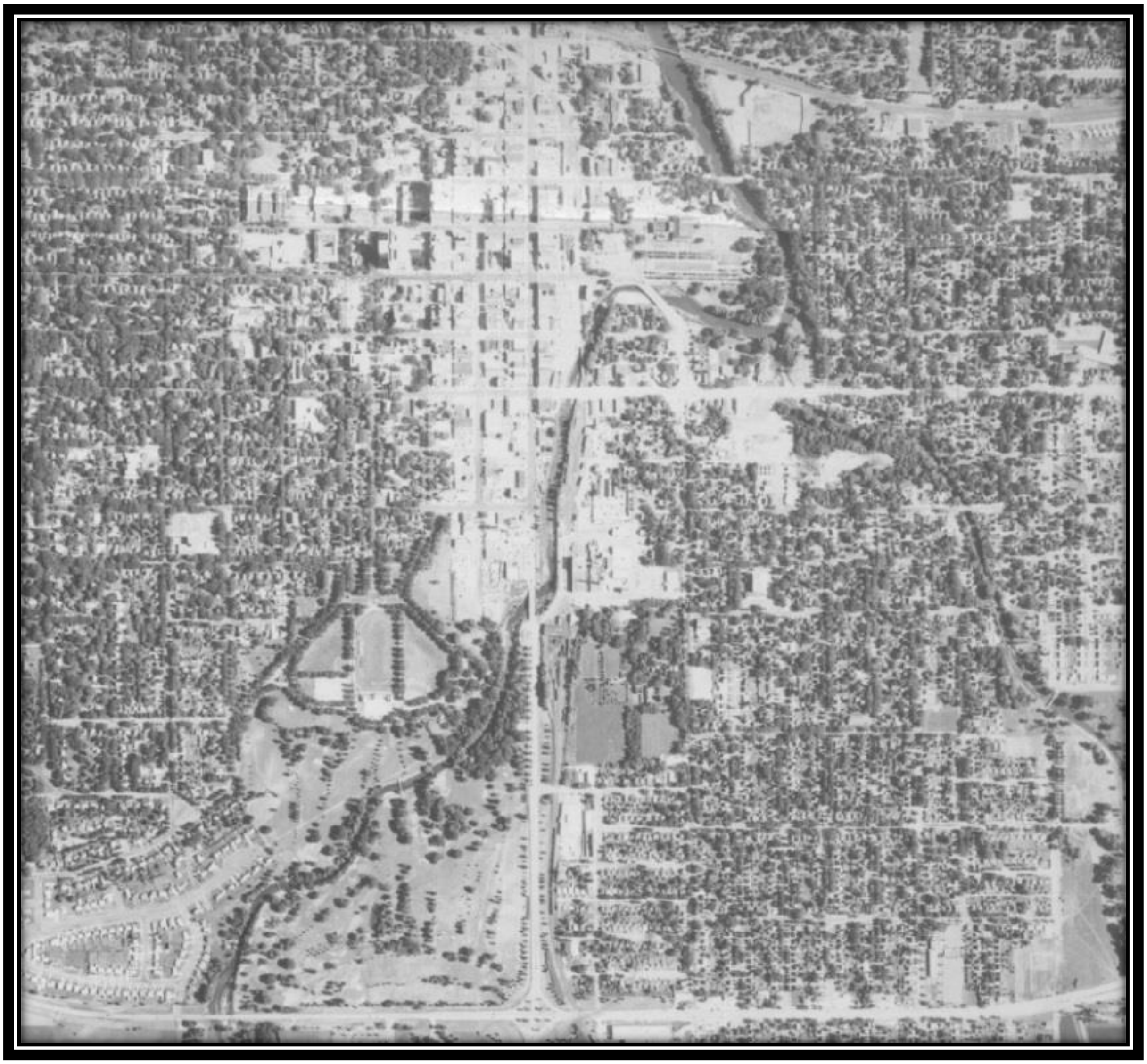
This railroad bridge was not on the mill run, but it once served the Rochester Milling Company flour mill. Can you see it on the Sanborn maps and in the old mill photos?



8

Rochester in 1958: 4th Street South and Broadway Area

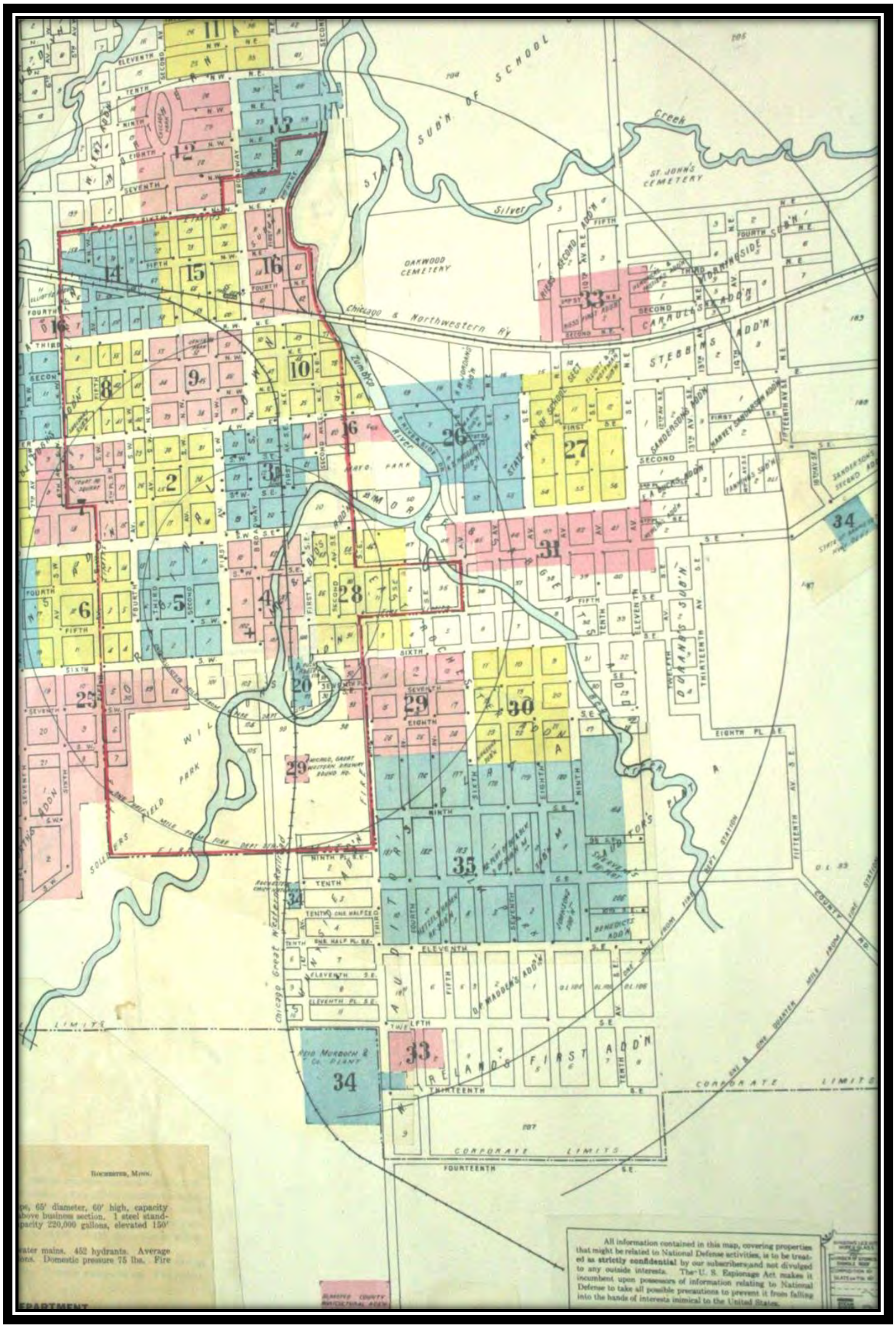


Source: Olmsted County Soil and Water Conservation District

Rochester in 1940: 4th Street South and Broadway Area

Source: Olmsted County Soil and Water Conservation District

Rochester 1928

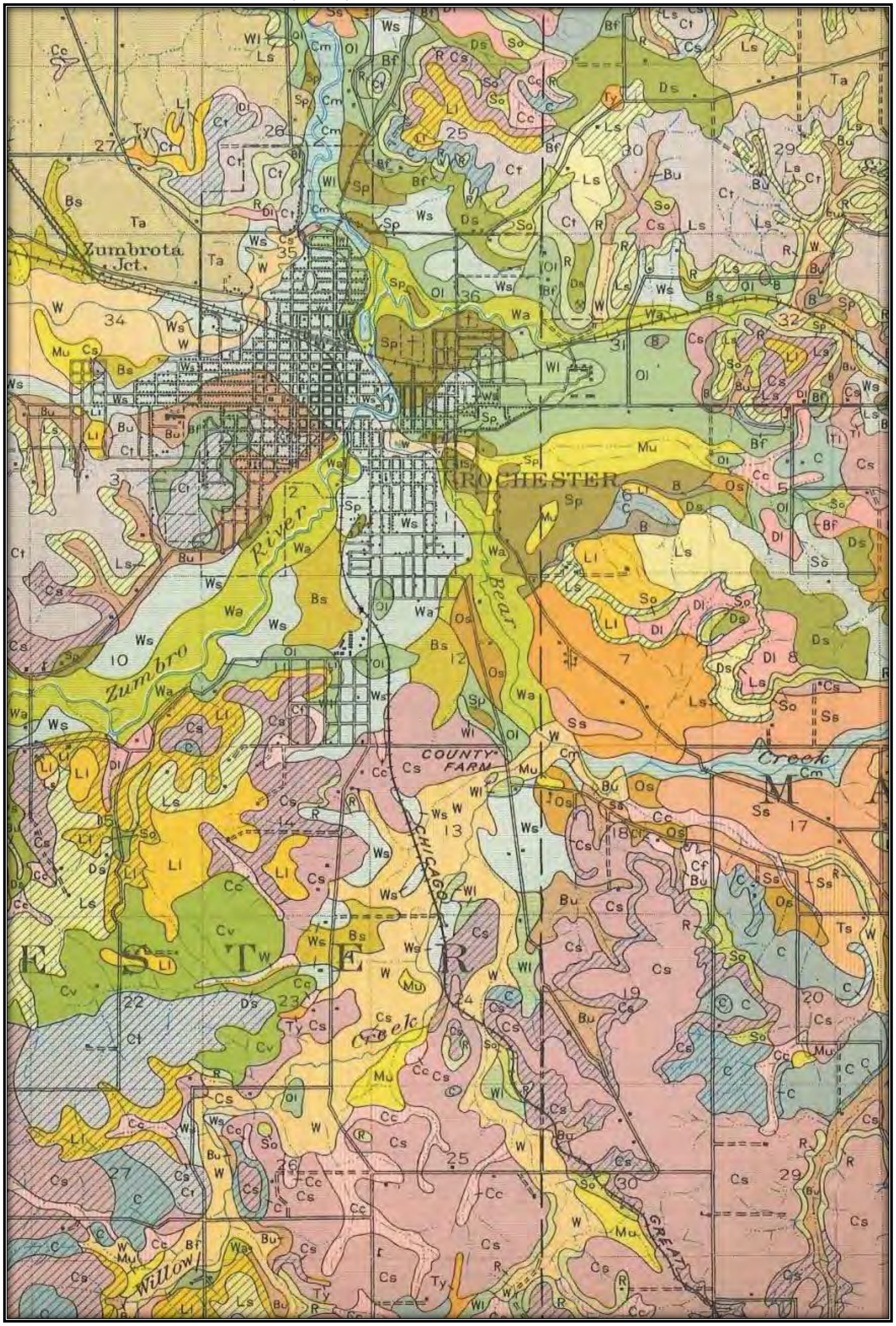


Source: Sanborn Map Company

Rochester 1928

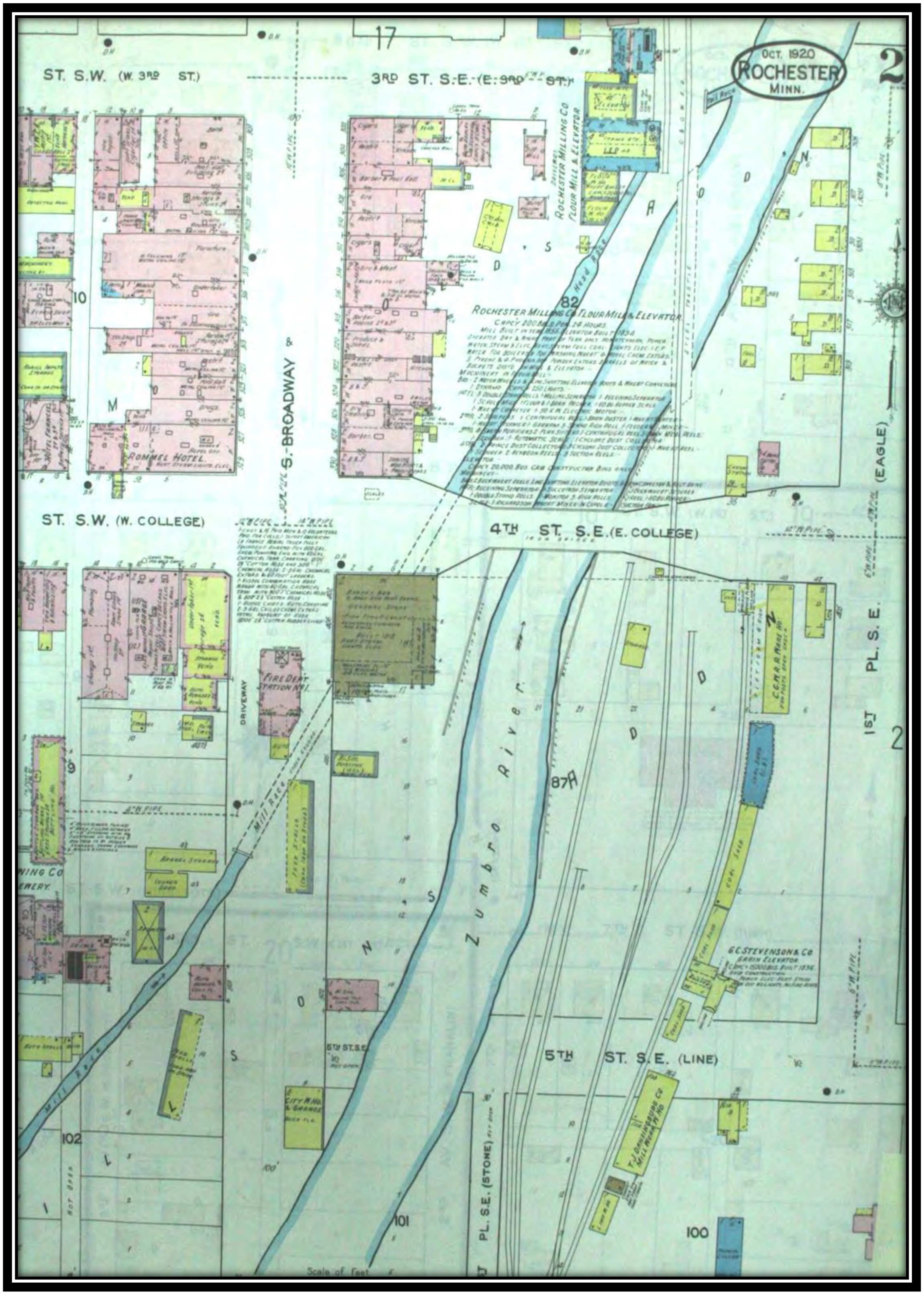
Source: Sanborn Map Company

Rochester 1923 Soil Survey Map



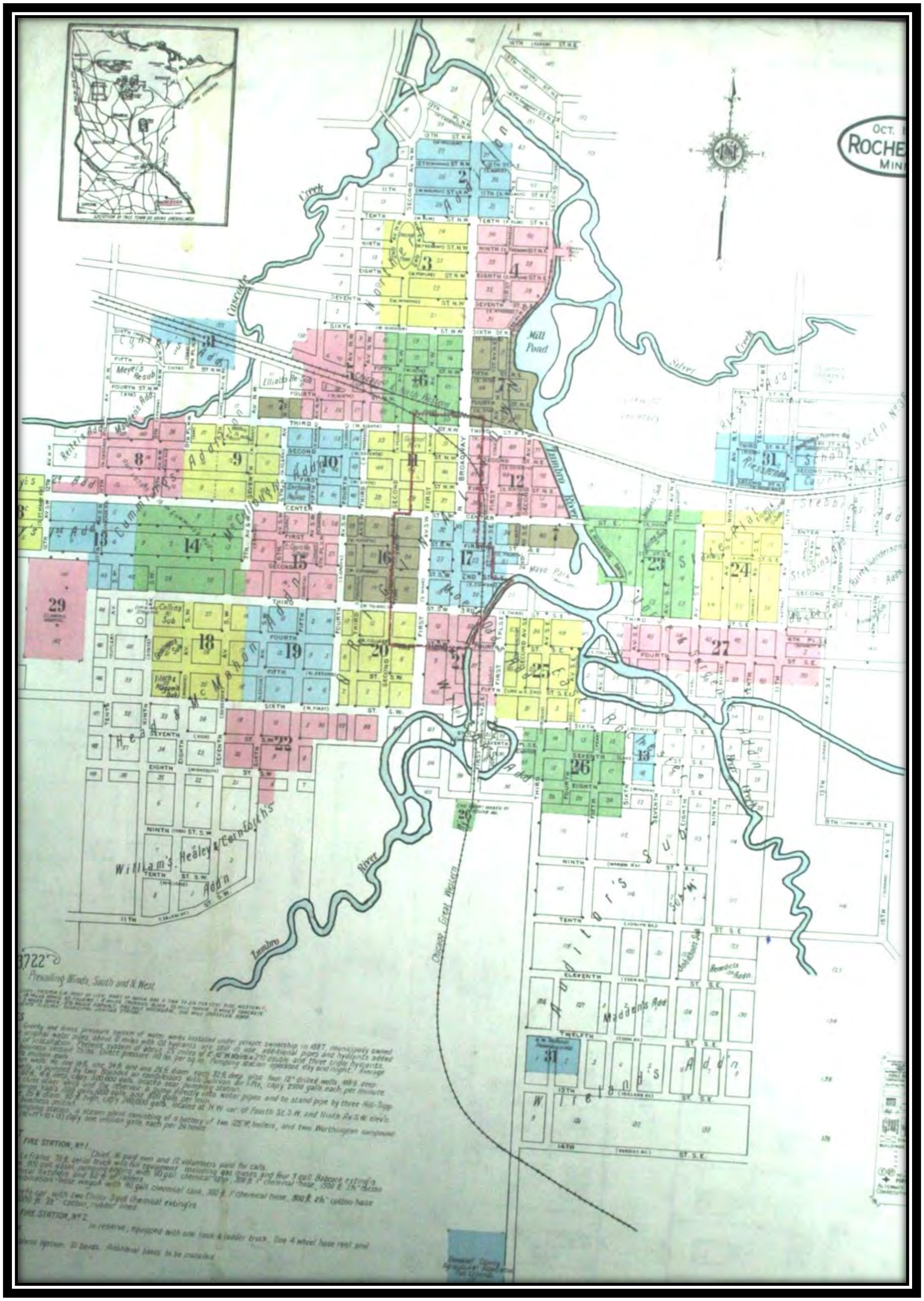
Source: Soil Survey of Olmsted County, Minnesota by J. Ambrose Elwell, G. B. Shivery. B.H.Hendrickson, Mark Baldwin, and A. T. Sweet

Rochester 1920



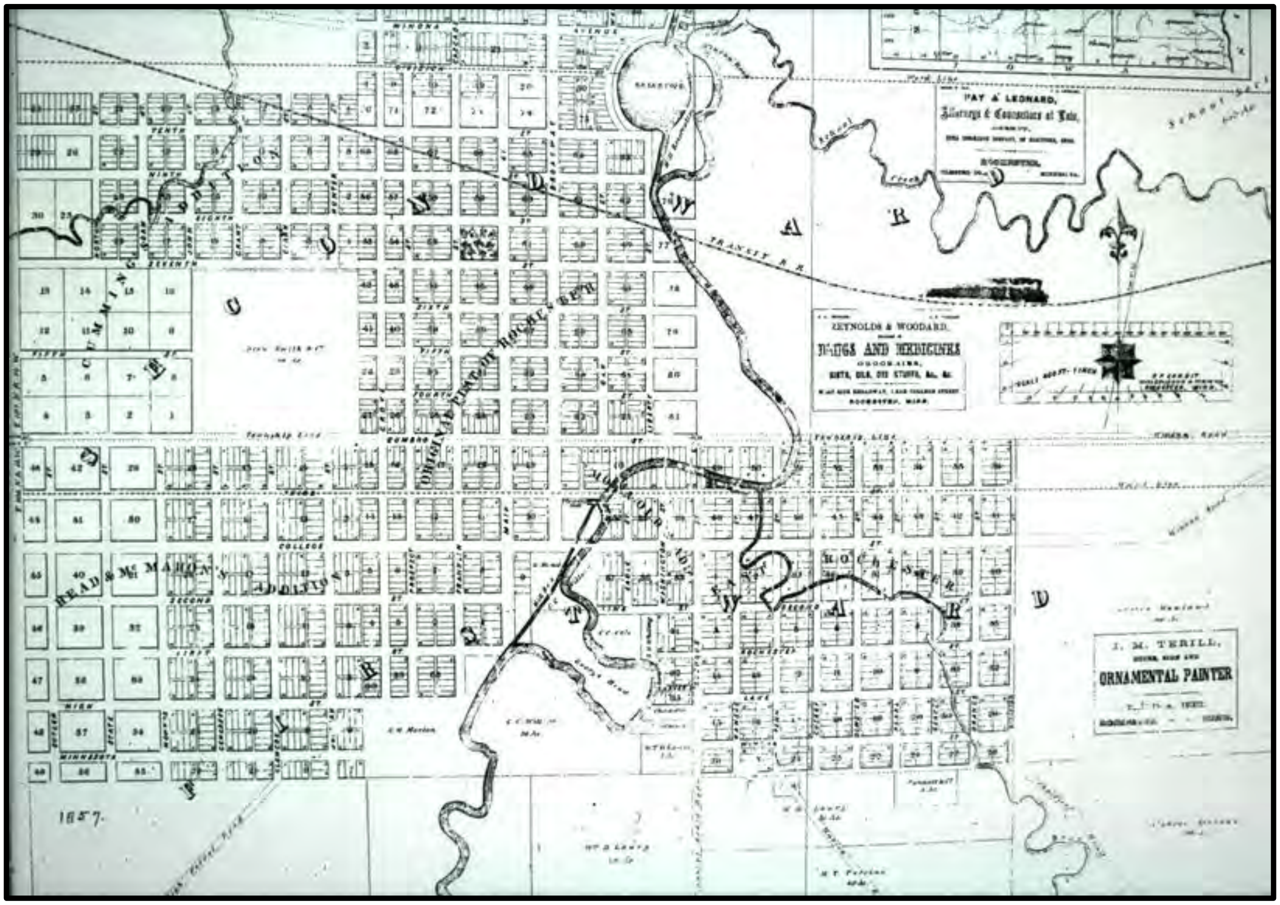
Source: Sanborn Map Company

Rochester 1920



Source: Sanborn Map Company

Rochester in 1857

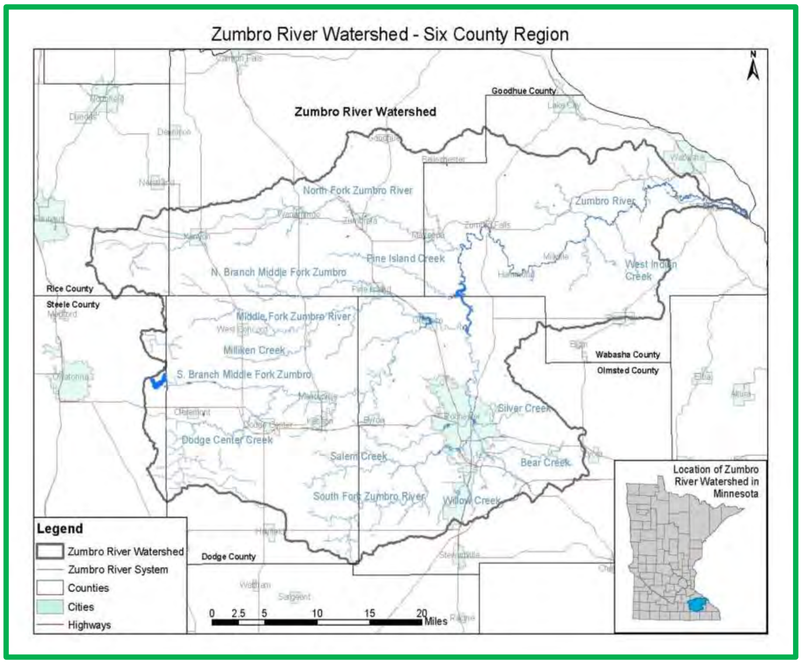


Source: Rochester Public Works

Important Water Dates in Rochester's History

- 1855 or 1859(records conflict) First recorded severe flood in Rochester
- 1858 Rochester incorporated as a city
- 1873 Elevated water tower and wind mill pump installed (4th Street SE & Broadway)
- 1874 Four underground cisterns built
- 1887 Waterworks constructed by Hodgkins, Moffet, and Clark for the City lease
- 1895 Sanitary sewers installed
- 1903 Rochester Water Company flooded
- 1906 (March 4th) Record flood
- 1908 (June 23rd) Fourth Street Bridge in Rochester destroyed by flood and the Rochester Water Company was again flooded
- 1919 Lake Zumbro Hydropower Plant constructed
- 1924 Beginning of an extended dry period that continued intermittently through 1940
- 1925 Chlorinator installed to treat water
- 1926 Rochester's first wastewater treatment plant constructed
- 1929 Beginning of severe drought in Midwest peaks in 1934 (Dust Bowl Period)
- 1940 Upper Zumbro Soil Conservation District is formed (now the Olmsted SWCD)
- 1942 (June 4th) Cascade Creek floods resulting in 1 death
- 1951 (July 21st-22nd) First of 15 record floods from 1951 through 1974 (see Rochester Flood Severity Table)
- 1958 Rochester's second wastewater treatment plant constructed
- 1960 Fluoride used in water system
- 1962 Planning for South Zumbro Flood Control Project begun
- 1976 Drought in Midwest
- 1978 (July 5th and 6th) Worst recorded flood in Rochester history
- 1983 NRCS flood control reservoir project approved
- 1986 Corps flood control river channel project approved
- 1986 (September 21st) Rochester floods
- 1988 Record setting drought in Midwest
- 1990 Olmsted County's First Water Management Plan adopted
- 1995 Corps flood control river channel project completed
- 1996 NRCS flood control reservoir project completed
- 2001 (April 6th) First post-flood control project record rainfall event; minimal flooding
- 2003 Rochester obtains its first storm water management permit
- 2004 (September 15th) Record rainfall event, minimal flooding
- 2007 (August 18th – 19th) Record rainfall event – minimal flooding
- 2010 (September 23rd) Record rainfall event, minimal flooding

Chapter 3 - Rochester's Natural Water Features

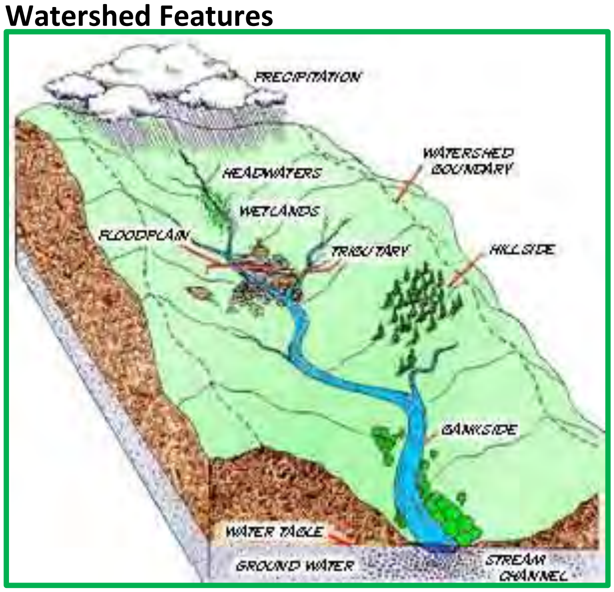


Source: Zumbro Watershed Partnership

With the exception of about 660 acres of the southern portion of the airport property, Rochester lies within the South Fork Zumbro River watershed. That means that everything that is left on the land surface in Rochester has the potential to be washed into the South Fork of the Zumbro River after each rainstorm or snowmelt.

A watershed is defined as all the land area that drains to a waterway. The boundaries of a watershed are based on topography. The highest elevations surrounding a water body become the boundaries or watershed divides. It is easy to imagine how the Continental Divide in the Rocky Mountains can separate flow from the Pacific to the Atlantic Oceans, but even flatter areas like Rochester have divides. They are represented by the black watershed boundaries shown on the map above. The Zumbro Watershed drains about 297,000 acres and is made up of three smaller subwatersheds, one for each tributary: the South Fork, the Middle Fork, and the North Fork. A common misconception is that water flows from north to south, or from the top of a map to the bottom. That's not true. Water always runs downhill from divides; it does not follow a certain direction on a map. Look at the Zumbro River: it starts flowing from west to east, but then turns north before heading east again before it empties into the Mississippi River. These direction changes provide clues about how the glaciers formed our topography and the elevation changes in our watershed.

Watershed Features



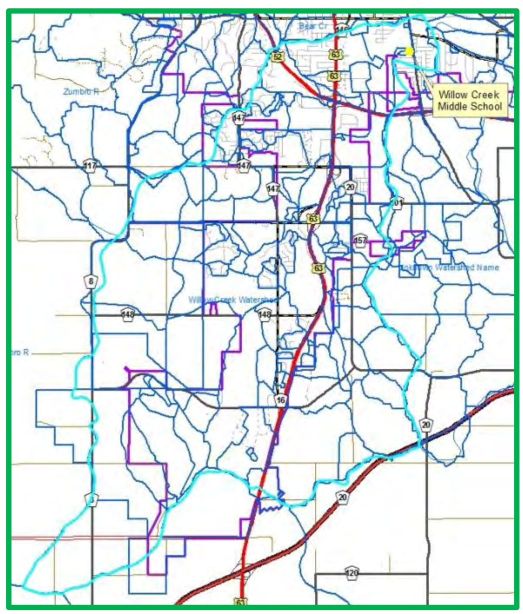
Source: www.rcrc.nm.org/glossary/gl-watershed.html

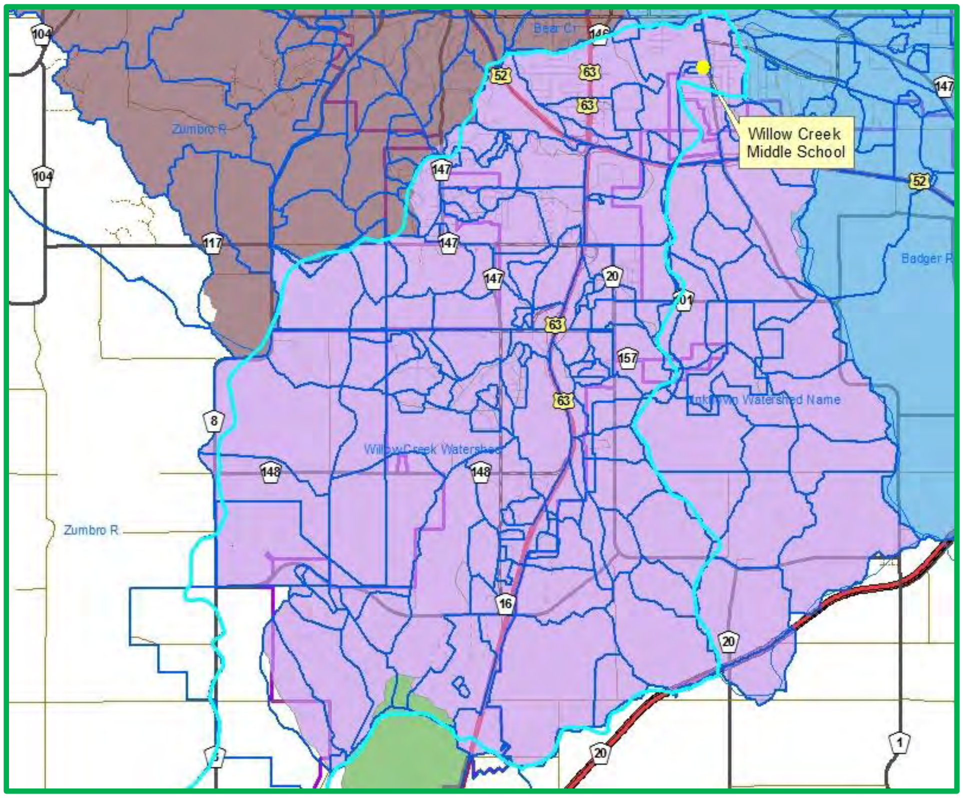
Mississippi River Basin

Source: http://www.epa.gov/gmpo/lmrsbc/

The Mississippi River flows south to the Gulf of Mexico. Imagine a water drop that fell in Rochester travelling all the way to New Orleans! Along the way, many tributary rivers join the Mississippi and each of those major rivers (like the Missouri, the Ohio and the Arkansas) has its own watershed boundaries, too. The Zumbro Watershed is part of the larger Upper Mississippi Watershed, which is part of the entire Mississippi River Watershed that covers such a large part of the U.S.

As you can see, watersheds can be defined as large or small areas. To understand how watersheds are nested within each other, let's look the Willow Creek Middle School and show how its watersheds fit together. (The maps below are from Rochester Public Work's Geographic Information System - GIS, which is a database that stores its storm water management information.) When rain falls onto the south half of Willow Creek Middle School, it flows to a small, on-site, private storm water management Pond (#229 in the picture below). The drainage area flowing to that pond is outlined by the royal blue watershed boundary. (Water falling on the north half of the school will flow directly to Willow Creek, without treatment.) There are dozens of the small (royal blue) watersheds within the watershed

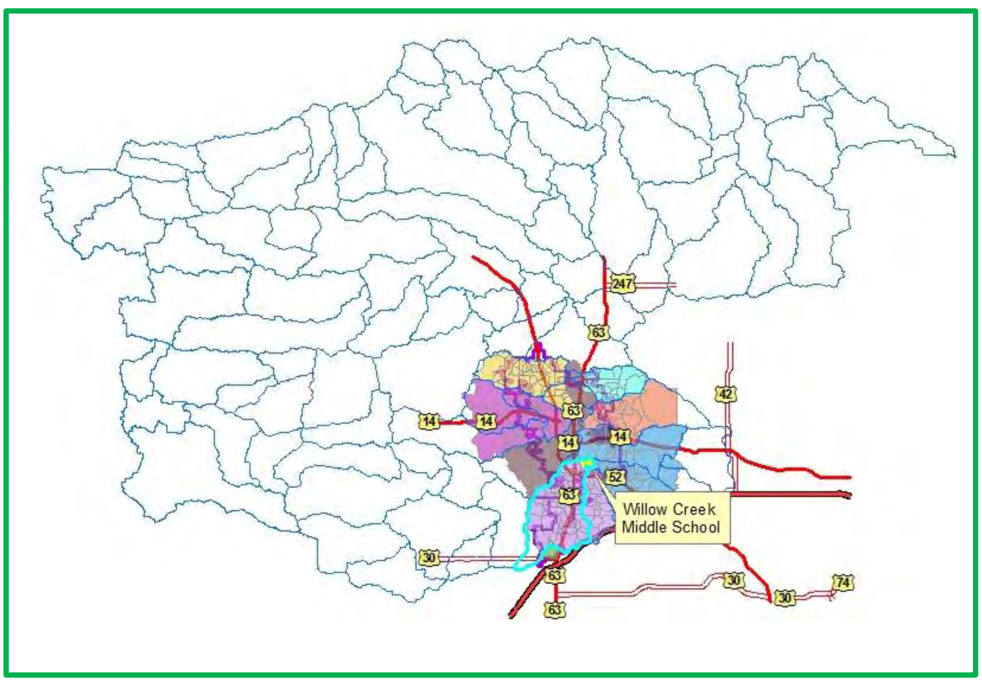




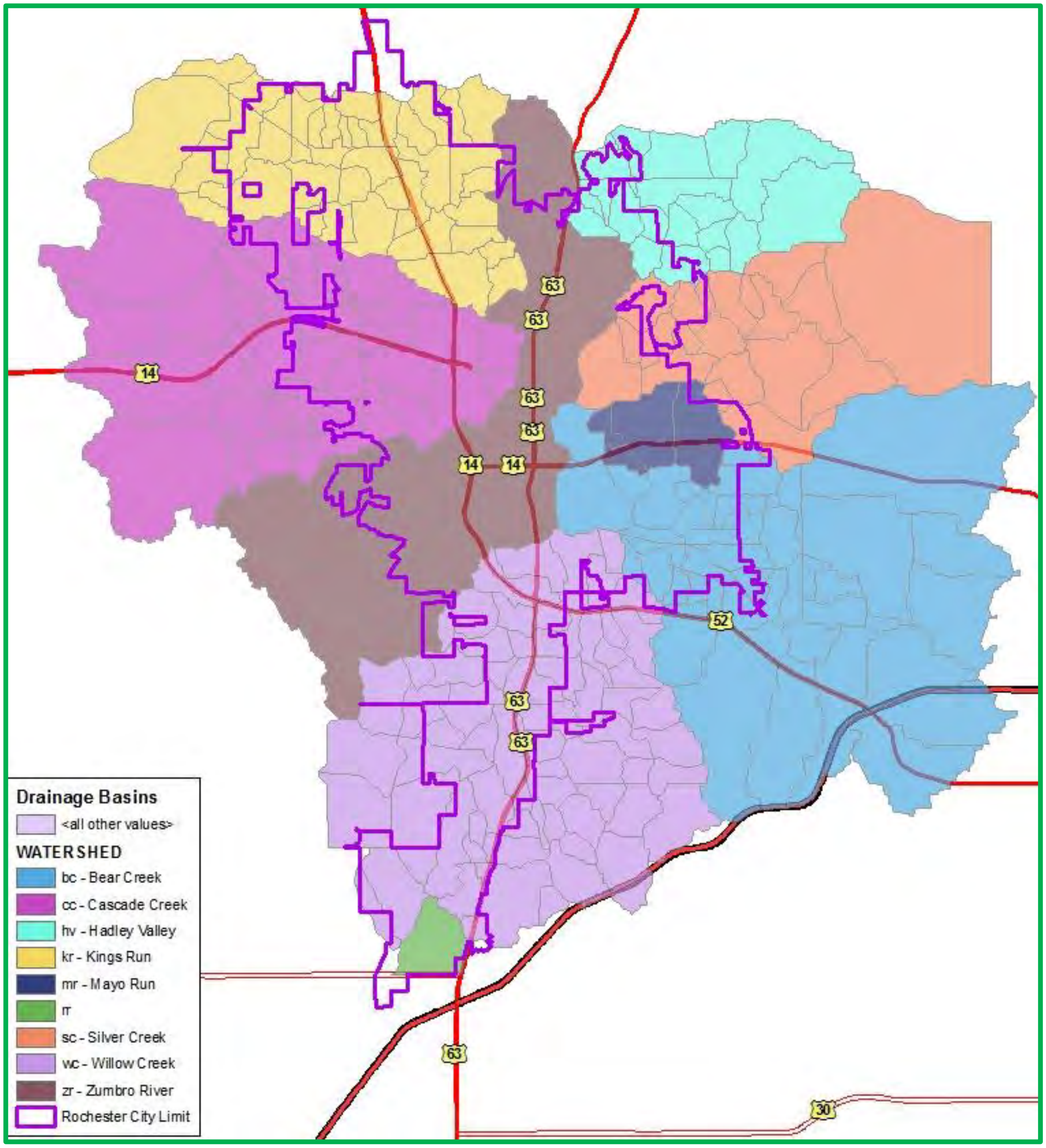
boundary for West Willow Creek (aqua blue boundaries).

The West Willow Creek Watershed (aqua boundaries) together with the East Willow Creek Watershed forms the purple Willow Creek Watershed.

The purple Willow Creek Watershed is one of several watersheds in Rochester that are part of the Zumbro River Watershed – that is part of the Upper Mississippi River Watershed – that is part of the Mississippi Watershed. All water is connected!



Which watershed (or drainage basin) do you live in?



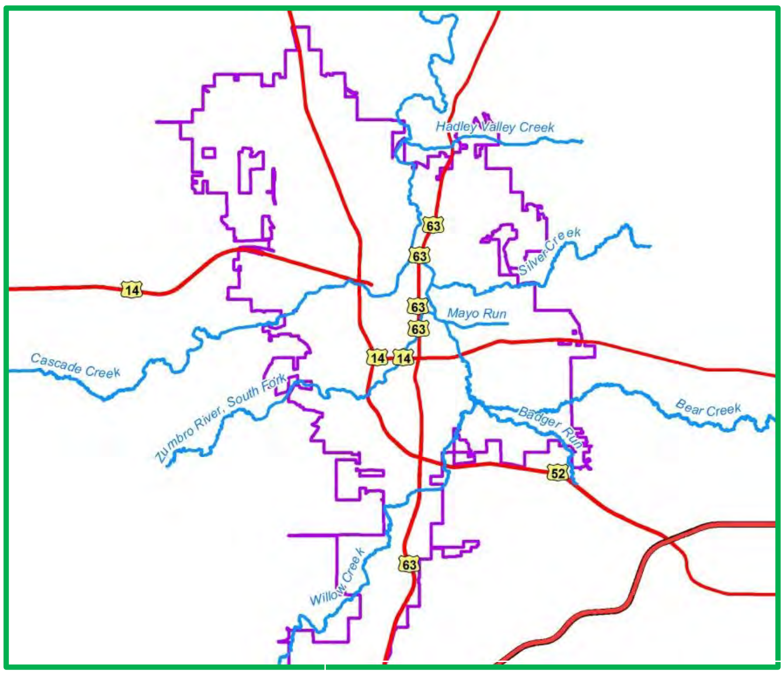
The EPA has a website that stores data about watersheds. To find out more information about the Zumbro Watershed, check out their link http://cfpub.epa.gov/surf/huc.cfm?huc_code=07040004

Zumbro River & Tributaries

Rochester was built in a river valley formed by the South Fork of the Zumbro River and its tributaries. Several creeks join the Zumbro River within the City limits, starting from the south and working clockwise: Willow Creek, Cascade Creek, Kings Run Creek, Hadley Creek, Silver Creek, Mayo Run, and Bear Creek. Not all rivers and streams carry water all the time. Those that always have water are called perennial streams, while those that don't are intermittent streams. Badger Run is a small tributary to Bear Creek and Quarry Hill Creek is a tributary to Silver Creek. They are examples of intermittent streams. Just because a stream is small does not mean it will be intermittent. Mayo Run has a constant water supply from hillside discharges and wetlands.

Intermittent means starting and stopping at times, so an intermittent stream is wet and dry at different times

Rochester Rivers



Source: Rochester Public Works

For current data about the flow of the Zumbro River through Rochester, go online at http://waterdata.usgs.gov/nwis/uv/?site_no=05372995&PARAmeter_cd=00065,00060,00062,72020 .

Wetlands

Early settlers to the region quickly learned that the native prairie lands had excellent soil for farming. They also discovered what historical documents refer to as "unimproved lands". The reference referred to steep hillside slopes and to wetlands that could not be plowed. In the Rochester area, wetlands are found both along the rivers and on hillside edges. Developers also thought the wetlands had little value, so they were commonly filled in so they could be built upon.

Today, we better understand the value of wetlands. Wetlands are natural filters and sponges. They serve as barriers that protect our rivers and lakes from polluted surface water. They are able to hold large amounts of water and slow running water during large rainfall events, thus prevent flooding. During droughts, wetlands can release water to maintain stream flow and may help recharge of underground water supplies. Wetlands provide wildlife habitat. Now there are federal, state and local laws that protect all these wetland values: Section 404 of the federal Clean Water Act, the Minnesota Wetland Conservation Act, and the City's Wetland Conservation Ordinance Ch. 59A. Wetland regulations alone are complicated, but because they are also related to other types of water regulations and involve several governmental agencies. Water law is very complex.

Wetlands can be harmed by pollutants, such as excess sediment and nutrients. Changes in hydrology can also impair wetlands. Invasive species can also destroy native wetland habitat. In Minnesota, the majority of the state has lost about half of its original wetland habitat. Some counties filled in up to ninety percent of their wetlands before Minnesota laws were enacted in 1991. Local governments did not start dealing with wetland regulations until 1993. Neither Rochester nor Olmsted County has calculated the loss of original wetland acres within their boundaries. In urban areas, wetlands can no longer be destroyed in any way unless there is an approved plan in place to replace the lost acres with twice as many wetland acres nearby.

Wetland at Autumn Ridge Church

Source: Deb Las

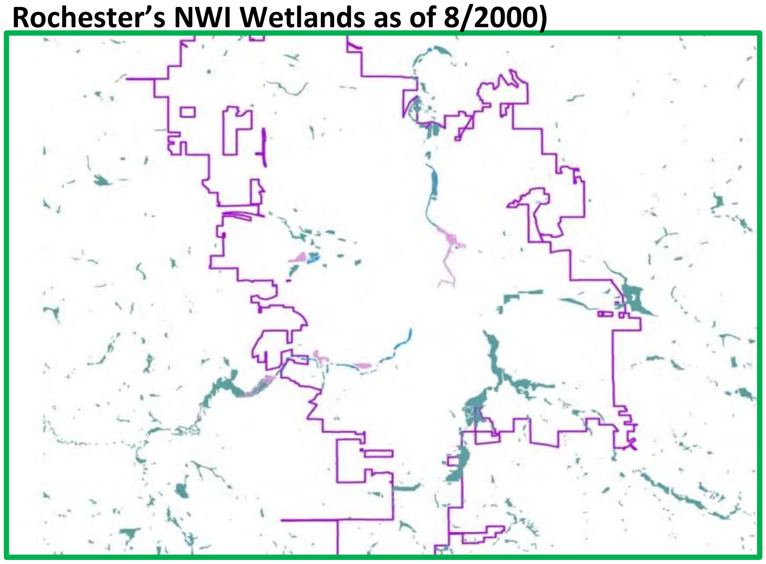
Wetlands are highly variable. They can range from an open water wetland to land that is dry part of the year. There are three things that all wetlands have in common: hydric (wet) soils, standing water or saturated soil for part of growing season (hydrology), and plants that like wet conditions (vegetation). If only one or two of those characteristics are present, the area is not classified as a wetland.

Several different classification systems are used to describe the different types of wetlands. Two commonly used systems are the Circular 39 system and the Cowardin system, both developed by the U.S. Fish and Wildlife Service. The Circular 39 system divides Minnesota wetlands into 8 types. The Cowardin classification system expands on this by creating sub-classifications that can be used to classify sub-portions of a wetland. To learn more about wetlands and see 7 of Minnesota's 8 wetland types, visit Cascade Meadow Wetlands & Environmental Science Center (2900 19th St NW).

Wetland Types Found in Minnesota

1. Seasonally Flooded Basins or Floodplains
2. Wet Meadows
3. Shallow Marshes
4. Deep Marshes
5. Open Water Wetlands
6. Shrub Swamps
7. Wooded Swamps
8. Bogs(only this type can't be seen in Rochester)

Rochester's NWI Wetlands as of 8/2000)



Source: Rochester Public Works

The U.S. Fish and Wildlife Service has been producing wetland maps and geospatial wetland data for the United States since the mid-1970s. Their inventory is called the National Wetland Inventory (NWI) and it classifies wetland into three groups: lacustrine, palustrine, and riverine depending on whether the wetlands were likely formed in a lake setting, a floodplain, or river setting. The NWI is good starting point to determine whether wetlands may be present on a parcel of land. To learn more, go to: www.fws.gov/wetlands/NWI/index.html.

Fens

Fens are wetlands that are primarily fed by groundwater instead of surface water. Calcareous fens are a type of fen containing unique plant species that have adapted to soils that are rich in calcium and magnesium bicarbonates. Calcareous fens are the rarest wetland plant community in Minnesota (and also one of the rarest in North America) and they are specially protected as Outstanding Resource Value Waters by state law. Within Rochester, there are five known calcareous fens that have been identified by the Department of Natural Resources (DNR). There are also similar wetlands at other locations that may be calcareous fens, but those have not undergone classification by the DNR. In Rochester, calcareous fens are most commonly located on shallow terraces within the Decorah Edge geologic setting, but they are also found where groundwater discharges from glacial till deposits.

Rochester's Calcareous Fens:

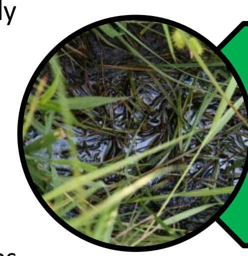
1) High Forest 15 (by the airport)
2) Marion 8 (SE Rochester)
3) Joyce Park (SE Rochester)
4) Rochester 23 (SW Rochester)
5) Haverhill 19 (NE Rochester)

Haverhill 19 Calcareous Fen

Source: Deb Las

Check out the Calcareous Fens Fact Sheet: www.bwsr.state.mn.us/wetlands/Calc_fen-factsheet.pdf

The Decorah Edge is a group of bedrock formations (the Decorah, Platteville, and Glenwood shale layers), that create an impermeable layer between the upper Galena Limestone layer and the lower St. Peter sandstone layer. Water can move downward through the upper permeable rock unit until it reaches the shale layers. There the water can only move downward through the shale very slowly. But the water can also move more quickly along the top of the shale until it reaches a hillside or road cut. The Zumbro River and its tributaries carved a valley through the rock layers surrounding Rochester, so there are many hillsides

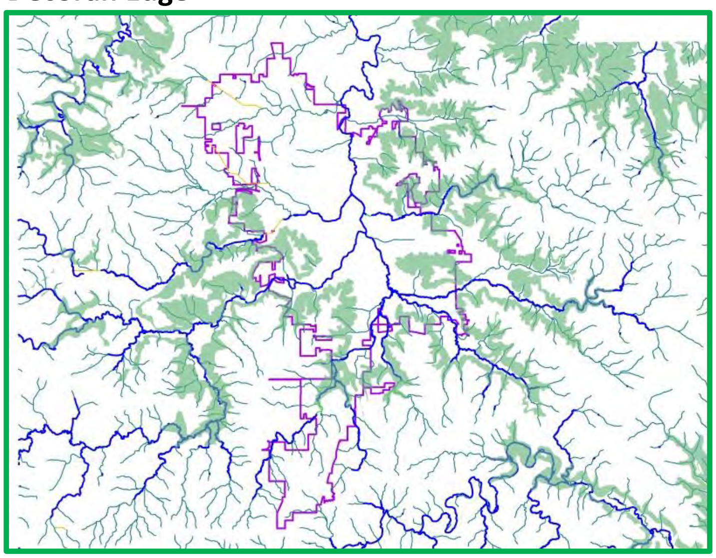


A seep is a moist place where groundwater reaches the surface.

where the shale is exposed and groundwater can discharge. Not all hillsides experience discharge, but where discharges occur, they can be in the form of focused discharge (springs) or diffuse discharge (seeps). A study by the US Geological Survey (USGS) has shown that a hillside fen can take up excess nitrogen from the Galena aquifer before it is recharges the St. Peter aquifer, thereby protecting our water supply.

The Decorah Edge (shown in green on the following map) surrounds much of the City (City limits shown in purple). The Minnesota Geological Survey (MGS) has done many studies to learn about groundwater recharge in the Rochester area. They have learned that 50% of the groundwater recharge comes from the Decorah Edge area. Together, the MGS and USGS point to the importance of protecting hillside wetlands in Rochester.

Decorah Edge



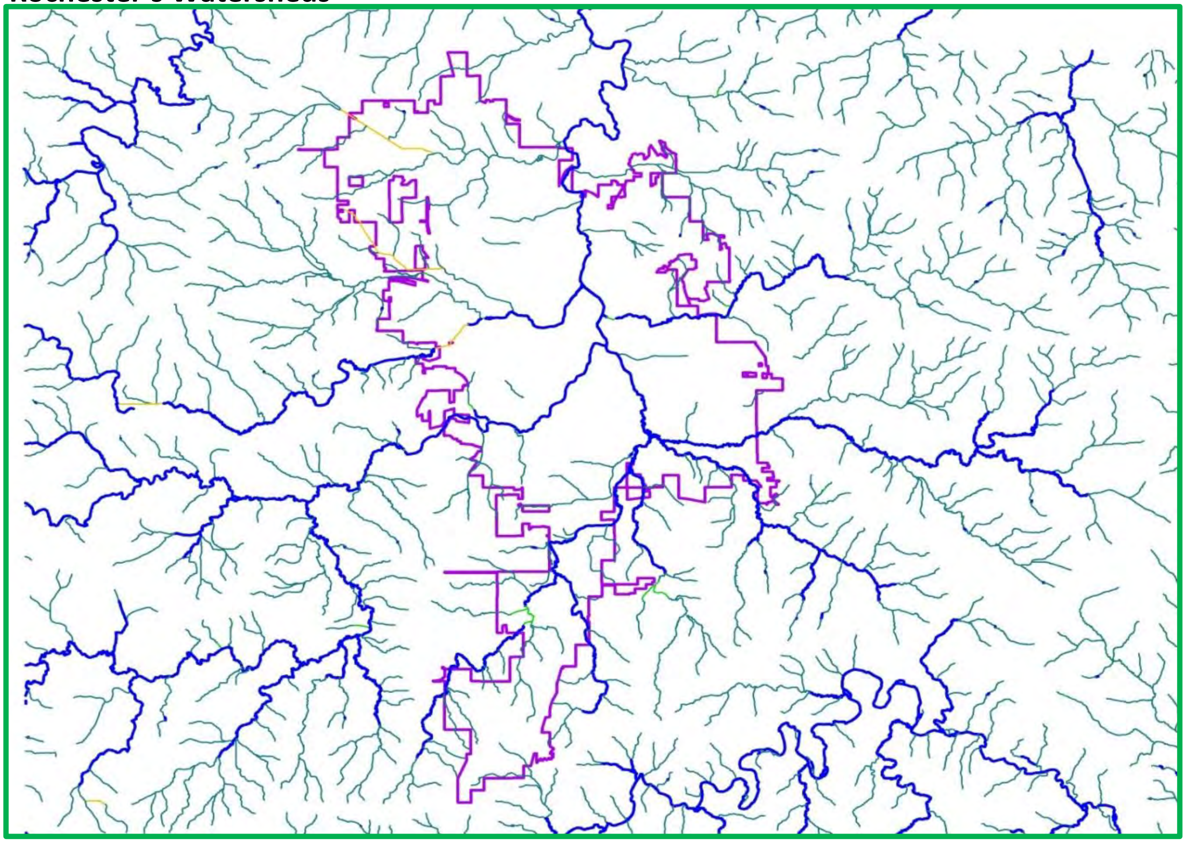
Source: Rochester Public Works

The other important natural water feature in Rochester is groundwater. It is discussed in Ch. 1 (Water Cycle and Geology) and in Ch. 5 (Water Supply).

Case Study: Watersheds

Try drawing your own watershed boundaries. The map below shows the Zumbro River and its tributaries. Draw lines around the streams to outline the divides and color in the watersheds. (An answer key is provided on the next map). The City limits are outlined in purple. Students should be reminded that water flows downhill from divides and the divides separate watersheds.

Rochester's Watersheds

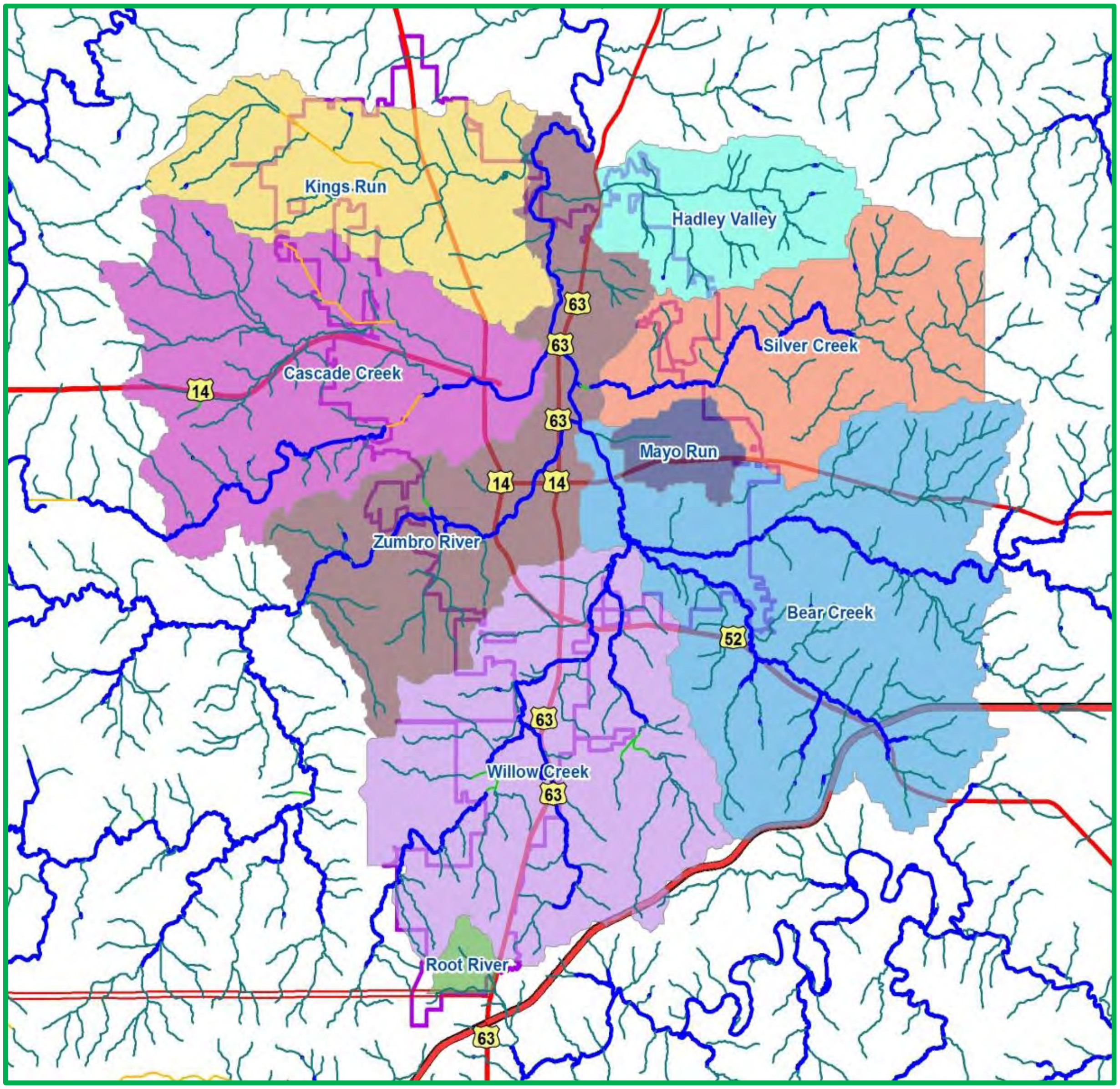


Source: Rochester Public Works

Part 1 Questions:

1) Compare your map to that of others and the suggested answer key. Do they match exactly?
2) What are the differences?
3) Where are the higher elevations on the map? How can you tell?
4) Where are the lever elevations on the map? How can you tell?
5) Select a random point on the map. With your finger, follow the flow of water across the map. Where do you end up?

Answer Key - Rochester's Main Watersheds



Source: Rochester Public Works

Part 2 Questions:

1. Which of Rochester's smaller watersheds is your school in?
2. What is the shortest distance from your school to the river or creek that drains your watershed?

Chapter 4 - Rochester's Constructed Water Bodies

In lake rich Minnesota, Rochester is lake poor. In fact, Rochester is located in Olmsted County, one of only four counties in Minnesota that does not have a natural lake. (The others are Mower, Pipestone and Rock counties.) In the 1930's, Rochester citizens wouldn't accept what nature gave them, however, so they created the City's first lake for a park. Both public and private landowners have continued the practice of modifying natural waterways for many reasons: for recreation, to protect the City from flooding, to provide storm water management, to create an aesthetic feature for a development, to extract sand and gravel, and to produce power.

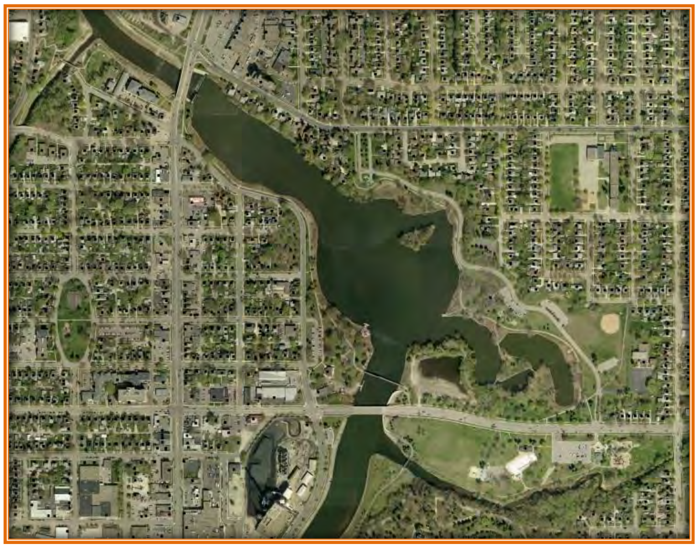
Silver Lake Reservoir

Silver Lake is actually a reservoir that was created by first, hand-digging a basin to hold water and then constructing a dam from 1935-1936 to back-up river water. It was built for half a million dollars during the 1930's Great Depression as a work relief project, providing work for over 400 unemployed men. Various New Deal programs supported the effort. The project was started by the Civil Works Administration (formed as part of the Federal Emergency Relief Act in 1933), then joined by the State Emergency Relief Administration in 1934, and later transitioned to a Works Project Administration project in 1935. Today, the water surface area of the Lake is nearly 40 acres. The land on which the Lake now lies was once a combination of small gravel and sand pits, poor pasture land, and "unimproved" marshy land.

Silver Lake 2013

Source: Rochester Public Works

Aerial Photo of Silver Lake 2012



Source: Rochester Public Works Department

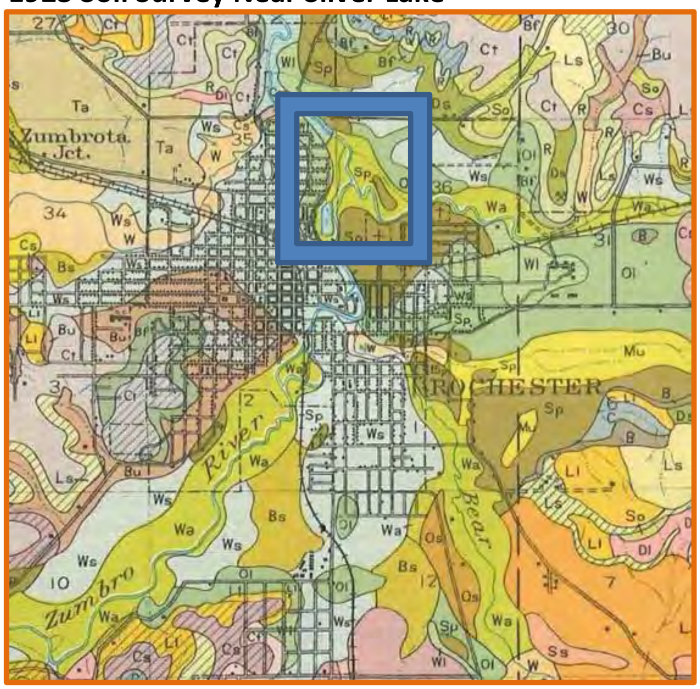
It is interesting to note that the sand from one of the pits that formed Silver Lake was known to be of such high quality that it did not need to be washed and it was used to build the original Kahler Hotel and other buildings in the area. Architect Hugh Vincent Feehan was hired by the City to design the layout of the lake and park surrounding it so it could be a recreational feature for the City. The original lake created was 17 acres, with a lagoon and small island to the east. Three arched bridges spanned to the island. Silver Lake Park was dedicated June 25, 1937.

Compare the aerial photograph of Silver Lake today with this 1923 soil survey map of Rochester. Can you see that today's east lagoons were once the Silver Creek channel? A new confluence of Silver Creek with the Zumbro River was another result of the Silver Lake project.

Silver Lake Characteristics:

Lake Area (acres): 40
Maximum Depth (ft): 11
Water Clarity range (ft): 0.5 – 4.5

1923 Soil Survey Near Silver Lake



Source: Soil Survey of Olmsted County, Minnesota by J. Ambrose Elwell, G. B. Shivery. B.H.Hendrickson, Mark Baldwin, and A. T. Sweet

Source: Deb Las

Silver Lake

Source: Deb Las

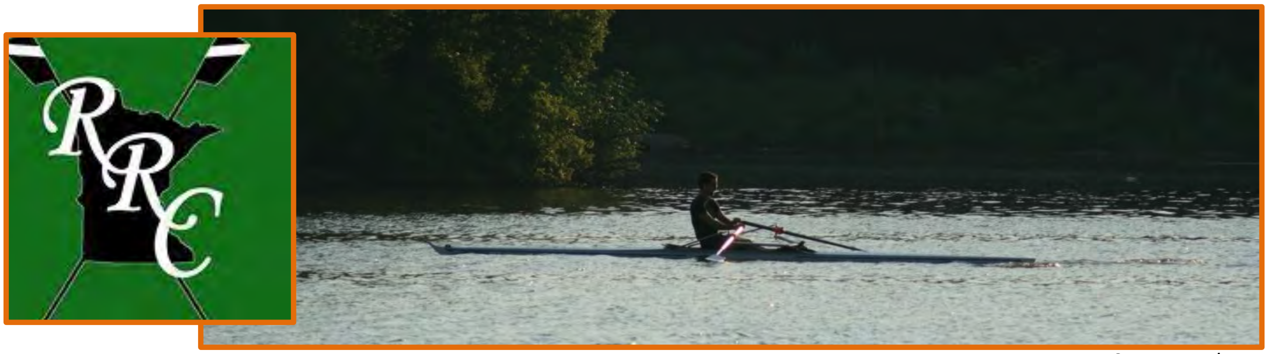
Today, the Silver Lake dam is managed by Rochester Public Utilities (RPU). It holds back the waters of the Zumbro River, forming the Lake and controlling water levels. The Lake acts as a stilling basin for the river, causing the water to slow down. With a decrease in velocity, the river cannot carry heavier materials, so sediment collects on the lake bottom. Over time, as sediment collected in the Lake, the Lake depth and volume decreased. Dredging the Lake to restore depth and recreational capacity was found to be necessary as early as 1945. The City purchased a floating dredge so it could operate seasonally from 1947 to 1962, until a flood destroyed the equipment. Dredging resumed in 1964 when equipment was replaced and continued in 1967, 1969, 1975, 1976, 1980, and also during the construction of the City's Flood Control Project between 1986 and 1995. Dredged material was used to fill the Old Mill Pond (where the Silver Lake Power Plant is currently located), old sand pits, and a swampy area south of 7th Ave NE and the Izaak Walton League cabin. When the sediment level reaches the threshold set by the Army Corps of Engineers for the flood control channel, a channel dredging project within the Lake will be planned.

The stretch of the Zumbro River most frequently dredged was designed as a wider channel by Army Corps engineers to slow the flow of water so sediments would settle out. That particular stretch was chosen because the bottom of the river channel is bedrock. That makes it less desirable habitat for fish and an easier location to collect sediment so flood storage capacity can be restored.

Dredging is the removal of bottom sediments. Watch a YouTube video of a Zumbro River dredging project here:

http://www.youtube.com/watch?v=eaVGtc5sG9Y

Silver Lake Park was originally created for recreation (See Chapter 2: Rochester's Water History) and it is still heavily used for that purpose today. Trails with benches encircle the lake. Tables and shelters are available for picnics. It is the site for the annual 4th of July concert and fireworks show. A private business rents paddleboats on the west bank. Silver Lake has been the home for the Rochester Rowing Club since 1992.



Source: Deb Las

A fishing pier and several limestone pathways make fishing access easy. The following table identifies the types of fish that are present in Silver Lake.

Source: David Leske

Fish Sampled in Silver Lake by DNR (2007)

Species	Gear Used	Number of fish per net		Average Fish	Normal Range
		Caught	Normal Range		
Black Bullhead	Trap net	0.29	2.5 - 70.2	0.57	0.1 - 0.5
Black Crappie	Trap net	15	1.3 - 27.7	0.25	0.1 - 0.4
	Gill net	1.5	2.0 - 19.0	0.42	0.1 - 0.2
Bluegill	Trap net	21.14	2.8 - 43.3	0.13	0.1 - 0.3
Common Carp	Trap net	0.14	0.4 - 2.9	2.98	1.4 - 4.5
Common Shiner	Gill net	2	N/A	0.1	N/A
Golden Redhorse	Trap net	2.29	N/A	0.71	N/A
	Gill net	9	N/A	0.67	N/A
Green Sunfish	Trap net	1.71	0.4 - 3.8	0.07	0.1 - 0.2
Hybrid Sunfish	Trap net	0.29	N/A	0.11	N/A
Largemouth Bass	Gill net	0.5	1.0 - 3.8	1.04	0.2 - 0.7
Northern Pike	Gill net	1	1.5 - 9.0	4.02	1.8 - 3.7
White Crappie	Trap net	1.14	0.3 - 8.2	0.36	0.1 - 0.5
White Sucker	Trap net	5.14	0.2 - 2.2	0.86	1.0 - 2.0
	Gill net	30	1.0 - 6.6	0.83	1.0 - 2.2
Yellow Bullhead	Trap net	0.43	0.3 - 4.2	0.5	0.5 - 0.8
	Gill net	0.5	1.0 - 4.1	0.4	0.5 - 0.7
Yellow Perch	Trap net	0.29	0.4 - 3.5	0.19	0.1 - 0.2
	Gill net	6.5	2.5 - 25.8	0.15	0.1 - 0.2

Source: www.dnr.state.mn.us/lakefind/showreport.html?downum=55000300

In the above table, Normal Range represents averages of typical catches for lakes with similar physical and chemical characteristics. The number of fish caught per net doesn't appear as a whole number because it is an average number based on the number of fish caught in all the nets. Click on the hyperlinks to go to the DNR web site to learn more about the linked fish species and the inventory techniques.

While fishing is allowed in Silver Lake and the Zumbro River, the Department of Natural Resources encourages moderation in the consumption of some fish species to limit exposure to mercury. Contaminants listed in the table below were measured at levels that trigger the stated advice to limit consumption. Pregnant women, women who may become pregnant, and children under age 15 have a lower consumption advisory.

Silver Lake Fish Consumption Limitations for the General Population

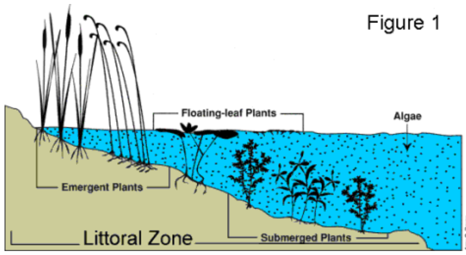
	Species	Meal Advice				Contaminants
		Unrestricted	1 meal/week	1 meal/month	Do not eat	
SILVER LAKE	Carp	All sizes				
Olmsted Co.	Channel Catfish		All sizes			Mercury
55000300	Crappie	All sizes				
	Redhorse Sucker	All sizes				
	White Sucker		All sizes			Mercury
	Yellow Perch		All sizes			Mercury

Source: www.dnr.state.mn.us/lakefind/fca/report.html?downum=55000300

Aquatic plants also live in Silver Lake and they are important in providing food and habitat for many animals such as fish, frogs, birds, muskrats, turtles, insects, and snails. The area within a lake or pond where aquatic plants grow is called the littoral zone. It is a shallow transition zone between dry land and the open water area of the lake. In Minnesota waters, the littoral zone extends from the shore to a depth of about 15 feet, depending on water clarity. The shallow water, abundant light, and nutrient-rich sediment provide ideal conditions for plant growth. Protecting the littoral zone is important for the health of a lake's fish and other animal populations.

As can be seen below, there are four categories of plants that typically grow in a littoral zone: emergent plants, floating plants, submerged plants and suspended algae. For many years, Silver Lake had an artificial shoreline made from pillowed concrete to control shoreline erosion. In 2007, native prairie and wetland plants were planted to create an upland shoreline buffer, but attempts to grow emergent plants on top of the concrete bank and in the lake were thwarted by the 2007 flood event (see Ch. 7 Rochester's Storm Water Management System).

Figure 1

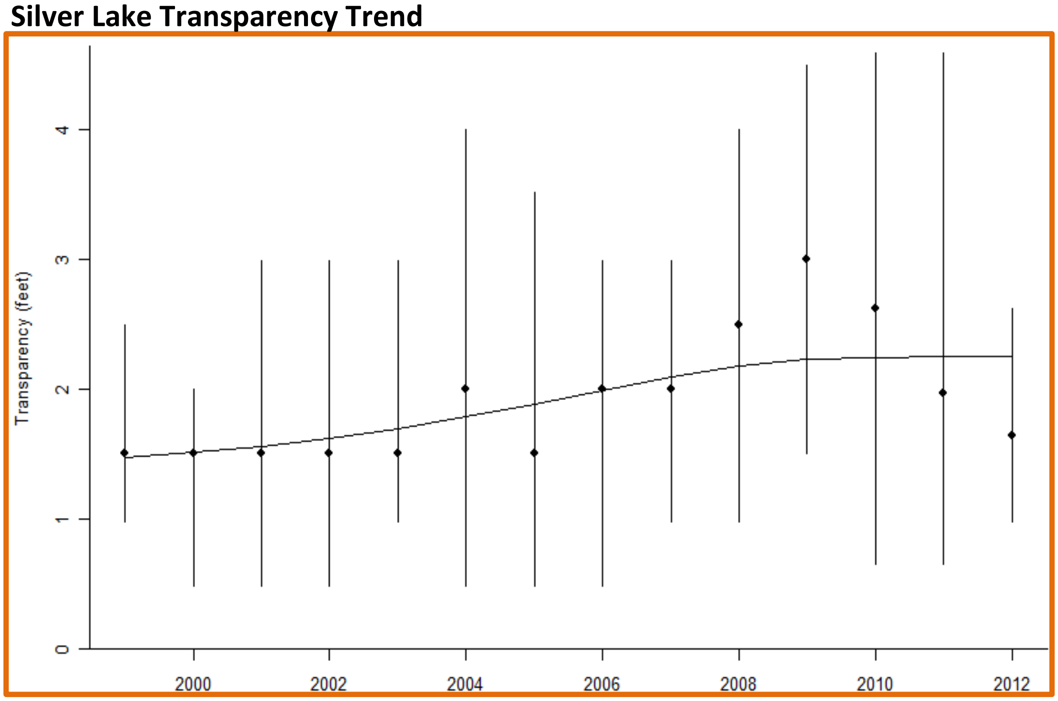


Littoral refers to the lake shore area where aquatic plants grow.

Water transparency is an excellent indicator of water quality. It is measured in lakes using an instrument called a Secchi disk, which is a circular, 8 inch diameter metal plate painted with alternating white and black colors. It is connected to a rope with distance measurements on it. The disk is lowered into the water until it disappears from view. The depth at which the disk can no longer be seen is the water clarity depth. The deeper the disk can be seen, the higher the number, the clearer the water. The clearest water generally occurs in the spring, shortly after ice-out. (A different device, called a transparency tube, is used to measure clarity in streams.)

Trend analysis of transparency results are presented in the chart below. It shows that the median transparency at Silver Lake increased by about 0.75 feet from 1999 to 2012. Although the annual trend is toward clearer water, the annual variability in clarity is still high (0.5 ft to 4.5 ft) and the lowest clarity readings are not improving significantly. This effect is probably due to the fact that the Zumbro River flows through Silver Lake. The river drains a large watershed, so sediment is transported into the river and through the Lake after each snowmelt and rain event.

Silver Lake Transparency Trend



Source: http://cf.pca.state.mn.us/water/watershedweb/datasearch/waterUnit.cfm?WID=55-0003-00

● Median for each year | Data range for each year — Trend line

Foster Arend Lake

Converting private sand and gravel mining pits to small lakes is common in Rochester. Foster Arend Lake is one example of an artificial lake created from a mine pit after all its sand and gravel was removed. The lake was originally the site of commercial mining by Rochester Sand and Gravel. The acreage was purchased by the City from Edward Foster and Raymond Arend on June 1, 1981, so that it could become part of the park system, offering swimming, fishing, and picnicking. Beach grading started in 1983 and continued into 1984. In 1985, a fishing pier was constructed and the beach opened. A rip-rap bank was installed for stabilization. The fishing pier was expanded to 150' in 1991. Trout are stocked annually by the Minnesota Department of Natural Resources. The pond has hosted events such as triathlons, lumberjack competitions, and polar plunges through the ice.

Foster Arend Fishing Pier and Beach

Source: Deb Las

Lake Characteristics

Lake Area (acres): around 17.7
Maximum Depth (ft): 42

Foster Arend -2012 Fish Stocking *55001900*

Brook Trout - 920 adults weighing 400.2 lbs.
Rainbow Trout - 7,800 yearlings weighing 5,283.5 lbs.

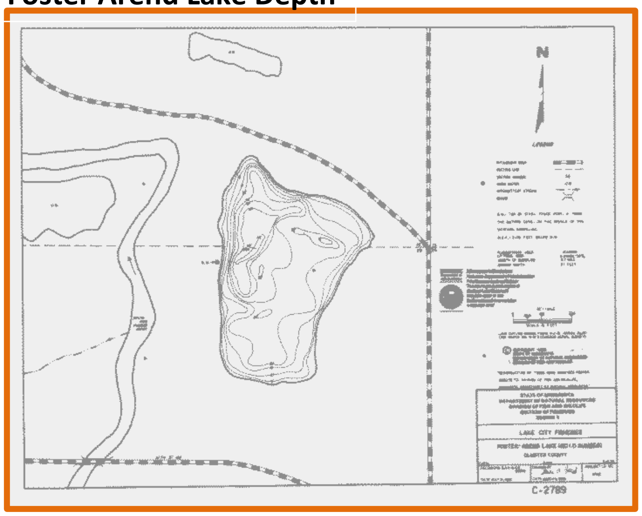
Foster Arend Aerial View 2012

Source: Rochester Public Works

Unfortunately, the 15 acre Lake was the site of eight drowning deaths between its opening in 1985 and 2007. In 2008, the City posted new signage, added chain link fencing around the water area, and installed gates to each entrance. The Park Board adopted new hours and rules for the Park. A security service was also added. Since these measures were added, no further incidents have occurred.

Like all mine pits in Rochester, if the sand and gravel is excavated at a depth below the water table, when mining is over, the pit will fill with cold, clear groundwater. That is why trout like it. The depth of Foster Arend Lake is determined by completing a bathymetric survey. This is a technique to measure the distance from the surface of the water to the bottom of the lake, either using marked cables or an echosounder (i.e., sonar) mounted on the side of a boat. A beam of sound or light is sent downward and the amount of time it takes to bounce off the bottom and return to the surface informs the equipment of the distance. Depth contours like those shown above can then be mapped.

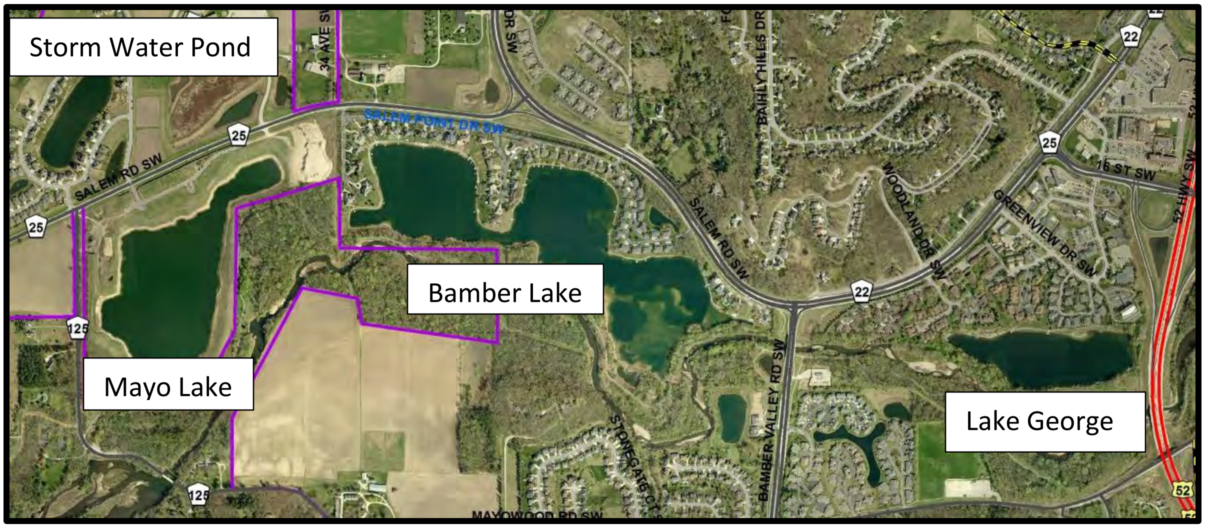
Foster Arend Lake Depth



Source: MnDNR

Other mining pits have also been converted to private water bodies that are used for recreation, for aesthetics, or to treat storm water. Bamber Valley Lake, for example, is a small, private lake owned by the Salem Sound and Salem Point housing developments.

Lakes and Ponds Along Salem Road SW, Rochester



Source: Rochester Public Works

Lakes and Ponds South of Hwy 14 NW, Rochester

Source: Rochester Public Works

Flood Control Project Reservoirs

Rochester has seven reservoirs specifically designed and constructed as part of the City's Flood Control Project to store rainfall in the upper, or headwater, portions of the South Zumbro Watershed. Once captured, the water can then be released slowly downstream over a longer period of time, significantly reducing flooding. As can be seen in the following table, the outflow rate for each reservoir is reduced from between 2% to 10% of the inflow rate. Inflow rates are based on peak inflow modeled for the contributing areas for the 500 year storm event.

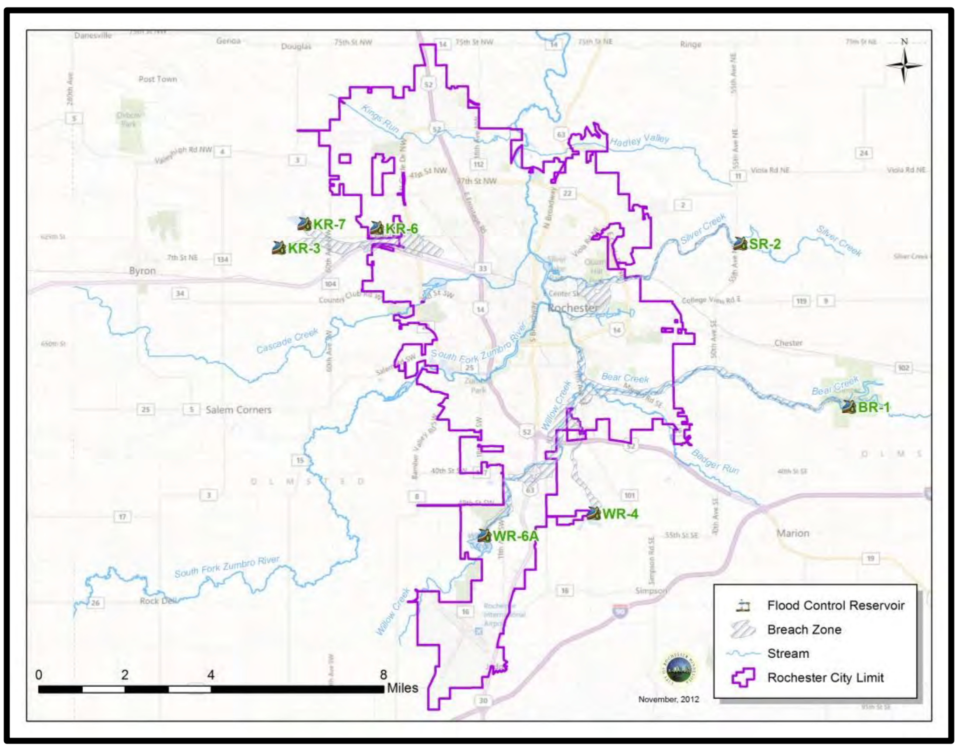
Predicted Inflow & Outflow Rates for a 500 Year Storm Event

(in cubic feet per second)

Reservoir	Inflow	Outflow
WR-4 (Willow Creek by Gamehaven)	2912 cfs	143 cfs
WR-6A (Willow Creek west of TH 63)	2824 cfs	275 cfs
BR-1 (Chester Lake)	5019 cfs	410 cfs
SR-2 (Silver Creek)	6944 cfs	113 cfs
KR-3 (Kalmar Twp, south of landfill)	1513 cfs	115 cfs
KR-6 (Kalmar Twp; dry)	2810 cfs	96 cfs
Kalmar KR-7 (Kalmar Twp, east of landfill)	2584 cfs	95 cfs

Source: U.S. Army Corps of Engineers

Reservoirs in Rochester



Source: Rochester Public Works

While the reservoirs' primary value is for flood control, they are also used for recreation. An example is the KR-7 Reservoir in Kalmar Township, east of the County's Kalmar Landfill. KR-7 was constructed in the early 1990 to store waters in the North Branch Cascade Creek Watershed, northwest of Rochester. An earthen dam holds back the waters collected in the reservoir after each rainfall event. The surface area of the reservoir covers about 20 acres and its maximum depth is about 8 feet.

In 2009, the DNR stocked 113 largemouth bass in KR-7 to try and increase the size of the bluegills, black crappies, and yellow perch. Even though the reservoir is considered "highly productive", both summer and winter fish kills have occurred due to a seasonal lack of oxygen.

Kalmar Reservoir and Dam

Source: Deb Las

North Branch Cascade Creek

Source: Deb Las

The North Branch of Cascade Creek discharges from KR-7 to the channel below the dam. The water flow is regulated through an engineered control structure.

A dam is an artificial barrier (together with any associated spillways and other related structures) that is placed across a watercourse or natural drainage area that impounds or diverts water.

Check out DNR's lake finder tool to learn about local lakes: www.dnr.state.mn.us/lakefind/index.html

Quarry Hill Pond & Other Water Features

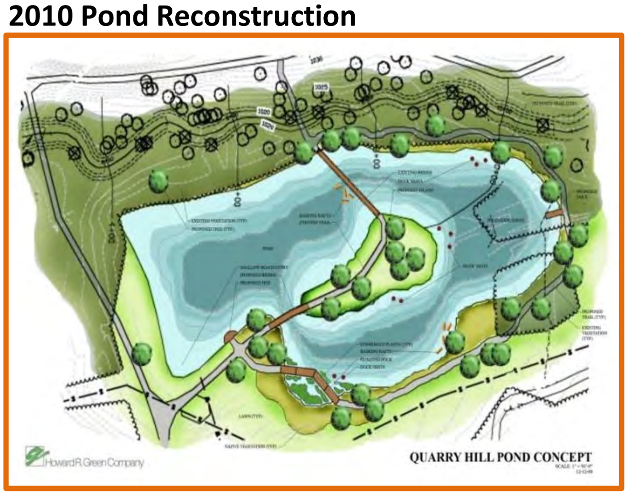
Quarry Hill Park and Nature Center are located near Silver Creek in SE Rochester. An artificial pond was constructed in the Park in 1978 as an environmental education feature. That pond was built using a plastic liner that was covered with soil. The million gallon pond was initially filled with water pumped from nearby Silver Creek. It was completed on October 12, 1979. Thereafter, water from the Nature Center was pumped into the pond to offset evaporation and to add oxygen to the pond. Unfortunately, the liner was ripped at the time of construction and burrowing animals caused other leaks that added to the problem of keeping water in the pond.

1978 Pond

Source: Quarry Hill Nature Center, Harry Buck

In 2010, the City got a grant to reconstruct and expand the pond. This time, clay excavated on site was compacted to form the pond liner. Additionally, when Quarry Hill Creek was returned to its original alignment west of the pond, an infiltration system was installed that allowed water to flow from the creek into the pond. An overflow structure was built in the pond to allow high water to flow from the pond into the creek so a more constant water level could be maintained in the pond. In addition to offsetting evaporation, the periodic influxes of creek water also add oxygen to the pond so that well water no longer needs to be used to maintain the pond's water level. By using creek water instead of well water, the Nature Center is also saving money on their water and electrical bills. The DNR stocked the pond with 324 adult bluegill sunfish in 2012.

2010 Pond Reconstruction



Source: Howard Green

Quarry Hill Pond Today

Source: Deb Las

Storm Water Pond

Source: Rochester Public Works

There are other types of constructed water bodies in Rochester, too. Some developments build a pond solely as a feature to beautify their landscape. There are hundreds of ponds built to manage storm water (see Ch. 7 Rochester's Storm Water Management System). Rochester was responsible for building the dam that created Lake Zumbro (another reservoir) to produce hydroelectric power. To meet floodplain regulations, some ponds are built to provide flood storage when it is lost because of construction in the floodplain. On golf courses, ponds are built to provide a challenge to golfers. It is difficult to know by looking at it why a water body was built, so the City keeps records of the intended functions of these artificial water bodies.

Throughout Rochester, there are many acres of constructed wetlands built to offset wetlands that are lost when new residential and commercial areas are constructed. Constructed wetlands must be created to meet the requirements of the Minnesota's Wetland Conservation Act (see Ch. 4 Rochester's Natural Water Features). A new technique being tried in Rochester today is the installation of floating wetlands to help absorb nutrients in storm water ponds.

Restored Wetland

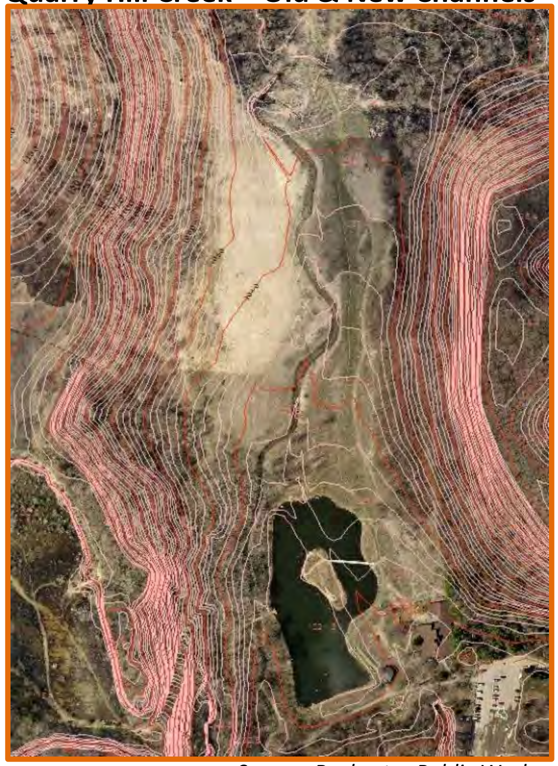
Source: Rochester Public Works

Floating Wetland

Source: Rochester Public Works

Rochester also has a history of reconstructing its rivers. Flows from the Zumbro River were redirected into constructed "mill runs" to power flour and lumber mills in the late 1800's. Back in the 1930's, the original confluence of Silver Creek became part of Silver Lake and a new channel connecting Silver Creek to the Zumbro River was dug. Quarry Hill Creek was moved during the Great Depression by the Works Project Administration, possibly to protect the quarry road from constant flooding. Seventy years later, this caused upstream damages that were corrected by moving the lower portion of Quarry Hill Creek from east of the meadow back to its earlier location on the west side. At the same time, the uppermost western tributary to Quarry Hill Creek was engineered using natural processes and structures to control overland storm water flows and provide native habitat. The Zumbro was widened and deepened in the 1980's to provide protection from floods. Portions of Cascade Creek, Bear Creek and the mouth of Silver Creek were also modified to control floods (see Ch. 2 Rochester's Water History). Portions of Mayo Run were directed into underground storm sewers, so it is no longer a free flowing river. Over the last century and a half, humans have changed water to meet their needs. What will our practices be in the next century?

Quarry Hill Creek – Old & New Channels



Source: Rochester Public Works

Important Artificial Water Body Construction Dates in History:

- 1911 Dam constructed on Zumbro River to form Mayowood Lake
- 1919 Dam constructed on the Zumbro River to form Lake Zumbro
- 1936 Dam constructed on Zumbro River to form Silver Lake
- 1978 Quarry Hill Pond built with a plastic liner for environmental education
- 1985 Foster Arend Lake and Park opened
- 1985 Rochester requires its first storm water management ponds
- 1986 Reservoir WR-6A (Willow Creek) built
- 1988 Reservoir WR-4 (near the Gamehaven Boy Scout Camp) built
- 1990 Reservoir SR-2 (Sliver Creek) built
- 1994 Reservoir BR-1 (Chester Lake) built
- 1994 Reservoir KR-6 (Kalmar Township, in west Rochester) built
- 1995 Reservoir KR-3 (Kalmar, south of landfill) built
- 1996 Reservoir KR-7 (Kalmar, east of Landfill) built
- 2010 Quarry Hill Pond reconstructed and expanded

Case Study: Sizing a Storm Water Pond

The effectiveness of treatment by a pond is dependent on the quality of the pond's design. Engineers are the professionals that have the knowledge and experience with hydrologic and hydraulic modeling to design wet sedimentation basins that meet these complicated requirements. These basins are also called wet extended detention ponds. In this exercise, you will be asked to complete two steps of this process.

Engineers, hydrologists, and other professionals work together to design and build ponds as part of the storm water management system. It is suggested that students also work together to solve the problems in this case study. Just as professionals have expertise in specific content areas, students also have different skill sets that complement each other. The important thing is to use every member's skill and knowledge in some way and to make sure every member of the group understands how the answers were calculated. Math, reading and problem solving skills are needed for real life applications. (NOTE: While this case study has left some terminology intact, it has been simplified for adaptation to the classroom.)

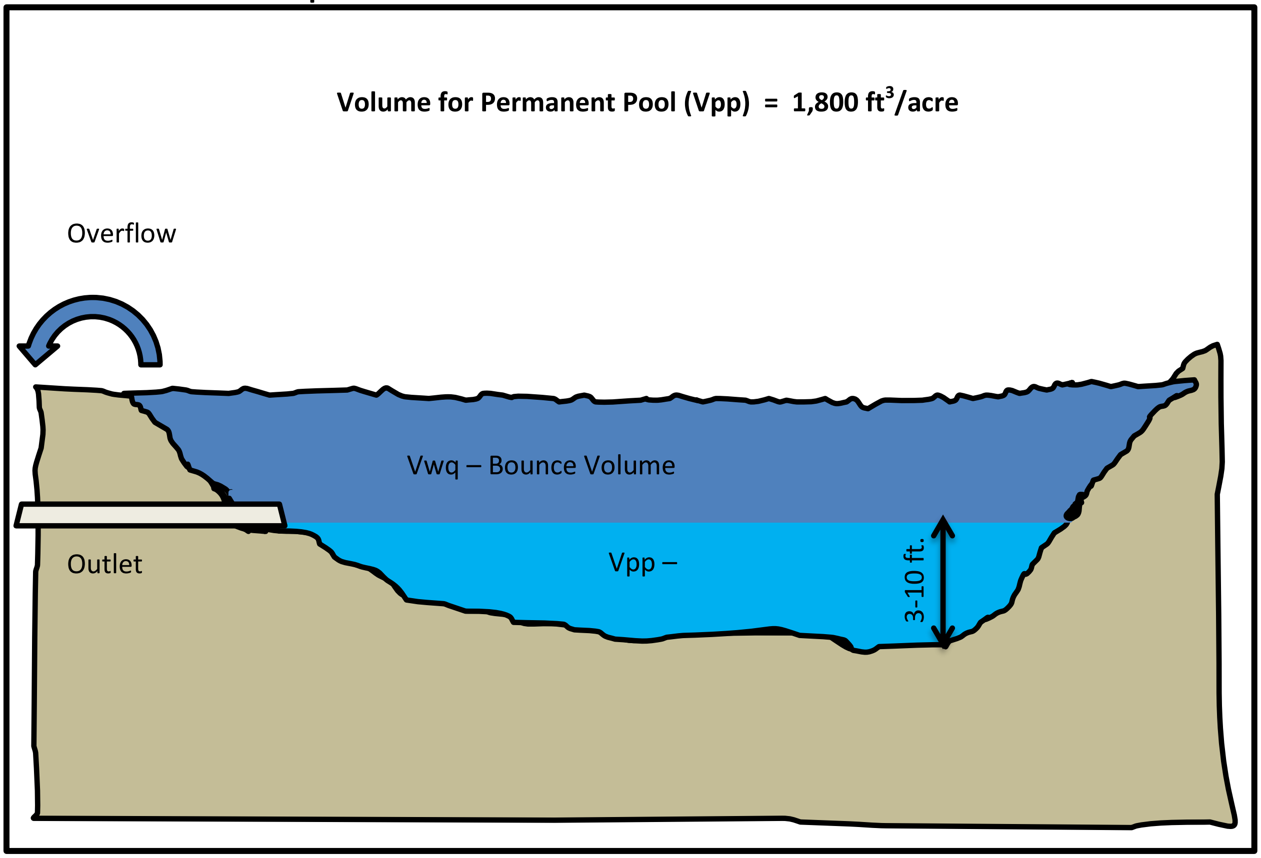
When Congress passed the Clean Water Act, the Environmental Protection Agency (EPA) had to develop federal rules that require the treatment of storm water runoff in cities like Rochester. EPA then gave authority to the Minnesota Pollution Control Agency (MPCA) to write the permits that meet the intent of the federal rules. Part of MPCA's Construction Storm water Permit contains the following requirements to address permanent treatment of storm water runoff in the constructed ponds:

Part III.D. PERMANENT STORMWATER MANAGEMENT SYSTEM (August 1, 2013 issued permit)
2. Wet Sedimentation Basin

a. *The Permitte(s) must design the basin to have a permanent volume of **1,800 cubic feet of storage** below the outlet pipe **for each acre that drains to the basin**. The basin's permanent volume must reach a minimum depth of at least three (3) feet and must have no depth greater than 10 feet. The basin must be configured such that scour or re-suspension of solids is minimized.*
b. *The Permittee(s) must design basins to provide live storage for a **water quality volume** (calculated as an instantaneous volume) of **one (1) inch of runoff** (or one (1) inch minus the volume of storm water treated by another system on the site) **from the new impervious surfaces** created by the project.*

A simple schematic of a treatment pond is shown below that demonstrates the two requirements listed above.

Storm Water Pond Requirements



Source: Rochester Public Works

According to the MPCA, "Ponds rely on physical, biological, and chemical processes to remove pollutants from incoming storm water runoff. The primary treatment mechanism is gravitational settling of particulates and their associated pollutants as storm water runoff resides in the pond. Another mechanism for the removal of pollutants (particularly nutrients) is uptake by algae and aquatic vegetation." Pollutants can react with other chemicals or they can shift to a gaseous state, thereby changing to non-toxic or less-threatening chemicals.

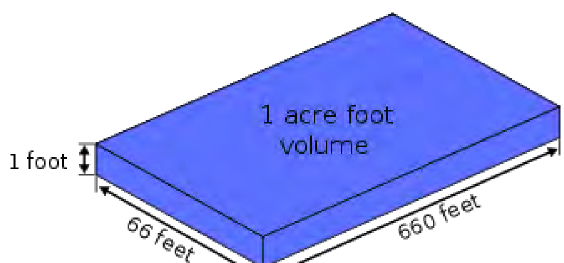
Using this information, solve the following problems.

1. a) A wet basin is required to have a permanent pool volume (Vpp) of 1,800 cubic feet of storage below the pond's outlet pipe for each acre that drains to the basin. Ridgeview Manor is a residential development in NW Rochester that contains homes, roads, parkland and wetlands. Assume the yellow line in the following map encompasses a drainage area of 50 acres and all the water within that area will flow to a pond to be located where the yellow oval is placed on the figure below. To treat the drainage from this area, how many cubic feet of storage will be needed below the outlet pipe? (Hint: 1,800 ft^3/1 acre = Vpp ft^3/50 acres.)

Answer: Vpp =_____________________________ ft^3

b) Cubic feet (ft^3) is one example of a volume measurement. Another common volume measurement is acre-feet. Imagine that one acre of land (66 ft X 660 ft) is covered by one foot of water. That amount of water is one acre-foot or 43,560 ft^3. How many acre-feet of water would need to be stored in this pond? (Hint: 1 acre/43,560 ft^3 = X acre-feet/Vpp)

Answer: __________________________ acre-feet



Source: Wikipedia

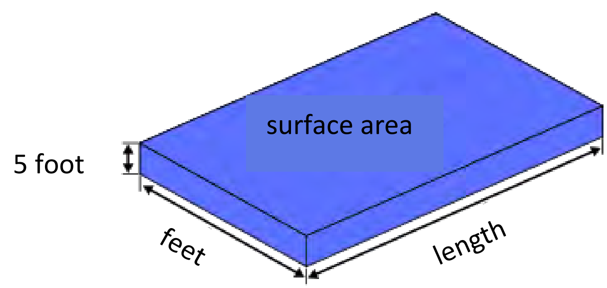
2. Constructed surfaces that prevent storm water from infiltrating into the ground are called impervious surfaces. Within this neighborhood, what types of impervious surfaces are present?

3. Assume that 16% of this drainage area is made up of impervious surfaces. How many acres of impervious surface would that be?

4. The total storage volume of the wet pond (Vts) will equal Vpp plus the additional storage needed for water quality treatment, which is called the water quality volume (Vwq), where Vwq equals 1.0 inch of runoff per impervious acre.
   a) What is the water quality volume needed to serve Ridgeview Manor?
      Vwq = (1 in)(___impervious acres)(1ft/12in) = _____ acre-feet
      (see answer #3)

   b) What is the total storage volume needed to serve Ridgeview Manor?
      Vpp _____acre-feet + Vwq ____ acre-feet =Vts ____ acre-ft
      (see answer #1b) *(see answer #4a)*

5. There is not a lot of room for the pond on the property, so it will need to be deeper than the minimum 3 feet deep. Assuming that the final permanent pool depth of the pond (Vpp) will be 5 feet, what will the surface area of the pond need to be? (Hint: See 1a; for easier calculating, assume that the pond is a prism, like the figure shown at the right).



6. If the pond (Vpp) is only allowed to be 100 feet wide, how long would it be? (Hint: L x W = Area)

(Answers on the next page.)

Answers:

1. a) $1{,}800\ ft^3$/acre x 50 acres = Vpp
   Vpp = $90{,}000\ ft^3$

   b) $90{,}000\ ft^3$ x 1 acre/$43{,}560\ ft^2$
   =$90{,}000\ ft^3$ x acre/$43{,}560\ ft^2$ = 2.066 acre-ft, or 2.07 acre-ft

2. Roofs, driveways, sidewalks, roads, bike trails

3. 50 acres x 0.16 = 8 acres of impervious surface

4. a) Water quality volume Vwq = (1 in)(8 impervious acres)(1ft/12in) = 0.666 or 0.7 acre- ft

   b) Total Storage Volume: Vpp: 2.07 acre-ft + Vwq 0.67 acre feet = Vts 2.74 acre-ft

   (see answer #1b) *(see answer #4a)*

5. $90{,}000\ ft^3/5\ ft = 18{,}000\ ft^2$

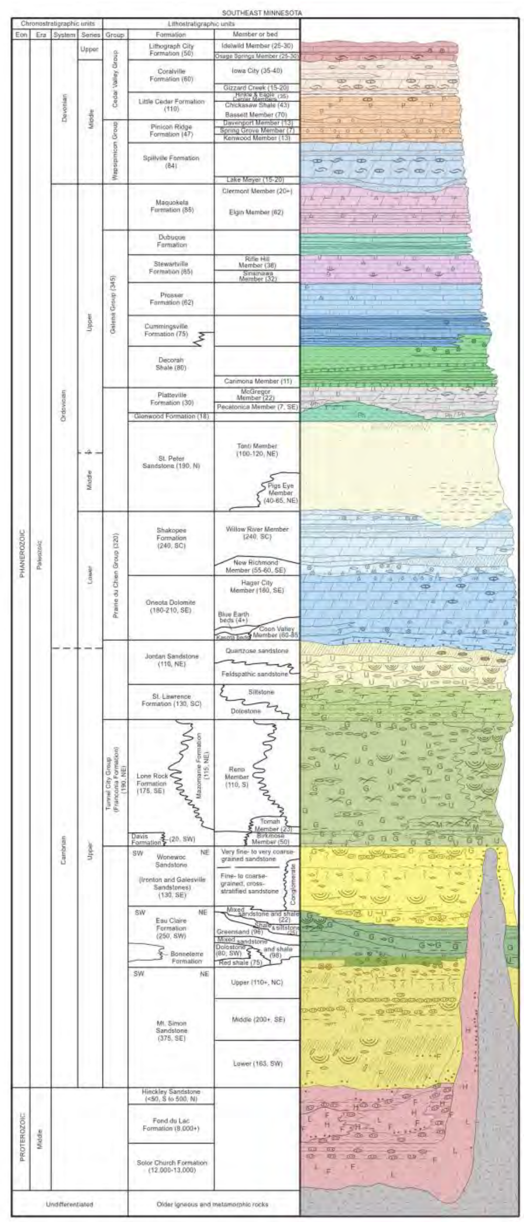
6. $18{,}000\ ft^2$ = L x W, where L x 100 ft
   L = $18{,}000 ft^2/100\ ft$ =180 ft

Chapter 5 - Rochester's Water Supply

Where does the water we drink come from? That is something many people do not think about. They turn on the faucet and water comes out. In Rochester, the City gets its water from deep under the ground. The entire process of taking the water from below ground and bringing it into the homes and businesses in Rochester is managed by Rochester Public Utilities (RPU). (For a brief history of Rochester's water supply, see Chapter 2.)

Rochester's earliest residents used surface water taken from the rivers to meet their personal and industrial needs. Today, Rochester's water supply is extracted from bedrock aquifers - large rock formations that hold water. Underground lakes or rivers that contain the water don't exist below Rochester. Rather, the water is held in small fractures within the rock layers or in the pore spaces between the particles that form the rock. Fractured limestone and porous sandstone are the aquifer forming rocks here. To be a dependable source of water, aquifers must be both porous, (meaning there are spaces for the water to be in) and permeable, (the water can move easily through the rock).

Most of Rochester's water comes from the Jordan Aquifer which is composed of sandstone. Rochester sometimes also uses other aquifers such as theSt Peter, Prairie du Chien limestone, the Ironton-Galesville sandstone, and the Mt. Simon sandstone.



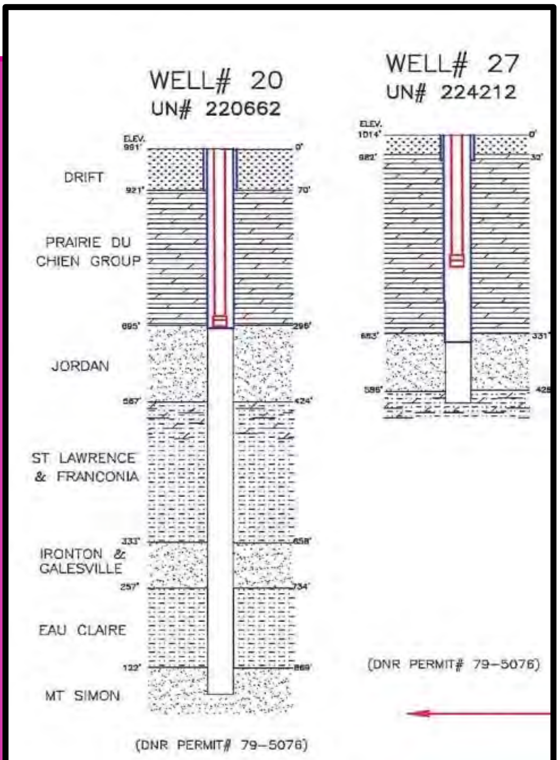
Source: modified from Mossler, J.H., Palezoic stratigraphic nomenclature for Minneosta. Minnesota Geological Survey Report if Investigations 65, 76 p.

Geologists use symbols to chart bedrock types. What symbols are used to represent sandstone and limestone in this geologic chart?

Rochester's Wells

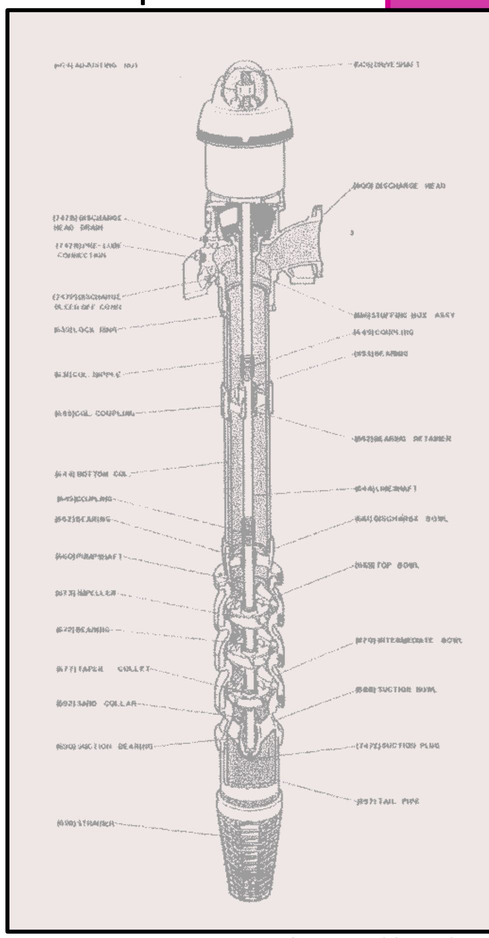
Water from the underground aquifers is drawn to the surface by 33 wells located throughout the city. Most of the wells are 24 inches in diameter and extend between 400 and 1,000 feet down into the earth. A pump is inserted into the well to bring water out of the ground.

Geologic Cross-Sections of Two RPU Water Supply Wells



Source: Rochester Public Utilities

Well Pump Schematic



Source: Rochester Public Utilities

While the method for collecting water is the same throughout Rochester, each well is a bit unique. Some older wells extract water from multiple aquifers while newer wells usually use only the Jordan aquifer. Connecting more than one aquifer within one well is a practice that has been discontinued where aquifers are separated by confining layers. This change was adopted to prevent contamination migrating from one aquifer into another. Rochester has limited the drilling of its municipal wells to the Jordan sandstone since 1980, as regulated by the Minnesota Department of Health.

Each well is housed in a building that matches the architecture of the area. The wells are numbered for ease of identification. Each well is continually monitored electronically by a computer system that automatically starts and stops pumping when water usage needs change or when water levels in towers reach different programmed levels. In addition, the computer system monitors the energy usage of the pumps and the water levels of the aquifers.

RPU Well Houses

Source: Rochester Public Utilities

In 2012, the average amount of water pumped by the City of Rochester was 13,183,000 gallons each day. The total amount of water pumped during 2012 was 4,825,000,000 gallons. This total was about 6 percent less than the record of 5,110,000,000 gallons set in 2007 for yearly volume pumped.

Currently, if all of Rochester's wells were pumping at full capacity, the system would be extracting 24,918 gallons per minute (gpm) or 35,882,000 gallons per day. RPU needs to plan for water usage peaks from increased water consumption so that water demands can be met without running out of water at any moment in time. The record for peak water demand was set in 2007 at 30,229,000 gallons of water pumped in one day during very warm weather and drought conditions.

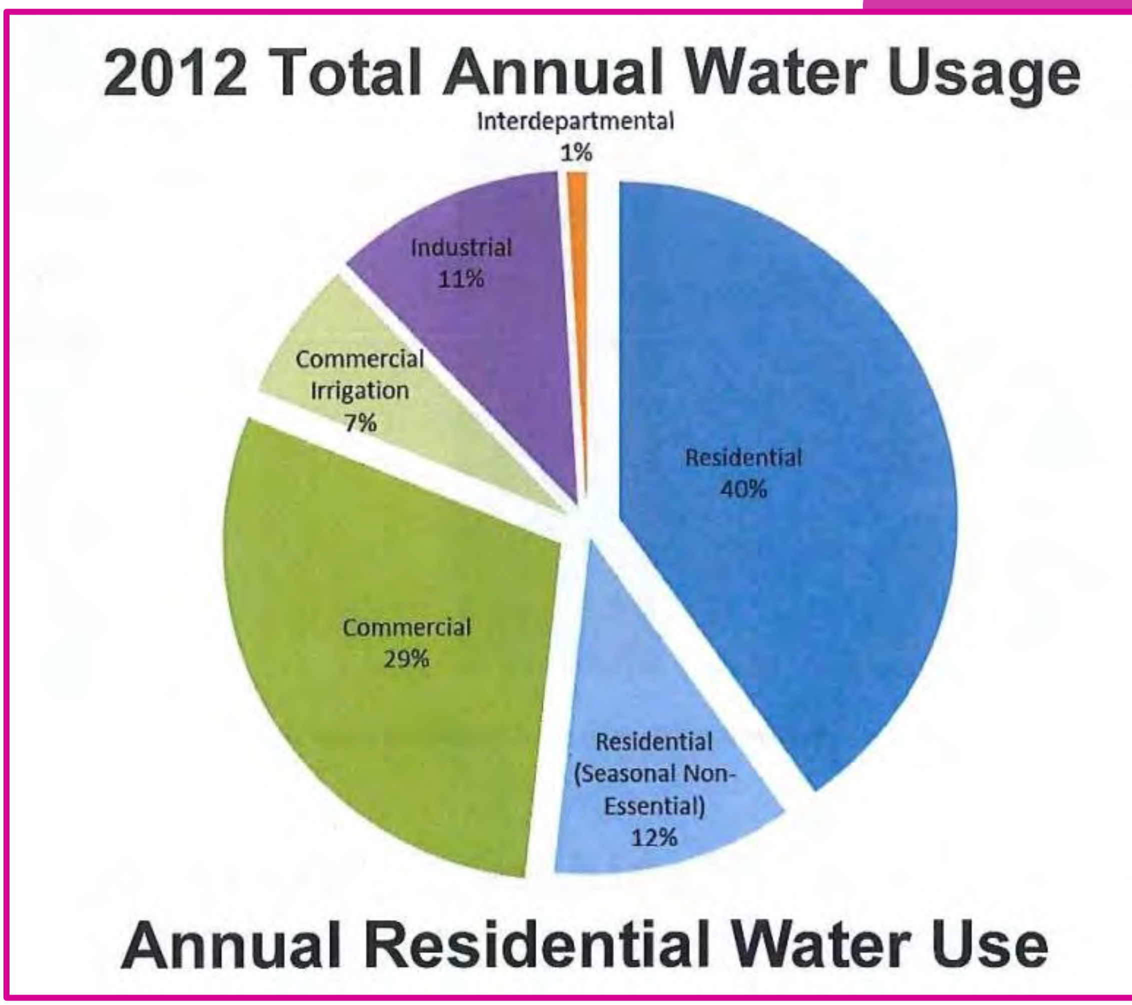
In April 2010, RPU launched a rebate program to encourage citizens to conserve water. In 2012 a total of 1,651 rebates totaling $204,763 were processed that year. It is estimated that the conservation practices put in place, as measured by the rebates, resulted in saving 9,280,206 gallons of water, the equivalent of over 25,425 gallons a day. Water conservation from the rebate program represents 0.19% of the total annual water consumption.

<u>Conserve & Save Water Rebates Processed in 2012:</u>

- 1,119 Clothes Washer - $27,975
- 86 Pressure Regulation Devices $258
- 334 High Efficiency Toilets - $16,850
- 76 Rain Barrels - $ 158.840
- 25 Rotating Sprinkler Nozzle - $75
- 4 High Efficiency Urinals $240
- 7 Weather-Based Irrigation Controllers $525

In 2010, RPU put water conservation rates into place to encourage conservation, by charging more for water when more is used.

RPU tracks how much water is used by each customer class. In the following chart, industries manufacture goods while commercial companies provide services. The "Residential (Seasonal Non-Essential" segment is the same as irrigation. The "Interdepartmental" segment is used by RPU. Overall, residential use makes up just over half of the total annual water use in Rochester.



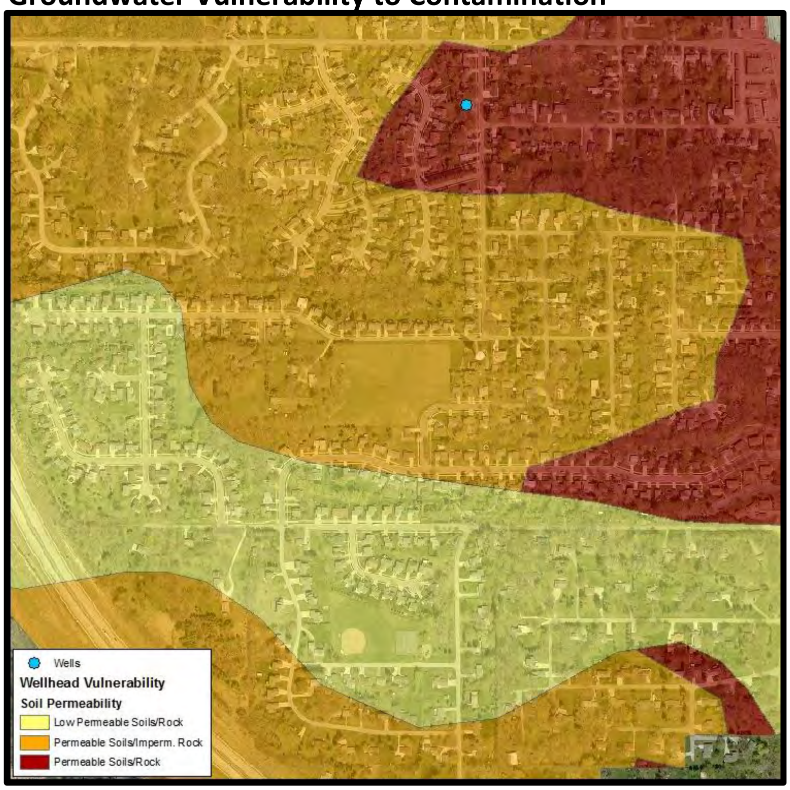
Source: Rochester Public Utilities

Additions to the Water

Rochester's water supply is of excellent quality due to the depth of the wells and the condition of the aquifers. The water could be consumed right from the ground as it is pumped out, with no treatment. However, Minnesota law requires that all municipal water systems add fluoride to drinking water to help prevent tooth decay. Fluoride levels are kept at an average concentration of 1.2 parts per million. To help assure this level, RPU performed over 3,200 fluoride tests around the City in 2012. Chlorine is added to kill bacteria that may be in the distribution system. The City tests 25 different sites each week in order to maintain an average chlorine level of 1.0 ppm. Polyphosphate (0.5ppm) is added to the water to help prevent corrosion and rusty colored water.

Even though the quality of the water supply is good today, the local geology presents risks for contamination. Where the underlying soils and bedrock are both permeable, the wells are vulnerable to pollution. The thicker and the less permeable the soil layer, the more the filtering capacity, reducing the risk for groundwater pollution.

Groundwater Vulnerability to Contamination



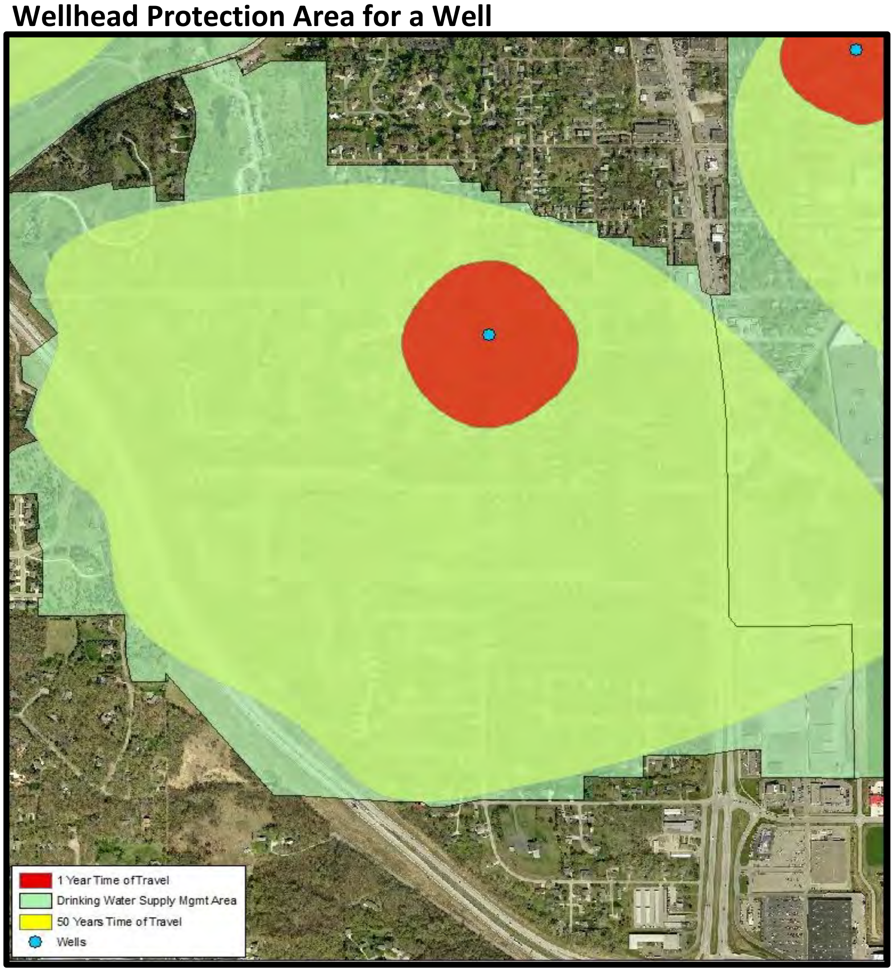
Source: RPU GIS

Wellhead protection

The Minnesota Department of Health administers the federal Safe Drinking Water Act in this state. One program related to this Act is the state's Wellhead Protection Program, which has a goal of preventing water supply pollution. Wellhead protection practices manage potential sources of contamination at the land surface inside the area where the well's water supply is extracted.

RPU has conducted computer modeling to determine how quickly surface pollutants would reach a well if a contaminant spilled or leaked on the land surface. The estimated rate of travel depends on factors, such as the type of soils and bedrock present, the depth and construction of the well, and the pumping rate of the well. A boundary line is drawn around the area within which it would take contaminants one year to travel; this area is called the "1 Year Time of Travel" zone or the "Emergency Response" zone. A similar "50 Year Time of Travel" zone is predicted; this is the wellhead protection area. A larger, "Drinking Water Supply Management Area" is created by using political boundaries that surround the wellhead protection area.

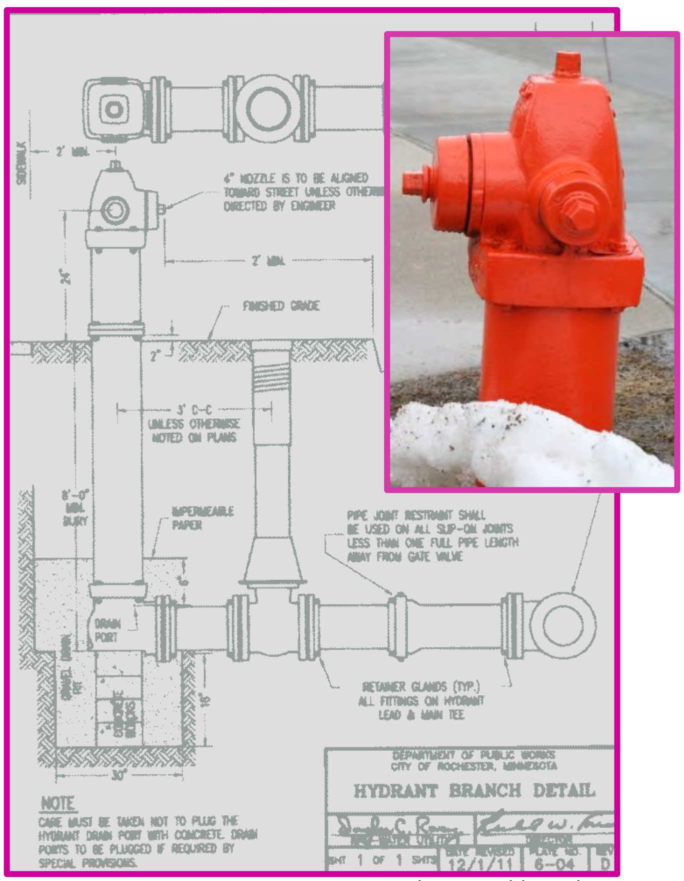
Wellhead Protection Area for a Well



Source: RPU GIS data

Each operating municipal well must obtain a maintenance permit from the Minnesota Department of Health. When a decision is made to stop using a well, perhaps because it can no longer provide the amount of water needed, it must be sealed by a licensed contractor. This is an important step because an unused, or abandoned, well that is not sealed is an open channel between the land surface and the aquifer(s) into which the well was drilled. Surface water, contaminants, or improperly disposed of waste could then contaminate groundwater after entering the open drill shaft. Sealing eliminates the ground-to-surface aquifer connection and involves removing the pump, clearing the well of any debris, and filling it with concrete grout. Sealing is also required for private wells that are no longer in use.

Piping System



Source: Rochester Public Utilities

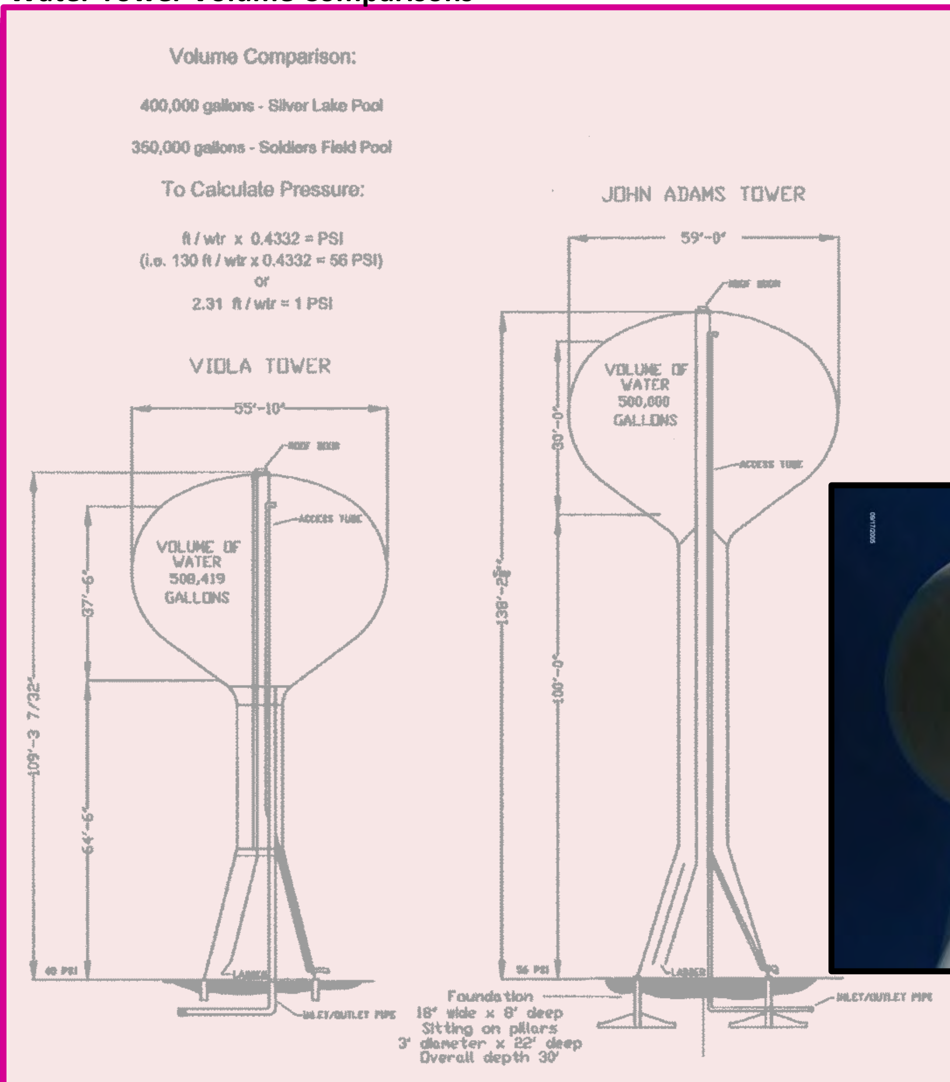
Water from the City's wells is pumped directly to homes and businesses through a series of interconnected underground pipes. At the end of 2012, Rochester had 573.6 miles of water pipes, also called mains, for distributing water. The distribution system also currently includes 14,903 valves used to shut off parts of the system when repairs are needed.

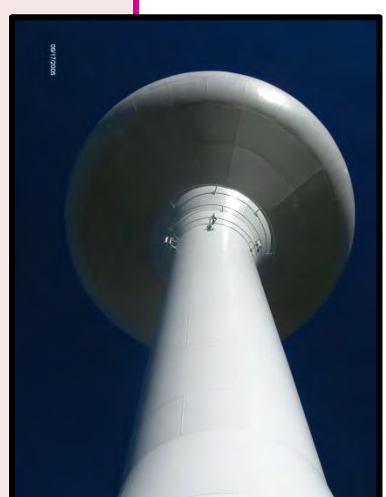
Fire hydrants are another important part of this underground plumbing system. Fire hydrants are used by the Rochester Fire Department to access water to fight fires. Hydrants are regularly flushed to help remove pipe residue from the water system. Rochester has 6,799 fire hydrants spread throughout the City.

Water Storage Facilities

Water storage facilities help maintain the pressure needed to keep water flowing. These also store water that may be needed during times of high water usage, power outages, or for fighting fires. The pumps that move water into the facilities require energy, but the water storage facilities themselves use the force of gravity to move water back out. This creates a hydrostatic pressure on the water based on the height of the water column.

Water Tower Volume Comparisons





Source: Deb Las

Source: Rochester Public Utilities

A Water Tower Under Construction & the Inside of a Finished

Source: Rochester Public Utilities

Source: Deb Las

In addition to the familiar water towers, water storage facilities can take on other forms, such as a standpipe or a hydropillar. In a hydropillar, the top bell is where the water is stored. A maintenance pipe and electric lines usually run through the center. RPU collects a fee from companies that use the towers to support cell phone networks. Water can also be stored in underground reservoirs. Currently, there is a water storage reservoir underneath a parking lot on 4th Street SE, but this is programmed for removal in the near future, when a new water reservoir to serve downtown Rochester is built near St. Mary's Hospital.

Hydropillar

Source: Rochester Public Utilities

Saint Mary's Water Tower and Standpipe

Source: Rochester Public Utilities

Cool Fact: Water levels in water storage facilities are raised and lowered in the winter to keep the water from freezing.

III-2

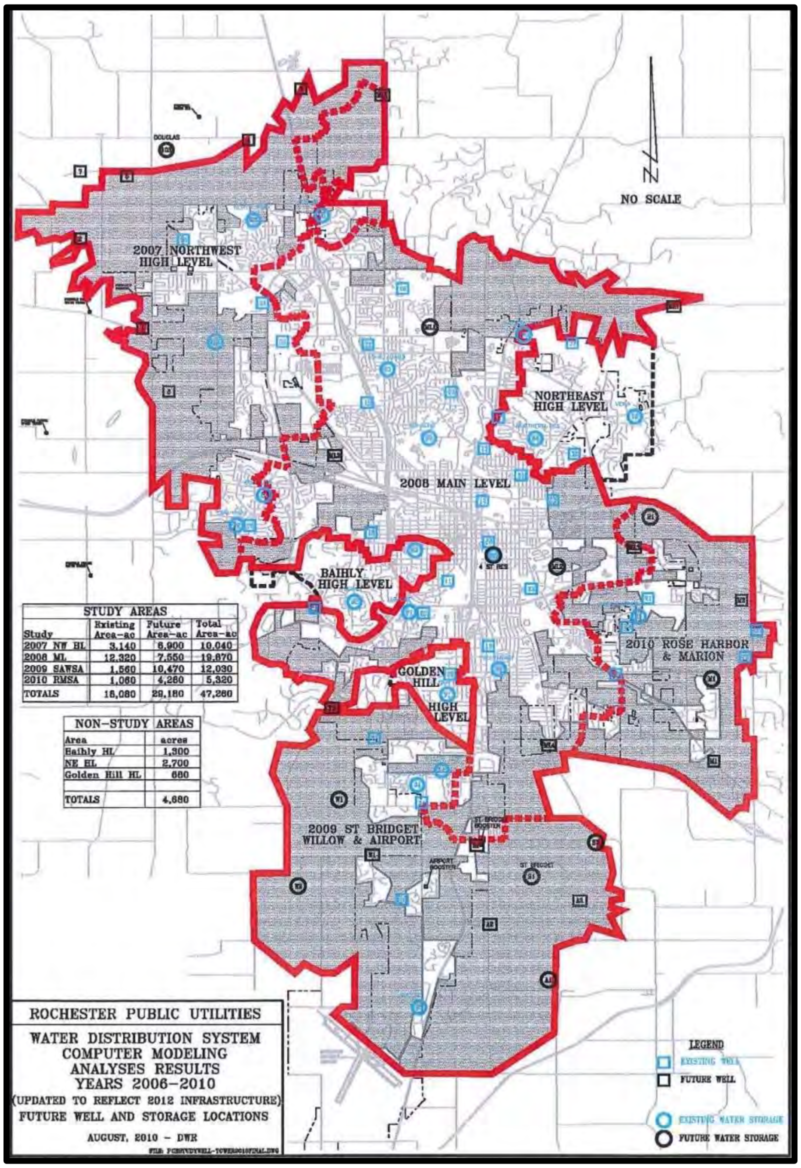
TABLE III-1: WATER STORAGE FACILITIES (12/31/12)

Site Number	Name	Location	Year Constructed	Style	Ring Wall Elevation	Low Level Elevation	Over-Flow Elevation	Head Range	Size	Capacity (gallons)
Main Level System Storage										
80	4th St Peaking Reservoir	323 4th St SE	1934	Reservoir	978.0	978.0	994.0	14'6"	84'L x 64'W	580,000
81	St. Mary's Reservoir	1001 4th St SW	1930	Reservoir	1,114.0	1,114.0	1,173.0	59'0"	65'D x 60'H	1,500,000
83	John Adams Tower	3110 18th Ave NW	1958	Tower	1,046.5	1,146.5	1,176.5	30'0"	Spheroid	500,000
84	CCM Standpipe	4040 7th Place NW	1959	Standpipe	1,107.5	1,106.0	1,176.0	70'0"	50'D x 70'H	1,000,000
86	SE Tower	501 20th St SE	1962	Tower	1,054.0	1,151.0	1,176.0	25'0"	Torospherical	500,000
87	Apache Tower	1200 Hwy 14 West - Apache Mall	1969	Tower	1,009.0	1,138.5	1,176.0	37'6"	Spheroid	500,000
90	Bandel Reservoir	6326 Bandel Rd NW	1979	Reservoir	1,134.0	1,134.0	1,176.5	42'6"	95'D x 45'H	2,250,000
95	Willow Heights Reservoir	601 36th St SW	1987	Reservoir	1,150.0	1,151.0	1,178.5	27'6"	81'D x 27.5'H	1,000,000
100	Morris Hills	3960 Stone Point Dr NE	2008	Reservoir	1,130.50	1,130.5	1,178.5	48'0"	60'D x 48'H	1,000,000
High Level System Storage										
82	St. Mary's Concrete [1]	901 4th St. SW	1924	Tower	1,125.0	1,215.0	(Approx. Top of Roof Elev. 1,253)			Not In Service
85	Northern Heights High Level	1206 Northern Heights Dr. NE	1959	Standpipe	1,243.0	1,243.0	1,363.0	120'0"	38'D x 120'H	1,000,000
88	Arnolds High Level	808 Woodgate Lane NW	1973	Tower	1,126.0	1,231.5	1,260.0	28'6"	Spheroid	100,000
89	CCM High Level	4403 Meadow Lakes Dr. NW	1978	Tower	1,168.0	1,257.5	1,290.0	32'6"	Spheroid	300,000
91	Golden Hill High Level	2323 5th Ave SW	1983	Tower	1,166.1	1,255.0	1,290.0	35'0"	Spheroid	400,000
92	Baihly High Level	2225 Baihly Summit Dr. SW	1985	Tower	1,204.0	1,277.5	1,310.0	32'6"	Spheroid	300,000
94	Willow Hts High Level	3811 10th Ave SW	1987	Tower	1,231.0	1,337.5	1,370.0	32'6"	Spheroid	300,000
96	Airport High Level	7037 11th Ave SW	1994	Tower	1,286.5	1,367.5	1,405.0	37'6"	Spheroid	500,000
97	North Park High Level	6380 Fairway Dr NW	1995	Tower	1,173.7	1,248.5	1,286.0	37'6"	Spheroid	500,000
98	Viola High Level	3180 Viola Rd. NE	1997	Tower	1,261.0	1,325.0	1,363.0	37'6"	Spheroid	500,000
99	Rose Harbor High Level	3213 Harbor Heights Ct SE	2001	Tower	1,202.0	1,272.5	1,310.0	37'6"	Spheroid	500,000
101	50th Ave NW Hydropillar	3975 50th Ave NW	2011	Hydropillar	1,170.5	1,250.0	1,290.0	40'0"	Hydropillar	2,000,000
						TOTAL STORAGE AVAILABLE (YEAR-END)				**15,230,000**

[1] Out of service (Booster Station in Base). This Tower site is major wireless communications antenna site.

Source: Rochester Public Utilities

As can be seen by the table above and the diagram on the following page, there are two water storage systems in Rochester, based on differences in ground surface elevation. This was developed because Rochester's downtown is at a lower elevation and it is surrounded by higher hills to the west, south, and east. These elevation differences create the need for the main level storage system (below 1,100 feet of elevation) and the high level system storage (above 1,100 feet of elevation). Having both a lower and an upper storage system helps maintain appropriate water pressure throughout the City.



Source: Rochester Public Utilities

While Rochester's water supply is of very high quality, care must be taken to keep it that way. Two key federal agencies, the U. S. Environmental Protection Agency and the U. S. Food and Drug Administration, regulate the amount of allowable contaminants in natural drinking water and bottled water, respectively. Each year, RPU tests the water supply for many unwanted contaminants, including: radon, nitrate (as nitrogen), barium, chlorine, alpha emitters, combined radium, haloacetic acid, total trihalomethanes, and tetrachloroethylene. Tests done by the City verified that the amounts of these contaminants were below established regulatory thresholds. In 2012, over 1,200 water samples were also tested for fecal coliform and Escherichia coli (E. coli) bacteria. No fecal coliform or E. coli bacteria were found in the water samples.

RPU is required to publish an annual water quality report. The report for the current year and previous years can be found online at http://www.rpu.org/environment/water-quality/.

What water feature created Rochester's bowl-shaped topography?

Case Study: Contamination of Water Supply

Below is an article reprinted from the 1943 Journal of the American Water Works Association. It describes the typhoid fever outbreak that occurred in SE Minnesota in 1939-1940.

Contamination of Water Supplies in Limestone Formation

By S. P. Kingston

Discussion Questions:

1) Why did people become sick with typhoid fever?
2) What role did the drinking water contribute to the illness?
3) What role did the sanitary sewer contribute to the illness?
4) How did geology contribute to the epidemic?
5) What corrective action was taken to prevent the future contraction of typhoid fever?
6) How does the situation in this article from 1943 relate to people today, both in Rochester and around the world?

Reprinted from
Journal of the American Water Works Association
Vol. 35, No. 11, November 1943

Contamination of Water Supplies in Limestone Formation

By S. P. Kingston

FOR many years the Minnesota Department of Health has recognized the dangers associated with obtaining water supplies from wells and springs situated in limestone formations. The *Manual of Water Supply Sanitation* of the Department contains the following statement: "There is common belief that contamination may seep through the soil for long distances and get into a well in this way, but such is not generally true in Minnesota although it should always be considered a possibility." The possibility exists in a portion of southeastern Minnesota where cavernous and fissured limestone formations lie relatively close to the ground surface, particularly at higher elevations.

In that portion of Minnesota (Fig. 1) where limestone formations are situated close to the ground surface, special precautions must be taken to protect ground water supplies from underground contamination. The black portion of the map (Fig. 1) indicates an area in which sinkholes predominate. The sinkholes are generally situated over the Galena limestone formation and are nothing more than openings or broken down spots in the loam or drift that connect directly to the limestone (Fig. 2, 3). They allow surface drainage, and in many cases domestic sewage and industrial waste, to enter the limestone. The sinkholes vary in diameter and depth from a few feet to over 100 ft.

The vertical and horizontal channels of the limestone quarry, indicate how easily contamination can travel great distances in the rock. In many cases contamination can, and has, entered municipal and private water supply systems.

A Typhoid Fever Outbreak

A little over five years ago, District No. 3 of the Minnesota Department of Health was organized with headquarters at Rochester. It was obvious at that time that one of the problems to be given special study was the possible contamination of municipal and private water supplies situated in the limestone area. Particular emphasis was given to the study when eleven cases of typhoid fever and one death occurred during the summer and fall of 1939 and the spring of 1940, in and adjacent to a village in Fillmore County (Fig. 4).

The first three cases developed at a farm in the southern portion of the village. The water supply for this farm was obtained from the village

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A paper presented on March 13, 1943, at the Minnesota Section, by S. P. Kingston, Public Health Engr., State Dept. of Health, Rochester, Minn.

water supply system and from a drilled well situated on the farm. The farm well which may be designated as well "A" was apparently cased only to the

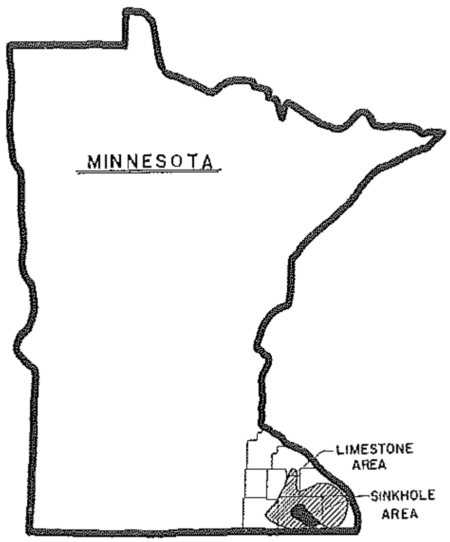

FIG. 1. Limestone and Sinkhole Area

first rock formation. This provided no protection from underground contamination.

A few weeks later five cases of typhoid fever occurred in the village. All of these persons had been using water supplied by the municipal system. The municipal supply is taken from two drilled wells which are designated as the old and new municipal wells. The old well is approximately 270 ft. deep and is cased only to the first rock formation. The new well is 1126 ft. deep and is cased to a depth of 400 ft. with 10-in. casing, to 340 ft. with 12-in. casing and to 20 ft. with 16-in. casing. All are cement-grouted in place for the purpose of excluding underground and surface contamination (Fig. 5).

In the spring of 1940, three more cases of typhoid fever occurred at a farm situated about two miles northwest of the village. The water supply for this farm was obtained from a drilled well cased only to the first rock formation. This well is designated as well "B" (Fig. 4).

At the time the typhoid fever cases occurred it was known that the village was discharging partly treated sewage into a sinkhole situated about 1500 ft. south of well "A" and 4000 ft. south of the municipal wells.

A complete epidemiological investigation disclosed no typhoid fever carriers with whom any of the cases had been in contact and no common vector other than the water supplies was found. However, the public health engineering work done in connection with the investigation revealed the following facts:

(a) Fluorescein dye (about three pounds) was introduced into the sinkhole receiving approximately 60,000 gpd. of partly treated sewage from the village. Periodic sampling was carried out at wells "A" and "B," and the two municipal wells. Within four hours the fluorescein dye appeared in water samples collected from well "A," a distance of approximately 1500 ft. from the sinkhole. However, no indica-

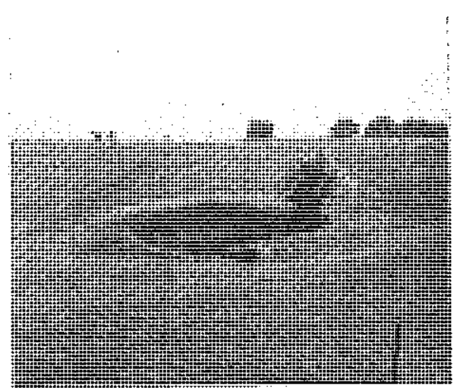

FIG. 2. Typical Sinkhole

tions of the dye were obtained from the samples of water collected from well "B" or the municipal wells. Bacteriological examination of water samples collected from well "A" showed a maximum concentration of 900,000 coliform organisms per 100 ml. as determined by the most probable number test.

(b) Just previous to the onset of the typhoid fever cases in the village, the old municipal well had been used during an emergency. All bacteriological samples collected from the old well, over a period of several months, contained coliform organisms with a maximum concentration of 1600 per 100 ml. At no time was any contamination found in the water obtained from the new municipal well.

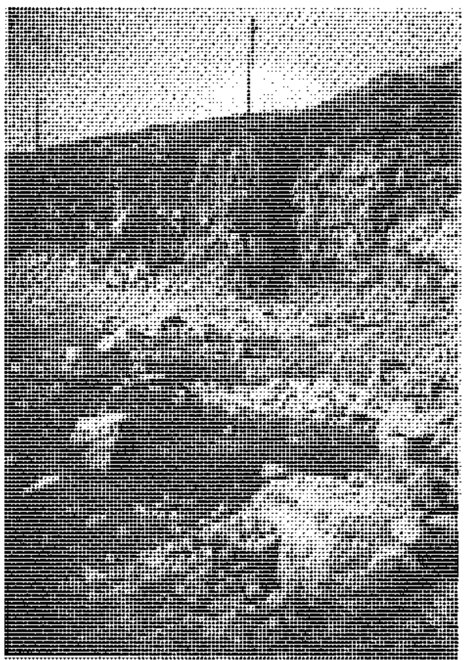

FIG. 3. Limestone Quarry

(c) Bacteriological examination of samples obtained from well "B" showed a maximum concentration of 92,000 organisms per 100 ml. In addition, typhoid organisms (*Eb. typhosis*) were isolated directly from 20-gal. water samples collected from the well. This indicated that excreta from a typhoid case or carrier were getting into the well. However, the investigation did not reveal the exact location at which domestic sewage was entering the limestone formations.

The foregoing engineering findings indicate that the eleven typhoid fever cases probably were water-borne and that infectious organisms had been transmitted through the cavernous and fissured limestone formations. Engineering recommendations were made to the municipality and to the individuals affected, as to methods of providing satisfactory water supplies and proper methods of sewage disposal.

Investigation of Farm Water Supplies and Sewerage Systems

The field work in connection with the typhoid fever outbreak, indicated the desirability of investigating a large number of farm water supplies and sewerage systems in the township immediately adjacent to the village. This investigation was conducted during the summer of 1941. The principal objects were to discover additional sources of contamination that may have contributed to the typhoid fever outbreak; and to collect engineering data on each water supply system. A total of 145 investigations were made at 130 farms. A summary of this investigation revealed the following:

(1) The major portion of all water supplies was poorly constructed above and below ground surface. Well casings in general were terminated at the first rock formation, thus providing no

protection from surface contamination that might enter the limestone.

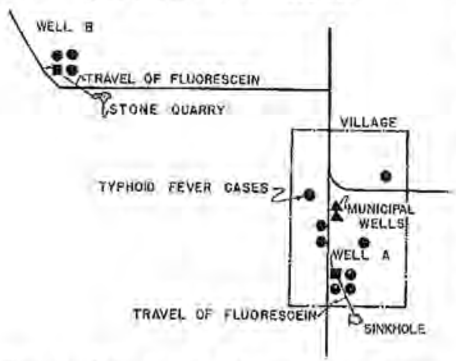

FIG. 4. Location of Wells, Typhoid Fever Cases, Sinkhole and Stone Quarry

(2) The bacteriological examination of 206 water samples collected during the course of the investigation showed 77 per cent of the supplies to contain coliform organisms; 20 per cent showed concentrations in excess of 100 organisms per 100 ml.; and 12 per cent were in excess of 1600 per 100 ml. In a few cases where it was possible to repeat sampling, there was an indication that the bacteriological counts increased after rains, showing that surface contamination was entering the wells.

(3) Approximately thirty-five of the farms were served with water-carriage toilet systems. Of these, 50 per cent were known to discharge sewage directly into the limestone formations, creating a serious hazard to the water supply for the farm, adjacent farms and municipalities.

(4) At a creamery, floor drainage was being discharged into a sinkhole approximately 150 ft. from the creamery well. Fluorescein dye (about 1 lb.) introduced into the sinkhole appeared in the well water within two hours, indicating a direct connection between the sinkhole and the well. It is needless to say that bacteriological results on samples collected from this well showed the water to be grossly contaminated.

(5) In an attempt to locate the source of contamination for well "B" fluorescein dye was introduced into an opening in the stone quarry (Figs. 3, 4). The opening had been used as a place of excreta disposal by the quarry employees. Within less than six hours the fluorescein dye appeared in a large spring situated approximately 100 ft. from well "B" and 1600 ft. from the quarry. The spring had been used for a drinking water supply up until the time well "B" was contructed. While

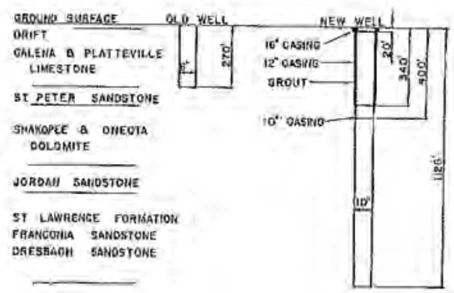

FIG. 5. Section on Old and New Municipal Wells

the dye did not appear in well "B" it is possible that during heavy rains and spring thaws contamination from the stone quarry could enter well "B."

Contamination of Water Supply

Another very interesting case of water supply contamination occurred during the summer of 1942, at a large private residence in Olmsted County. The situation was brought to the attention of District No. 3 after several cases of gastro-enteritis developed in persons visiting the residence. The cases appeared to be of a water-borne nature.

Plans and specifications for the residence, completed in the fall of 1941, showed the proposed location of the well and specified only that a certain amount of water per minute be obtained. No other well specifications were given. The well driller provided a 6-in. well 198 ft. in depth, cased only 8 ft. into the Platteville limestone, thus giving very little protection from underground contamination.

The plans indicated a septic tank and leaching pit situated approximately 110 ft. from the well. The plumber installed the septic tank in the creviced Platteville limestone and to provide a method for final disposal of the effluent a leaching pit was blasted in the rock (Fig. 6).

FIG. 6. Platteville Limestone

The engineering investigation revealed the water supply to have an odor of organic matter, indicating the probability of sewage contamination from the leaching pit. Again fluorescein dye was used. About one pound of the dye was introduced into the leaching pit and in less than fourteen hours the well water turned a deep green, indicating a direct connection between the leaching pit and the well (Fig. 7). This finding was substantiated by bacteriological results.

Immediate steps were taken to correct this situation. The use of this well was discontinued and a new drilled well was constructed (Fig. 8). The new well is 285 ft. deep and is cased with 8-in. casing to a depth of 145 ft. The 8-in. well casing was placed in a 16-in. drill hole and the annular space between the casing and the drill hole was filled with cement grout. A cast-iron sewer was provided for the effluent from the septic tank and a soil absorption system constructed in suitable soil about 250 ft. from the well. When all construction work was completed on the new well and sewerage system, the old well was filled with concrete and the old leaching pit filled with clay.

Contamination of Municipal Water Supply

The investigation of the contamination of water supplies situated in the limestone area, of course, included all of the municipal water supplies. Most of the municipal water supplies are obtained from deep wells but a few large springs are used. The springs are apparently subject to surface drainage through sinkholes, etc. This occurs during periods of heavy precipitation and spring thaws when the water becomes turbid and the concentration of coliform organisms increases. One very large spring, although not used for a municipal water supply, is clear during normal weather conditions but during periods of heavy rains becomes extremely turbid and occasionally straw and corncobs appear in the water, indicating a direct connection to the ground surface.

In the spring of 1942 during an investigation made of a municipal water supply derived from a typical limestone spring, it was reported that there had been several cases of gastro-enteritis during the preceding month, particularly during a period when the water had been turbid.

To confirm these reports a survey was made by visiting every fifth household in systematically selected sections of the village to determine the incidence of gastro-enteritis during the preceding month. Seventy-two households were visited and information obtained from 274 persons, or approximately 13 per cent of the population. The survey indicated that an outbreak of gastro-enteritis affected approximately 10 per cent of the population during a thirty-day period. Many of the individuals questioned associated their illness with the time when the water supply was turbid and unsatisfactory for domestic use.

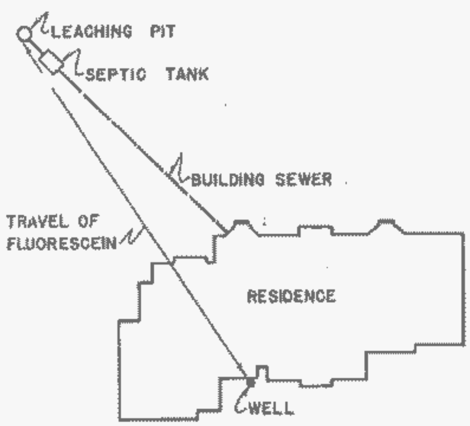

Fig. 7. Location of Well and Leaching Pit at Private Residence

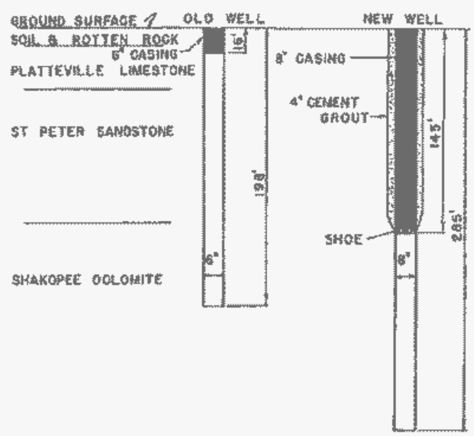

Fig. 8. Section of Old and New Wells at Private Residence

Summary

The main purpose of this report has been to discuss some definite instances where municipal and private water supplies obtained from limestone formations, have been seriously contaminated, and not to propose any detailed methods of correction. However, it is probably advisable to summarize the more salient features and to formulate broad corrective measures as follows:

(1) It is obvious that there is real danger of underground contamination of municipal and private water supplies situated in the fissured and cavernous limestone area of southeastern Minnesota. This is borne out by the fact that on four separate occasions underground sewage flow was traced, with the aid of fluorescein dye, up to a maximum distance of 2000 ft. and in every case the dye was recovered from a water supply that had been used for drinking purposes. In connection with a typhoid fever outbreak it was possible to isolate pathogenic organisms (*Eb. typhosis*) directly from a well water supply.

(2) A very large portion of farm or private water supplies are of unsatisfactory construction and are further endangered by the practice of discharging sewage directly into the limestone formations.

(3) In the development of under-

ground water supplies great care should be exercised in the selection of well locations, the use of impervious overlying geological strata and special structural features to exclude underground contamination. Municipal water supplies should be provided with subsequent treatment as required.

(4) Water supplies that are obtained from springs in the limestone formations should be considered as surface water supplies and be provided with adequate treatment.

(5) The practice of discharging sewage into the limestone formations should be eliminated.

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Chapter 6 - Rochester's Wastewater Treatment System

Water is not limitless. Water consumption is required for everyday life and we have an obligation to be good stewards of the water we use. This means we have a responsibility for returning clean water to the local environment as part of the larger goal of maintaining a healthy global water cycle.

In the hydrological cycle, water is cleaned by nature through multiple chemical, physical, and biological processes. Examples of natural, water-cleaning processes are filtering water through soil, bacteria and algae feeding on suspended nutrients, or solids settling to the bottom of a lake. The key component to the natural water cycle is balance. Ideally, the supply of chemicals used by microbes and plants will match their population size. However, as the amount of chemicals in the water increases, the populations of plants and microorganisms can explode. When they die, their decomposition uses the oxygen that other aquatic organisms need to survive, upsetting the natural cycle. Adding a large population of humans to a local water cycle can also upset the balance. Rochester's Water Reclamation Plant (WRP) was built to treat the large amount of wastewater produced here, to help maintain the natural water balance. As the City's population has grown, the municipal WRP has expanded operations, as well.

Municipal is the term used to refer to a city owned system, such as Rochester's Water Reclamation Plant and sewer system.

Wastewater is used water that is generated from residences, commercial buildings and industrial plants. It is also sometimes called sanitary sewage. According to the U.S. Environmental Protection Agency (EPA), the average American produces 100 gallons of wastewater each day. In this case, the term "waste" does not mean that the water is thrown away. The goal of the City of Rochester is to return wastewater to the water cycle at the Zumbro River, with as little environmental impact as possible.

An Aerial View of the WRP

Source: Rochester Public Works

After water goes down the drain or the toilet is flushed, where does the water go? Wastewater is carried from homes, and commercial and industrial businesses, through a network of buried pipes, called a sanitary sewer collection system, to the WRP located in NW Rochester at the intersection of 37th Street and the Zumbro River. Once there, the water undergoes an advanced and complex process that reduces contaminants to levels required by WRP's operating permit before being returned to the environment via the Zumbro River. The WRP engineered processes mimic natural processes to treat most pollutants, but complete them at a much faster rate and in a controlled environment.

Rochester's WRP serves Rochester's 108,000 residents, its visitors, and its businesses. Initially, the WRP was located far outside the City limits, but as Rochester's population grew, the City encircled the treatment campus. More people also meant more wastewater and the WRP has expanded many times over the years to meet the new demands. Plans have been made to ensure that WRP can be expanded at its current site to serve a future population of over 300,000 people. The existing treatment capacity of this High Purity Oxygen (HPO) facility is 19.1 million gallons per day (mgd). The parallel treatment facility, called the Aeration Basin Complex (ABC), is rated at 4.75 mgd capacity. Currently, about 14 mgd of wastewater is treated at WRP. Each gallon of wastewater takes about 24 hours to treat from the time it enters the plant as influent to the time it is released from the system as effluent. Separately, the solids that result from the 24-hour treatment process undergo further treatment that takes over 30 days.

The WRP is not supported by taxes. Instead, it is part an "enterprise fund utility" that operates on a fee-for-service basis. Each month, customers receive a bill that covers the cost of all these WRP operations, along with the cost to build and maintain the sanitary sewer network.

Influent - wastewater entering the WRP

Effluent - treated water leaving the WRP

Sanitary Sewers

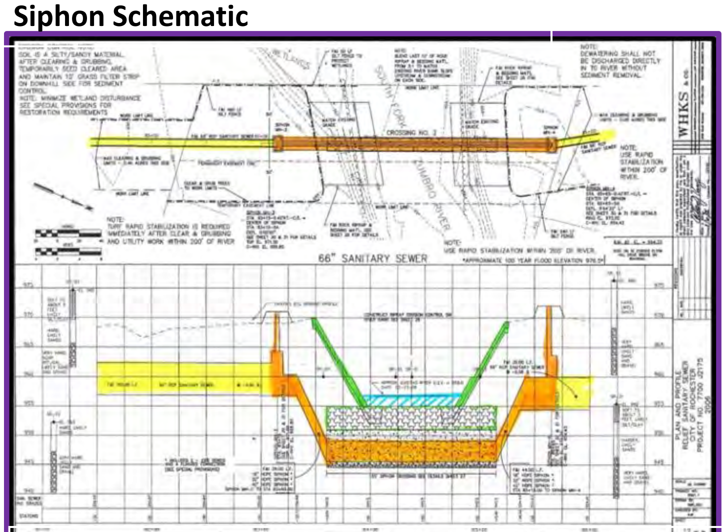
Sanitary Sewer Installation

Source: Rochester Public Works

The sanitary sewer system in Rochester carries both domestic (i.e., residential) and industrial wastewater. The wastewater is carried from each building in Rochester through 2,670,520 feet (505.8 miles) of pipe to the WRP. New sanitary sewer is added as City grows. The diameters of the pipes in the network vary, generally from 8 to 84 inches, although some older 4 and 6 inch pipes are still in service. The smallest pipes are service connections between buildings and the main, or "trunk" sewers that are 12 inches or larger. The largest pipe is 84 inches and it is the final pipe entering the WRP. Rochester has over 488,320 feet (92.5 miles) of trunk sewers as of 2013. It takes wastewater about two hours to be conveyed from downtown Rochester to the WRP.

Most of the wastewater moves through the pipes in gravity or siphon mains, although there are a few areas in Rochester where "lift stations" are needed. Since water flows downhill, pumps are needed to lift wastewater through areas with an uphill grade. Rochester has four public lift stations that are owned and operated by the City. Developers and/or home owner associations own and operate an additional 9 private lift stations. This unusually small number of lift stations, for such a large City, is due to the fact that the City is located in a river valley.

Siphon Schematic



Source: Rochester Public Works

The Zumbro River and its tributaries are obstacles for installing buried pipe. To solve the problem of getting under rivers while maintaining the needed slope, engineers design a specialized set of pipes called inverted siphons or depression sewers. To work, the pipes must dip below the river and then rise to the needed pipe elevation on the other side. This prevents the wastewater from moving simply by gravity, as it does in other areas. The siphon system uses basic hydraulic principles to keep the sewage moving at 3 ft/sec, the speed needed to keep materials in suspension and to prevent pipes from clogging. Because of the pipe bends in an inverted siphon (highlighted in orange), the liquid flowing in one end of the pipe forces the liquid up and out the other end. To create the necessary velocity, pipe size and the discharge or volume of wastewater must be balanced. Typically, a series of three pipes with different diameters are used. If flow is low, the smaller pipe captures the flows to keep the desired pressure. Inverted siphons are also used to avoid other underground objects in Rochester, such as major utilities or Mayo Clinic's pedestrian tunnels.

Wastewater Reclamation Plant (WRP)

At the WRP's pump station entrance, wastewater is screend with 3 inch opening trash racks. These trash racks prevent large debris from entering the WRP lift station. The WRP influent lift station is composed of five pumps that lift wastewater up 72 feet.. Water travels via gravity through the rest of WRP until it flows into the Zumbro River.

Raw Wastewater Pump Entrance Station

Raw Wastewater Pump Discharge Pipes

Source: Deb Las (all photos)

Preliminary Treatment – Screening

Once the wastewater reaches WRP, it must undergo a series of treatments before it can be released into the Zumbro River. The initial process removes large solids by passing the wastewater through ¼" stainless steel screens. The only items that should go down the toilet are water, human excrement, and toilet paper. Other products, such as cleaning wipes, paper towels, and pet waste, for example, should be disposed in the garbage so they don't lead to costly equipment repairs. After screening, the collected solid materials are transported via conveyer belts to a shoot where they fall into plastic bags and are readied for incineration at the Olmsted Waste-to-Energy Facility.

Influent Screen

Solids Conveyor

Solids Disposal Preparation

Next, the wastewater passes through the grit chamber where the wastewater is slowed enough for sand, grit, and gravel to fall to the bottom of the tank. The grit is then washed to prepare it for disposal at the Olmsted County Kalmar Landfill.

Grit Washing Process

Washed Grit Ready for Disposal

Primary Treatment – Settling Tank

Primary Clarifier

After preliminary treatment, wastewater moves to the primary treatment stage. The water is conveyed into large settling tanks called clarifiers. This stage removes about 30% of the pollutants. Most of the solids that can either float to the top of the tank or sink to the bottom are collected. Mechanical scrapers loosen solids that have settled out of suspension so they can be pumped out of the bottom of the tank. The heavier, sludge-like material is known as "primary solids" and the light materials that float, such as oil and grease, are skimmed off the top of the water. Both waste materials are pumped to the anaerobic digesters for further treatment.

Primary Solids Pumps and Pipes Deliver Sludge to the Anaerobic Digester

Secondary Treatment – Aeration & Biological Treatment

Secondary treatment is a two stage process that involves aeration with biological treatment and settling. In this process, dissolved solids are consumed by microorganisms and converted into "settleable solids".

Aeration Basins

Secondary treatment is an important step because organic matter is removed at this time, thereby lowering Biological Oxygen Demand (BOD) so aquatic life in the Zumbro River does not have to compete for oxygen.

While some of the solids are removed in primary treatment, the wastewater still contains contaminants that are dissolved in the water. In nature, many of these contaminants would be food for living microscopic animals and plants, such as protozoa and algae, or bacteria. The engineered wastewater treatment process uses an artificial environment that mimics the ideal conditions of nature where these microorganisms also consume such pollutants. The engineered process controls oxygen levels and detention time so microorganisms can work quickly and efficiently to consume dissolved solids, converting them into settleable solids within the man-made habitat. To achieve this, wastewater that has completed the preliminary and primary treatment steps is combined with microorganisms in a large aeration basin. Oxygen is added and mixing occurs for several hours to produce carbon dioxide (CO_2), cleaner water (H_20), and more microorganisms. This first stage is known as the activated sludge process and it takes several hours.

In the HPO plant the secondary treatment is divided into first and second stages. The first stage is for the removal of BOD during a detention time of about 2 hours. Some of the microorganisms are returned to the first stage aeration process and the solids are removed for processing. During the second stage, ammonia is oxidized to nitrate after a detention time of about 4 hours.

Intermediate Clarifiers

The term BOD is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C.

In *The Field of Dreams* movie, the main character hears: "If you build it, he will come." That is the case with the bacteria in sludge. As long as the proper environment is provided, the bacteria will multiply and keep eating the dissolved pollutants. The particular strain of bacteria in this process is not important as long as it is a type that clumps together as it multiples. By clumping, enough mass is produced to force the bacteria to fall to the bottom of the tank. Bacterial samples are monitored weekly to prevent the production of filamentous bacteria that do not settle out as well. Filamentous bacteria can be caused by over aeration of the wastewater.

After the microorganisms have been allowed to interact with the wastewater, the mixture is sent to settling tanks called final clarifiers. The wastewater is evenly distributed to each of the four final clarifier basins via a splitter structure. The wastewater enters the platform from the center and the flow is divided by going over one of the four sides. The final clarifier further separates the suspended solids from the treated water, leaving the heavier solids on the clarifier floor. By the end of the secondary treatment process, about 95-98% of the waste has been removed from the flow of water.

The settled sludge is then sent to the anaerobic digesters or recirculated. The sludge is recirculated to the aeration basin to provide the necessary life forms to continue the secondary treatment process (this material is called return activated sludge). The remainder of the sludge is sent to anaerobic digesters and is converted to biosolids. (See the Section titled "Byproducts of Wastewater Treatment for more information.)

Final Clarifier Splitter Structure

Final Clarifier

Final Clarifier Effluent Water

Vocab Focus:

Aerobic - with oxygen

Anaerobic - without oxygen

Tertiary Treatment – Chemical Additions & Biological Oxidation

In the tertiary, or advanced stage, phosphorus is removed. Phosphorus is a plant nutrient that can cause excess algae growth in surface water. Excessive algae growth can block sunlight from reaching beneficial aquatic plants that provide food, shelter, and oxygen to the aquatic environment. Excessive algae can also decrease the dissolved oxygen in water when the algal cells die and decompose. Because the WRP discharges to the Zumbro River, which eventually flows into Lake Zumbro, it is important to remove phosphorus for both river and lake health. Phosphorus is removed three different ways in Rochester: the settling of solids, biological uptake by microorganisms, and chemical addition of ferric chloride and alum. Ferric chloride is added to the influent in the primary clarifier. Alum and an anionic polymer are added to the final clarifiers to further remove phosphorous. Both chemical additions help precipitate the phosphorus so it comes out of solution.

Disinfection – Chlorine

The last step in the treatment process is the addition of chlorine to disinfect the water by killing bacteria and viruses. The chlorine gas is injected into the flow coming from the final clarifiers into the chlorine disinfection basins, where it remains for several hours. Sodium bisulfite is then added to neutralize the chlorine as the water leaves the WRP via a single pipe. The effluent water now meets the permit requirements and can be returned to the Zumbro River to rejoin the natural hydrological cycle.

Chlorine Disinfection

Effluent Discharge to the River

Byproducts of Wastewater Treatment

Biosolids are one of the key byproducts of wastewater treatment because they can be reused as fertilizer. In fact, the White House lawn is fertilized by biosolids. About half of the solids that settle during the clarification steps are reused in the secondary process. All the rest of the solids are transported to an anaerobic digester where they are processed in much the same way as a human stomach would breakdown food. The activated sludge is thickened on gravity belt thickeners, blended with primary sludge and then digested in an oxygen-depleted environment for about 20 days to create the biosolids. The biosolids are rich in nitrogen and phosphorus, the primary nutrients used in commercial fertilizers. The WRP stores its biosolids all year and then applies it to local farm fields as fertilizer in the spring and fall.

Gravity Belt Sludge Thickener

There are regulations for application of biosolids. Fields must meet specific conditions, such as slope and soil type, to receive a land application permit from the state. While WRP has about 8,000 acres available under its permit, biosolids are applied to only about 2,000 acres annually. Extra land is needed because applications are rotated to different fields each year. Approximately 12,000,000 gallons of biosolids (at 6% solids content; this is equivalent to 3,000 dry tons) are generated and used as fertilizer each year. The value to the farmer is estimated at $300 per acre.

Biosolids Load-Out Facility

The WRP coordinates the transfer of biosolids from two large storage tanks in the loading garage to tanker trucks that are driven to the farm fields. At the fields, application tractors distribute the biosolids and inject them into the soil. Both the City and the farmers benefit from the biosolids application process.

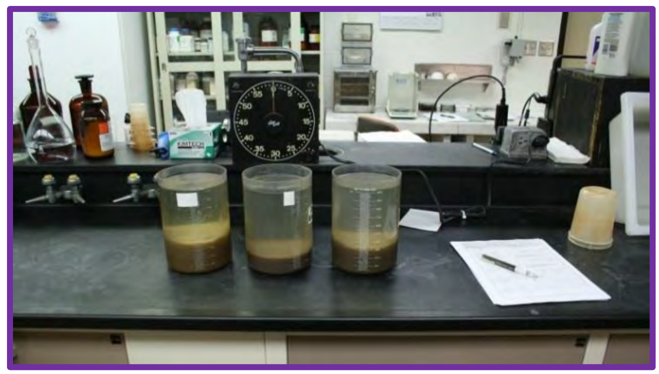
Biosolids Applicator Tractors

Tanker Trucks

High Pressure Gas Storage Sphere

Another byproduct of treating Rochester's wastewater is biogas. Digesting solids gives off biogas, a mixture of about 61% methane (CH_4), plus carbon dioxide (CO_2) and hydrogen sulfide (H_2S). Biogas produced is used immediately or stored in a separate containment facility, the high pressure gas storage sphere. Since it is similar to natural gas, it can be burned. The WRP produces about 40% of its own energy by using this gas. That is equivalent to about $600,000 worth of energy per year. The gas is burned in two engines to generate electricity and the jacket water and exhaust boiler heat exchangers provide heating for the buildings.

Engine Generators

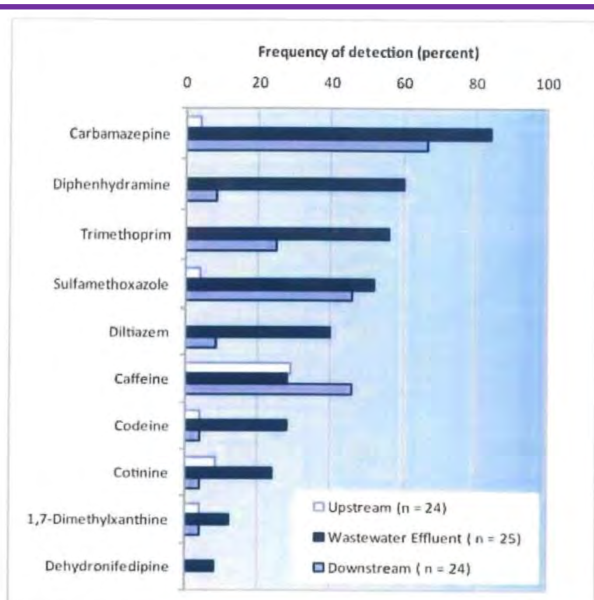


Each step of the wastewater treatment process is chemically monitored. Water samples are collected automatically from around the plant and transported to a centralized location about every six minutes. This creates an averaged water sample that is held in collection containers until analyzed by the lab technicians, using the specialized equipment shown.

Contaminants of Emerging Concern

An area of emerging concern for wastewater treatment is the issue of chemicals contained in pharmaceuticals (i.e., prescription and over-the-counter medications) and personal care products. Personal care products can enter wastewater by washing our bodies. Drugs may not be entirely absorbed into the body and can enter into wastewater in urine and excrement. The treatment processes do not remove all of these chemicals from wastewater. Recent research has shown very low concentrations of these chemicals in water that are now being detected because of advances in analytical technology. The EPA and the University of Minnesota are continuing their research into the possible effects these chemicals may have on aquatic and human health. Do not dump unused pharmaceuticals down the drain. Either put these medicines in the trash mixed with coffee grounds or cat litter or bring them to a drop off location established by local organizations.

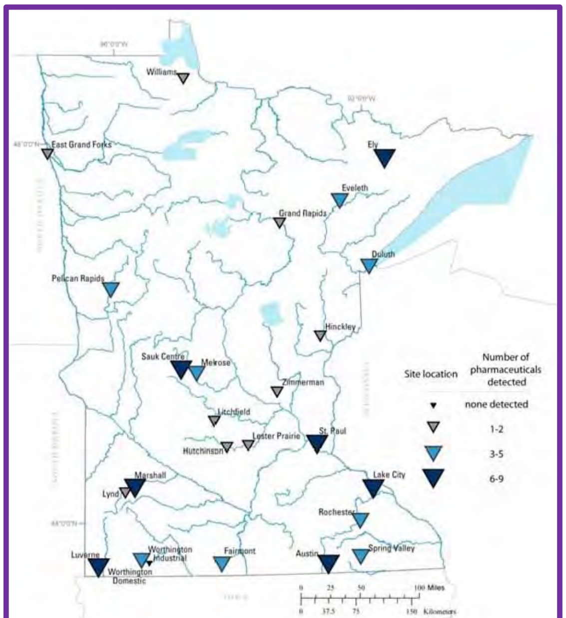
Pharmaceutical Chemicals Detected in Wastewater and Surface Water



Graph showing the frequency of detection of pharmaceutical compounds measured in water samples collected from wastewater effluent and from stream sites located upstream and downstream of effluent discharge during 2009.

Source: U.S. Geological Survey

Wastewater Treatment Plant Sampling Locations



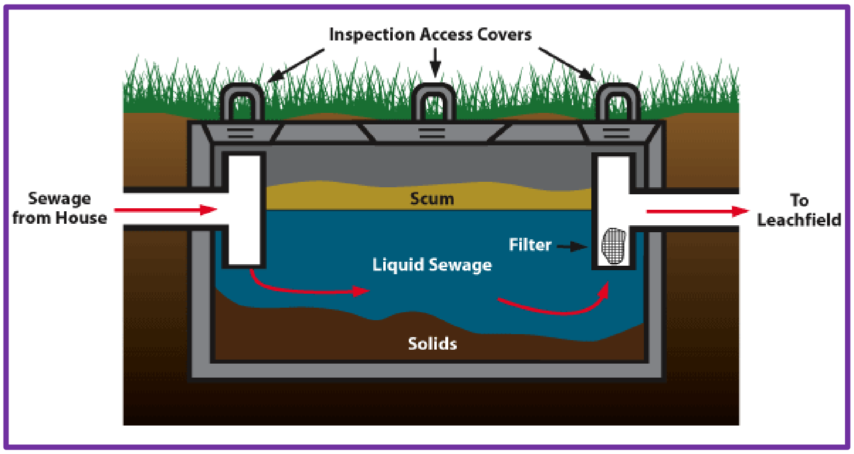
Source: Minnesota Pollution Control Agency

Septic Systems

Before centralized wastewater treatment became available, people either discharged their wastewater to a sewer that emptied directly into the river or used an individual sewage treatment system made up of a septic tank and a drain field. In the 1990's, many homes in older subdivisions surrounding Rochester were dealing with failing septic systems and did not have large enough yards to support a new drain field. Because failing septic systems can cause groundwater pollution, the City began working with the older neighborhoods to extend sanitary sewer and water lines to them, annexing those neighborhoods into the City. This Water Quality Protection Program was assigned $22.5 million of sales tax revenue to fund this effort. Since the first project was constructed in 1999, the City has helped connect about 1,350 homes to the WRP and the City's water supply.

There are still a few homes in Rochester that are not connected to the City's sanitary sewer system. Some houses may be too far away to hook up to the system. Other houses may have been built before the sewer lines extended to their area. These homes still rely on individual septic systems buried in their yards to treat their wastewater.

Septic Tank Diagram

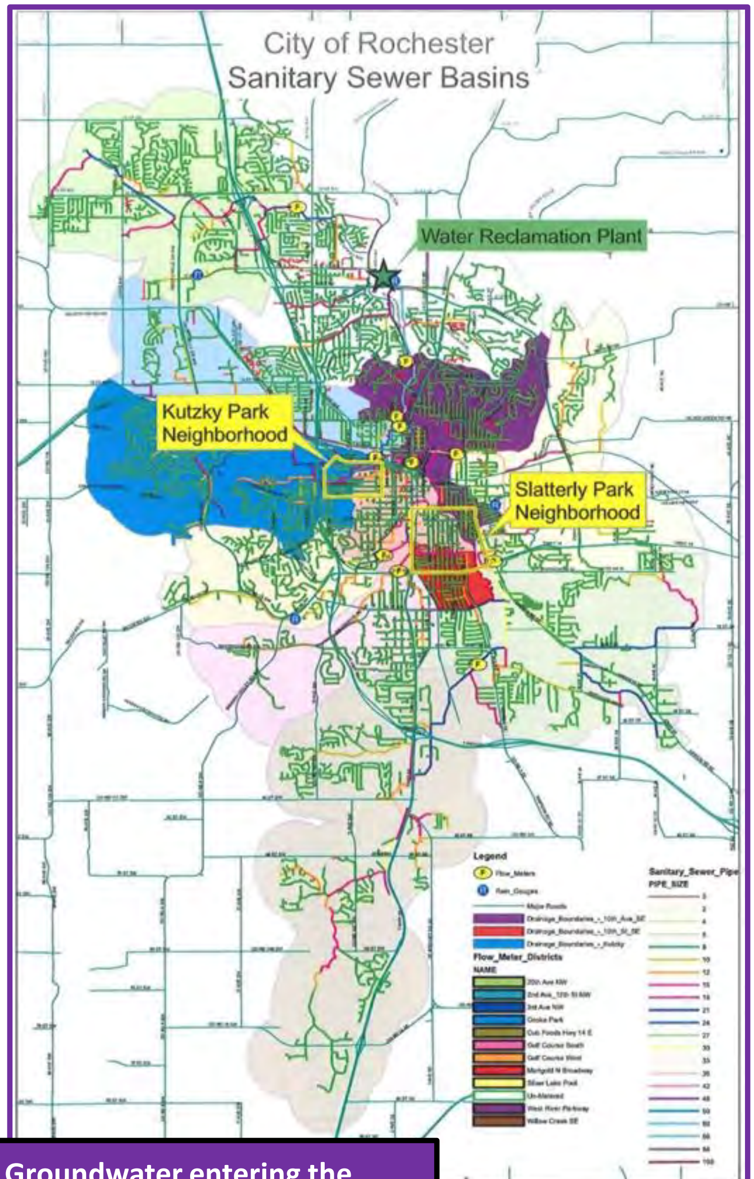


Source: Septic System Installation by J. Hockman, Inc.

A septic tank is a large (usually 1,000 gallon) concrete or plastic tank that is buried underground. Wastewater enters one side of the tank and flows out the other side into the underground area known as the drain field or leachfield. The tank acts a bit like a simple wastewater treatment plant. Heavier solids sink to the bottom. Lighter materials float to form the scum layer. Water with dissolved pollutants is found between the layers. The drain field is a series of pipes with small holes that are laid in a gravel bed to drain the effluent. The overlying plants and the underlying soils provide an environment where bacteria and plants can consume the dissolved pollutants.

Case Study: Slatterly Park and Kutzky Park Neighborhoods 2007-2008 Sewer Backup

Rochester's sanitary sewer system is an engineered network of pipes that, with the exception of four municipal lift stations, uses gravity to move wastewater throughout the entire City. As the City expands and older pipes degrade, there is a need for constant additions and upgrades. Insufficient capacity in older pipes or leaking pipes can cause conveyance problems and, occasionally, problems for homeowners.



A record rainfall event that started on August 18, 2007 caused several sanitary sewer backups in homes located in the older Slattery Park and Kutzky Park neighborhoods. When backups occur, sewage flows from the pipe into the home, instead of the other way around. The City has conducted an infiltration and inflow (I & I) study to identify causes for the backups. Recommendations from this study and others are being implemented throughout the City to minimize these types of situations.

***Infiltration*- Groundwater entering the sewer due to defective pipe joints or broken pipes**

***Inflow* - Surface water entering the sewer due to inappropriate connections between the surface and the pipes (e.g., sump drainage or leaking manholes)**

Review the PowerPoint presentation that was given to neighborhood residents about the I & I study and then read the summary of the Slatterly Neighborhood Sewer Rehabilitation and Capacity Assurance Program Report found at the hyperlinks listed below:

https://www.rochestermn.gov/departments/publicworks/hottopics/SanitaryIIStudy/Slatterly/Slatterly%20Park%20Meeting%20Powerpoint%20January%2022,%202008.pdf

www.rochestermn.gov/departments/publicworks/hottopics/SanitaryIIStudy/Slatterly/Slatterly%20Park%20Meeting%20January%2022,%202008.pdf

Answer These Questions:

1) What is the problem that needs to be solved?
2) What are the factors related to this problem?
3) What actions by individuals might be contributing to the problem?
4) What sanitary sewer system conditions might be contributing to the problem?
5) What might be a possible solution?

Important Dates in Rochester's Wastewater Treatment History

- 1895 Rochester's sewer control ordinance adopted
- 1926 Typhoid epidemic in SE MN linked to sewage contamination of the water supply
- 1926 Rochester open its first wastewater treatment plant south of Elton Hills Drive using a suspended growth process only six years after the process is patented
- 1950 Rochester opens its second wastewater treatment plant out of town at the current 37th Street location, naming it the Wastewater Reclamation Plant
- 1957 A County study of water quality in subdivisions without sanitary sewers found high nitrate levels, leading to the adoption of the Olmsted County Sewage and Wastewater Treatment Ordinance
- 1964 Rochester adopted a policy requiring annexation into the City before sewers could be extended to unsewered areas
- 1966 Several local committees and boards recommended extension of sewer services into older subdivision areas outside of Rochester
- 1971 Olmsted County adopted a requirement that residences utilizing septic systems must have lots at least two acres in size to provide space for future replacement drain fields
- 1980s WRP added the two-stage high purity oxygen activated sludge process. The project was partially funded through a Federal grant.
- 1990 WRP added solids treatment processes.
- 2004 WRP expanded to add treatment capacity

Chapter 7 - Rochester's Storm Water Management System

Rochester's water cycle is no longer natural; it has become "urbanized" by the creation of human habitat with lots of hard, or impervious, surfaces like streets, roof tops, or even construction sites. These impervious surfaces prevent infiltration of precipitation, so when it rains or snow melts, this run-off (or storm water) runs across both natural and constructed surfaces. When the water can't infiltrate, it misses the soil filtration step where microorganisms consume many pollutants. As a result, this change to urban areas causes lost recharge and more runoff that moves across the landscape faster. More and faster moving water can cause erosion and can collect pollutants as it moves and transports them to receiving waters.

An impervious surface does not let water go through it.

Today, storm water pollution is regulated at the federal, state and local levels. The regulations derive from the Federal Clean Water Act (CWA) that was passed by Congress in 1972. (Groundwater is governed under the Safe Drinking Water Act, as is wastewater treatment.) The CWA is the primary law governing the prevention and control of "point source" water pollution. That is pollution that comes out the end of pipes or off a small site. A basic goal of the CWA is to have waters meet water quality standards so surface waters are fishable and swimmable. Initially, the law called for surface water to meet standards for human sports and recreation by 1983 and for the elimination of additional water pollution by 1985. Those goals were not met, so the law has since been updated to create the National Pollutant Discharge Elimination System (NPDES) permit program. Congress then directed the Environmental Protection Agency (EPA) to establish rules for three permit programs that authorize storm water discharges at municipal, industrial and construction sites. EPA can delegate their authority to administer the NPDES permit programs to states that have agencies meeting their requirements. In our state, EPA delegated their authority to the Minnesota Pollution Control Agency (MPCA). So the MPCA wrote three state permits (municipal, industrial and construction) that authorize storm water discharges for specified entities within Minnesota, as long as the permit requirements are met.

Point Source pollution comes from a single identified source. Non-point pollution comes from a diffused sources, not single sources.

This chapter will focus on the Municipal Separate Storm Sewer System (MS4) permits and storm water management in Rochester. (For more information on the industrial and construction storm water permit programs, go to: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/index.html.) The MS4 permit program evolved in two phases, based upon the size of a municipality. The “Large MS4” permit, or Phase 1, started in 1991 for cities with a population greater than 100,000. Phases 2 began in 2003 for cities larger than 10,000 but smaller than 100,000. Rochester was smaller than 100,000 in 2003, so federal rule designated it as a “Small MS4”, even though today it is larger than 100,000 people.

The primary goal of Minnesota’s MS4 permit is to “restore and maintain the chemical, physical, and biological integrity of waters of the state through management and treatment of urban storm water runoff”. To meet its permit requirements, the City must describe and implement Best Management Practices (BMPs) that manage storm water. Together, these BMPs comprise the City’s Storm Water Pollution Prevention Program (SWPPP), which is organized according to the federal Minimum Control Measures (MCMs). These fall into six categories:

1. Public Education & Outreach
2. Public Participation & Involvement
3. Illicit Discharge Detection & Elimination
4. Construction Site Storm Water Management
5. Post-Construction Storm Water Management
6. Good Housekeeping and Pollution Prevention

In addition to the MCM requirements, the City must also act in accordance with other rules, like those that pertain to:

- Impaired waters, (tied to Total Maximum Daily Load reports and implementation plans),
- Discharges to waters with restricted discharges, like our calcareous fens, and
- Source water protection, which is managed by Rochester Public Utilities.

Since storm water does not flow to the Rochester Water Reclamation Plant for treatment, there is no single discharge point for storm water to re-enter the Zumbro River. Therefore, it is impossible for storm water permits to have effluent standards the same way a wastewater treatment permit does. Instead, the storm water permit standard says that permit holders must reduce the discharge of storm water pollutants “to the maximum extent practicable” (MEP). Although the Rochester Public Works Department manages the MS4 permit, meeting the permit’s MEP standard can only be accomplished if every citizen and business in Rochester works toward reducing storm water pollution individually and together.

Storm Water Pollutants

The reason for storm water management regulations is the need to control pollution from storm water so it is not added to surface water. Storm water pollutants have many forms and sources. Some are artificial and some are natural, but intensified by human actions. People commonly think of trash as being a pollutant, but may forget about pet waste or oil from cars. Sediment, or just plain old dirt, can be a pollutant if there is too much of it suspended in the water. Construction and farming activities disrupt soils so they are more easily eroded to become pollution. Turbidity in streams raises water temperatures and disrupts food chains. Read the following list of common storm water pollutants. Which do you contribute? Can you reduce your impact?

Common Storm Water Pollutant Categories and Sources:

- Sediment
  - Erosion (construction, farming)
- Toxic Chemicals
  - Pesticides and fertilizers
  - Hazardous Wastes (dumping)
  - Fuels, oils, grease (motor vehicles)
  - Salt (winter deicing)
  - Trash
- Nutrients
  - Fertilizers
  - Yard Waste (leaves, grass clippings)
- Bacteria
  - Animal Waste (wildlife, pets)
  - Feedlots (livestock)
  - Failing Septic Systems

Examples of Storm Water Pollutants: Leaves, Dog Poop, Litter and Cigarette Butts

Source: Deb Las (All)

Many people do not realize that their actions on the land affect water quality. All of the materials listed above can be washed off the land into the storm sewers system. In central Rochester (the areas built before 1985), these pollutants can reach our surface waters without any treatment. Therefore, prevention is the best answer to storm water pollution. Remember: no matter where you live in Rochester, you have waterfront property!

Pipes & Connectors

Storm water management programs must accomplish many objectives. In addition to teaching people how to prevent pollution, a system must be built to move, or convey, the water and treat pollution. Engineered structures that intentionally move water are the first part of the storm water management system.

Rochester's conveyance system is a vast network of storm drains (also called catch basins), underground storm sewers, and ground-level drainage ditches whose purpose is to move storm water quickly away from structures (at home, you use gutters to direct water away from your house). The storm water conveyance process starts with graded constructed sites so water will run into streets or ditches. Water collected on streets runs into the catch basin grate, which is attached to an underground pipe, called a storm sewer. Storm sewers range in diameter from 4 to 96 inches. They can serve small or large areas. Ultimately, the water is released from the pipe into a storm water treatment pond or one of Rochester's receiving waters, like Silver Lake or the Zumbro River. That discharge point, or outlet, is known as an outfall. Similarly, water that runs into ditches is often directed into storm sewers. If the ditch is close to a river, it will outlet directly into it.

Catch Basin with Pollutants

Source: Deb Las

Outfall to the River

Source: Deb Las

Groups and individuals mark catch basins around Rochester with "no dumping" decals. These help remind people that storm water flows from the streets into our streams. Only about 11% of catch basins have been labeled, so if your group wants to help, contact Megan at: mmoeller@rochestermn.gov or 328-2440. Or, you can help by "adopting" a catch basin near where you live or work to keep it clear of debris between street sweepings.

Source: Deb Las

In the following map, look at the locations of streams and lakes, storm sewers (pink lines), catch basins (pink squares), and treatment ponds (blue circles, squares and arrows with numbers). Follow the arrows to find the flow of storm water. Can you find which property drains directly to a surface water body without treatment?

Storm Sewer Network

Source: Rochester Public Works

The South Fork of the Zumbro River is the primary river that flows through Rochester. About 9 miles of its course is in the City and another 103 miles of its tributary creeks pass through the City, too. As of 2012, Rochester's constructed storm water conveyance system had the following public and private components:

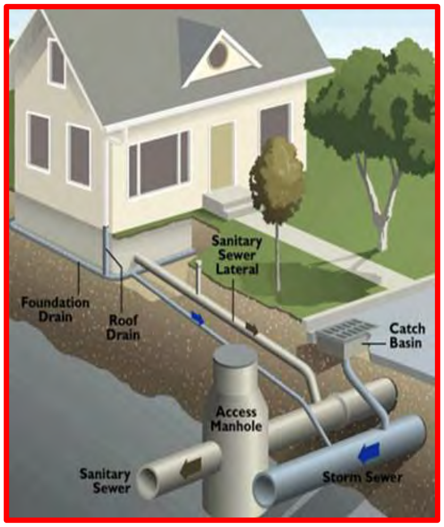
- 422 miles of storm sewer pipe,
- 1,755 outfalls to receiving waters,
- 15,699 storm sewer catch basins,
- 7,986 storm sewer manholes,
- 61 bridges and box culverts,
- 834 lane miles of City streets, plus
- 330 lane miles of open road ditches and thousands of road culverts.

Waterway Conveys Snow Melt

Source: Deb Las

Storm sewer pipes that direct storm water to the river are a separate system from sanitary sewer pipes that take wastewater to Rochester's Water Reclamation Plant. A big difference between the two systems is that storm water is not treated for pollutants prior to release, while wastewater is treated.

Two Different Piping Systems



Source: http://www.vil.spencerport.ny.us/departments/public-works-sanitary-

Storm Water Ponds

Another part of storm water management is treating storm water pollutants in ponds. The ponds collect and hold water so pollutant removal processes can take place. Pond environments are designed to operate a lot like mini-wastewater treatment plants; many processes are at work to remove pollution. A primary pollutant-removal step is the settling of sediment. Because many pollutants adhere to the sediment, cleaner water stays at the top where it is then discharged.

Natural Pollutant Treatment Processes in Ponds:
- Nutrient uptake by plants
- Consumption by micro-organisms
- Chemical reactions by sunlight & oxygen
- Settlement of sediment & other solids

In general, these ponds are located downstream of new or expanding development and upstream of receiving waters. In addition to providing water quality treatment, wet ponds also provide rate control to help with flood protection. A few ponds are now being constructed that allow infiltration to help recharge groundwater. Ponds may be owned by a governmental agency, a commercial development, or residents of a homeowners' association. In 2013, there are 361 storm water ponds within Rochester and 145 of them are public ponds maintained by the City.

Storm Water Pond After a Rain Storm

Source: Rochester Public Works

The location, structure, and maintenance of storm water ponds are carefully planned. Under dry weather conditions, the normal water level of water quality treatment ponds must be maintained between three and ten feet deep below the discharge pipe. Of course, after storm events, the water level will rise, so ponds are designed with enough capacity to hold water from a 100-year storm event. Regulations specify that the size of the pond must allow for an inflow of 1,800 cubic feet per second per acre and the outflow must be less than 5.66 cubic feet per second. (See the Chapter 4 Case Study to learn more about sizing storm water ponds.) Native plants are often planted around a pond for added pollutant removal.

Because ponds are designed to collect sediment before it reaches the river, they can lose their water quality treatment function if they accumulate too much sediment. When the amount of sediment fills a pond half full, the sediment must be removed. Depending on the pond location and the amount of sediment, a dredging permit and coordination with several agencies may be needed.

Ponds are intended to capture pollutants from storm water and should not be used for recreational activities such as swimming or fishing. (See Chapter 4 to learn about recreational water bodies.)

To Adopt-A-Storm Water Pond, go to: www.rochesterstormwater.com/adoptapond.asp.

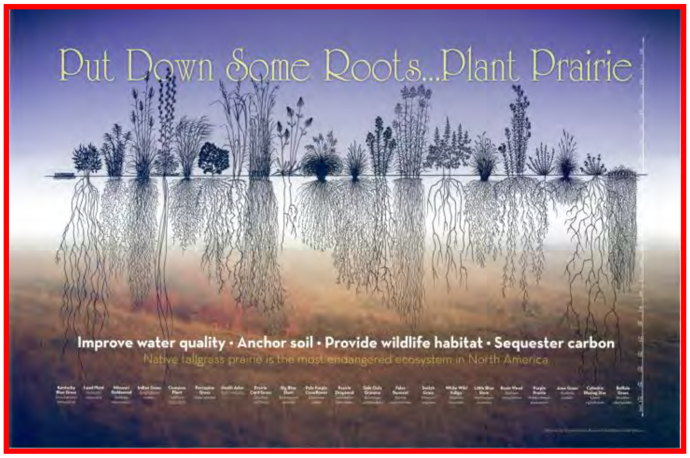
In addition to ponds, there are many other types of engineering designs are used to control the rate of storm water discharge, treat it, or infiltrate it into subsurface, like those shown on the following table.

Storm Water BMPs in Rochester (2013)	#
Storm water Pond: Retention – Wet Basin	280
Storm water Pond: Detention – Dry Rate Control Basin	73
Storm water Pond: Detention – Filtration Basin	3
Storm water Pond: Detention – Infiltration Basin	4
Biofiltration: Biowales	8
Biofiltration: Constructed Wetlands	3
Biofiltration: Filtration Trench	3
Biolfiltration: Infiltration Trench	31
Biofiltration: Raingardens	53
Catch Basin Sump	8
Grit Chamber	8
Internal Energy Dissipater	3
Pervious Pavement: Permeable Pavers	2
Pervious Pavement: Porous Pavement	6
Rock Check	4
Small Basin	40
Underground Detention	4
Construction Basin (Temporary)	19

State and federal agencies are recommending a shift from using storm water treatment ponds to emphasizing the installation of "Green Infrastructure" BMPs that retain storm water as close to where it falls as possible. Storm water ponds will still be prevalent, though, because they provide flood protection in addition to storm water management. For more information about each BMP type, look at the MN Stormwater Manual: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesotas-stormwater-manual.html.

Green Infrastructure

A raingarden is one type of Green Infrastructure that is becoming more common. They are desirable because the help capture and infiltrate storm water close to where the precipitation falls on the ground, so the opportunity for the storm water to collect pollutants is reduced. Of course, the intensity and duration of a rain event can affect how much rain soaks into the ground, as can the type of soil below it. Water that soaks into the ground can be used by plants or travel deeper to recharge groundwater. Native plants are ideal for raingardens because they take up a lot of water and they promote deeper infiltration.



Source: Minnesota DNR

Grant

Source: Rochester Public Works

Raingardens can be beautiful additions to any yard. Rochester has a cost-share grant program to help promote the installation of residential raingardens. Locally, grants are available to help establish new raingardens. Go to: www.rochesterstormwater.com/r_r_r.asp for more information on how to apply

Benefits of Raingardens:

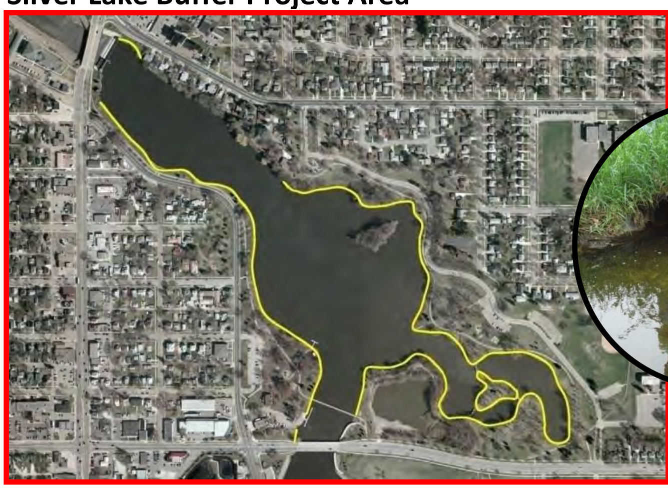
- Soak up 30% more runoff than lawn
- Filter polluted runoff
- Recharge groundwater
- Help prevent flooding
- Habitat for wildlife
- Beautify your yard
- Less maintenance than turf grass

Other types of Green Infrastructure include "green pavements" like porous concrete or porous bituminous surfaces and permeable pavers. These hard surfaces are engineered to allow infiltration instead of causing runoff like traditional pavements. Biowales, constructed wetlands, filtration trenches, infiltration trenches and water storage devices like rain barrels or underground detention chambers are other practices that help mimic pre-settlement hydrology. Visit the Cascade Meadow & Environmental Science Center (2900 19th St NW) or the Rochester Public Works Operation and Transit Center (4300 East River Rd NE) to view many of these BMPs at work.

Buffers

Buffers are vegetated borders of native plants that help treat pollutants in runoff. They can be planted around a storm water pond, along a stream or river, or around a wetland or lake. The City received a grant to help pay for the installation of an upland prairie and wetland buffer around Silver Lake. Its purpose is to reduce storm water contaminants, including: fecal coliform bacteria, suspended solids, Kjeldahl nitrogen, and phosphorous. The section of the Zumbro River flowing through Silver Lake is listed as impaired for fecal coliform bacteria because bacteria levels exceed water quality standards. By helping to reduce the bacteria load in the Lake, the buffer is helping the City reverse this impairment. Silver Lake was an important place to target fecal coliform bacteria reduction because the concentration of Canada geese and their poop in Silver Lake was a likely source of the impairment. It took 4 years to create the buffer and now it is maintained by the City Park and Recreation Department. They combine mowing, spot weed removal and prescribed burning to keep the native plants healthy.

Silver Lake Buffer Project Area



Source: Rochester Public Works

Total Kjeldahl nitrogen or TKN is the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+) in the chemical analysis of water.

The project converted about 8,700 feet of shoreline into storm water buffer. The plans for the buffer project consisted of three vegetative zones: upland, transition, and aquatic. The upland zone included a prairie area planted with native seed, several created wetlands, and tree groves. To prepare for the transition zone planting, the old pillow concrete rip rap had to be punched with holes and covered with compost before it was seeded with prairie and wetland species and covered with erosion and sediment control netting. Thirty, 50-foot long areas were selected for planting aquatic plants in the lake edge. To protect these areas from wave action and ice damage, concrete barriers were placed in the lake. Then coir fabric (a biodegradable fabric made of coconut fiber) containing emergent

Emergent plants grow in the water, but extend up through the water surface.

plant plugs grown at a nursery was installed. Physical barriers were installed to protect the new plantings from geese and fish predation. The barriers were removed once the plant communities were established, a period of about three years. Unfortunately, the transition and aquatic plantings suffered substantial damage when seeds and plants were washed away in the August 2007 flood. Those areas are slowly recovering as new plants grow into those areas.

Before

Source: Rochester Public Works

During

Source: Rochester Public Works

After

Source: Deb Las

Funding

Rochester operates its storm water management program as a utility, just like wastewater and water supply. The monthly fees paid by land owners in Rochester pay for all the storm water management services required by the permit. Since there is no way to turn on or turn off precipitation, the storm water system must be fully operable at all times for everyone. The "meter" for the fee is the amount of impervious surface on a parcel of property, because the higher the amount of impervious, the more storm water management is needed. The storm water management fee appears on the monthly RPU bill. Go to: www.rochesterstormwater.com/fundraising_projects/fundingprojects_utilityfee.asp to learn more about the utility fee.

Additionally, developers pay a "storm water management area charge" at the time of new development to connect to the storm water system and to contribute to the construction of required water quality treatment practices.

Evidence of storm water management activities can be seen throughout the City. Whenever you see these kinds of features, they are clues that storm water management is happening.

Spring Street Sweeping

Scour Stop

Construction Site Erosion Control

Stream Bank Stabilization

Outfall

Source: Rochester Public Works

What You Can Do

Pollution in the Zumbro River

Source: Deb Las

Improving the quality of storm water will improve water quality in our lakes, rivers, and wetlands. Each individual's actions on the land determine how clean our water will be. Storm water management is everyone's responsibility. Are you willing to help end pollution like this? Read the list below and pick one new thing that you will do to help.

With Your Car and Other Vehicles:
- Repair fluid leaks
- Attend to your car while fueling so gas doesn't spill on pavement
- Keep a trash bag in your car for waste
- Cover loads
- Use a commercial car wash

At Home:
- Keep hard surfaces free of litter, yard waste, and chemicals
- Pick up after your pet
- Minimize salt use in winter
- Bag and tie your trash bag before putting it in your trash bin to prevent litter

In the Yard:
- Minimize and correctly apply chemicals
- Plant a tree
- Plant more long-rooted, native plants
- Direct downspouts to vegetated areas
- Use a rain barrel
- De-chlorinate your pool before emptying it
- Plant a raingarden

Be Proactive:
- Report water polluting activities by calling 328-2440
- Learn more at: www.rochesterstormwater.com

Case Study: Quarry Hill Park's Water Story

Take a step back in time by taking a self-guided hike through Quarry Hill Park and discover the interesting ways humans, land, and water have converged there. What was done in the past, affects us now. What we do now, will affect us in the future. Read the following information before you begin.

Geology: Local geology governs how surface water and groundwater flow in Quarry Hill Park. Storm water becomes groundwater when it soaks into the upper Galena limestone formation (the burgundy layer in the diagram below). Gravity pulls the water downward until it reaches the highly impermeable Platteville-Glenwood-Decorah shale unit (the gold layer). Once there, groundwater flows outward and over hillside edges until it reaches the porous St. Peter sandstone bedrock (the green layer). There it infiltrates and recharges our water supply. Elevation changes in the landscape control surface water flow, descending from the highlands and through the lowlands. After you have taken your hike, look at this map again and see if you can find the: wet pond, infiltration basin, riffle/pool section of Quarry Hill Creek, filtration basin, and fen terrace.

Vegetation: Long-rooted native prairie and wetland plants that are adapted to our climate are highly desirable for controlling erosion and treating storm water. Most of the original vegetation in the Park was lost to agriculture in the late 1800's. The absence of prairie-sustaining wildfires and the abundance of competitive, invasive plants (like reed canary grass, buckthorn and crown vetch), makes restoration of desirable native plants in the Park very challenging. Once established, ongoing management is needed to support reintroduced plant habitats.

Humans and the Environment

Humans have been affecting water movement in Quarry Hill Park since the late 1800's. In 1879, Minnesota's second hospital for the insane opened on the land that became Quarry Hill Park in 1966. Many patients worked on the 500-acre farm, which later became known as the Rochester State Hospital, tending crops and animals and taking limestone from the quarry.

Quarry Hill Creek is an intermittent stream (the blue line on the map) that flows from the uplands into the valley between the east and west hills of the Park. The first significant change affecting water flow happened in 1934, when the Civilian Conservation Corps (CCC) moved the creek from the west to the east side of the Park, perhaps to protect the quarry road from flooding and to create larger crop fields. The second major change started when Rochester grew north of the Park, adding hard surfaces and more storm water discharges. Both changes eventually led to the major repair and treatment projects that are described below and that can be seen in the Park. Just follow the Water Drop Trail in the Park (the yellow dots on the map; the water drop signs in the Park.)

The Water Drop Trail at Quarry Hill

Source: Rochester Public Works

Drop Structure Built by CCC Workers

Source: Deb Las

Drop A—The CCC Was Here

Look at the craftsmanship in this old limestone structure. It was built in 1934 by the CCC to stabilize the new junction of Quarry Hill Creek with Silver Creek. This change created a steeper and shorter creek, triggering a cycle of soil erosion and deposition that disconnected the creek from its floodplain, led to flooding near the nature center, and was a contributing factor to Silver Creek's inability to meet state water quality standards.

Drop B—A New, Old Confluence

The location where one stream enters another is called a confluence. The City of Rochester returned Quarry Hill Creek to its former channel to halt and correct erosion that started over 70 years ago. This new confluence near its original location was engineered to withstand rainfall events of at least 6.1 inches in 24 hours. This special reinforcement was needed because the area that drains to Quarry Hill Creek today has many more impervious surfaces like roofs, sidewalks, driveways, and streets. As the impervious cover increases, the speed and amount of storm water increases, so a small, natural creek channel can no longer withstand the erosive effects of big storm events in an urban setting. The reinforced banks also protect a buried sanitary sewer line from future erosion.

Drop C—Sinuosity And Stability

Do you see the S-shaped path the stream takes? A meandering channel was chosen to help keep the new creek stable over time. This design mimics how streams naturally evolve in areas with very gentle slopes.

Stabilizing a new creek takes some clever engineering. In the short term, erosion control mats and slope control structures keep the channel bottom in place. Can you see glimpses of the biodegradable coconut fiber blankets that keep the soil on the banks? As native grasses and shrubs take root, they add long-term stability.

Drop D—Older And Wiser

Until the 1980's, managing storm water focused on quickly moving it away from buildings and roads to protect structures and people from flooding. Discharging storm water into natural drainage ways was a common practice when the Parkwood Hills neighborhood was built on top of the hill. We've learned that when loose soils overlie wet Decorah shale conditions, the slopes can be too weak to transport the focused discharges from the bluff tops, leading to significant soil erosion.

To repair the eroded ravine, it was necessary to bury a limestone rock channel in this hillside to carry groundwater while also holding the steep, fragile slope. Look for the native grasses and trees that will increase slope stability as they mature.

Drop E—All Aboard the Treatment Train

Four engineered systems are linked together here to minimize storm water impacts. First, a vegetated drainage swale helps slow runoff and absorb excess lawn chemicals from backyard drainage. Underneath the swale is a pipe that collects storm water from front yards and roads in Parkwood Hills. Next, a wet pond receives and holds runoff from the swale and the storm sewer for more cleansing. Many natural processes are working to help treat the water: settlement of sediments, uptake of chemicals by plants, addition of oxygen by wind and plants, and UV radiation from sunlight. Finally, the treated storm water enters an infiltration basin where it can recharge our groundwater supply and sustain the base flow of Quarry Hill Creek.

Drop F—Basins, Riffles & Pools, Oh My!

This filtration basin acts like a wet pond *and* an infiltration basin in one! The site soils here were not permeable enough for a dry infiltration basin, so this design allows water to slowly filter through underlying soils. Then it seeps into drain tiles which release water to recharge the downstream riffle/pool stream channel.

Severe erosion in this stream channel also needed correction. Without room for a meandering channel here, a sequence of rock riffles separated by shallow pools was designed to slow and retain water to halt and prevent erosion. Instead of meandering side to side, the channel meanders up and down!

Drop G—Hillsides as Headwaters

When groundwater flows out of the upper limestone bedrock and across broad Decorah shale terraces, groundwater-fed wetlands, known as fens, can form high in the landscape. These small, rare hillside fens are scattered throughout Rochester. They may not look impressive, but these unique habitats are *very* important; they help remove nitrate pollution and they are the headwaters of our streams.

A deep erosion channel was draining this fen, so it was filled with soil and rock “dams”. By stopping this water loss, wetland vegetation restored itself and the two, split wetlands were reunited into one healthy wetland.

Source: Rochester Public Works

Chapter 8 - Water Resource Management Agencies

There are a number of Rochester-based organizations that focus on water. Some help regulate water quality. Others are involved with public education about water. The people in these organizations are working hard to protect Rochester's water resources, increase water stewardship, and educate citizens. Everyone, however, has a part in using water responsibly. These organizations are a great resource for answering questions and planning projects. Don't hesitate to contact them!

This chapter is divided into three sections. The first section highlights a few local organizations that have worked with educators and students on water projects in the past. The second section lists additional water resource management organizations alphabetically. The third section is a listing of water topics tied to responsible organizations.

Working With Students

Cascade Meadow Wetlands & Environmental Science Center
2900 19th Street NW
Rochester, MN 55901
Phone: (507) 252-8133
Website: www.cascademeadow.org
Contact: Stefan Theimer, Education Program Coordinator
Phone: (507) 252-8133 ext. 104
Email: stheimer@cascademeadow.org

Cascade Meadow connects people and communities through water, energy, and sustainability education. Their mission is to establish Cascade Meadow Wetlands & Environmental Science Center as a regional resource for environmental education. Visit their indoor exhibits, outdoor trails, and attend special programs.

Water Resource Services

Environmental Resources Department • clean air • clean energy • clean soil • clean water •

Water Testing Lab --
The lab provides water quality testing for private well owners in southeast Minnesota as well as the samples collected from the County's aquifer, stream, and lake monitoring networks.

Water Quality Monitoring --
Streams, lakes, reservoirs, and aquifers are routinely monitored to assess their condition.

Chester Sewer District --
Sewer service is provided to 120 homes and businesses that had previously relied on failing septic systems. Sewage is collected and pumped to the Rochester Water Reclamation Plant for treatment.

Zumbro River Restoration --
The 2010 Zumbro River Flood severely damaged the Oronoco dam and drained Lake Shady. Work is underway to replace the dam with a rock rapids and restore a natural river channel in the old lakebed. The lakebed will become part of the Oronoco Park and will provide opportunities for public canoeing, kayaking, fishing and hiking. $1M in State Dam Safety funding has been provided for the project.

Lake Zumbro Dredging –
The lake provides a range of boating, fishing and other water recreational opportunities. Plans are underway to dredge the lake to restore areas lost to sedimentation . In 2011, $3M in State Bonding funds were awarded for the project.

Olmsted County Environmental Resources
2122 Campus Drive SE, Suite 200
Rochester, MN 55904
Phone: (507) 328-7070
Fax: (507) 328-5090
Website: www.co.olmsted.mn.us/environmentalresources
Email: pwservice@co.olmsted.mn.us
Contact: Terry Lee, Water Resources Coordinator
Email: Lee.terry@co.olmsted.mn.us

rpu *we pledge, we deliver*®

Rochester Public Utilities
4000 East River Road NE
Rochester, MN 55906-2813
Phone: (507) 280-1500
Website: www.rpu.org
Contact: Todd Osweiler, Environmental & Regulatory Affairs Coordinator
Phone: (507) 280-1589
Email: tosweiler@rpu.org

RPU provides Rochester's citizens with an abundant supply of high-quality water by constructing, operating and maintaining wells, storage facilities and water lines.

Rochester Storm Water Management
Rochester Public Works Department
201 4th St. SE, Room 108
Rochester, MN 55904
Phone: (507) 328-2440
Fax: (507) 328-2401
Website: www.rochesterstormwater.com
Twitter: @CleanWaterRoch
Contact: Megan Moeller, Storm Water Educator
Email: mmoeller@rochestermn.gov

As our community grows, so must our commitment to protecting and improving the quality of our water resources. Our lakes, rivers, and wetlands help make Rochester one of the nations' most livable communities. Keeping our water resources clean and useable is in everyone's interest.

Rochester Water Reclamation Plant
301 36th Street NW
Rochester, MN 55901
Phone: (507) 328-2650
Contact: David Lane, Environmental Coordinator
Phone: (507) 328-2656
Email: dlane@rochestermn.gov

The Water Reclamation Plant constructs, operates and maintains the wastewater treatment plant and several lift stations. It operates 24 hours per day, 7 days per week. Tours are available.

Quarry Hill Nature Center
701 Silver Creek Road NE
Rochester, MN 55906
Phone: (507) 328-3950
Website: WWW.QHNC.ORG
Contact: Pam Meyer, Executive Director
Email: pameyer@rochester.k12.mn.us

QHNC is a joint City-School District-Non-profit Foundation enterprise that offers year-round classes, day camps, trips and activities within a 320-acre City park that features several native habitats, biking and hiking trails, a pond, and a historical hand-dug sandstone cave. In the winter months, cross country skis and snowshoes are available for rent to use in the park.

Zumbro Watershed Partnership
2900 19th Street NW
Rochester, MN 55901
Phone: (507) 226-6787
Website: www.zumbrowatershed.org
Email: admin@zumbrowatershed.org
Contact: Kevin Strauss, Education Coordinator
E-mail: education@zumbromwatershed.org

The Zumbro Watershed Partnership is a nonprofit organization dedicated to working for "Cleaner Water and Fewer Floods" in the Zumbro River watershed. ZWP hosts cooperative clean water projects and presents educational programs, like its monthly "Water Ways" speaker series to interested audiences.

Additional Water Resource Management Agencies

Minnesota Board of Water & Soil Resources
3555 9th Street NW
Rochester, MN 55901
Phone: (507) 206-2889
www.bwsr.state.mn.us

Minnesota Department of Health
18 Woodlake Drive SE
Rochester, MN 55904
Phone: (507) 206-2700
www.health.state.mn.us

Minnesota Department of Natural Resources
3555 9th St. NW, Suite 350
Rochester, MN 55901
Phone: (507) 206-2852 (Ecological & Water Resources)
(507) 206-2829 (Fisheries)
(507) 206-2841 or 206-2847 (Parks & Trails)
(507) 206-2859 (Wildlife)
www.dnr.state.mn.us/index.html

Minnesota Geological Survey
2642 University Ave West
St. Paul, MN 55114-1032
Phone: (612) 627-4780
www.mngs.umn.edu

Minnesota Pollution Control Agency
18 Woodlake Drive SE
Rochester, MN 55904
Phone: (507) 285-7343
www.pca.state.mn.us

Olmsted County Environmental Health Services
2100 Campus drive SE, Suite 100
Rochester, MN 55904
Phone: (507) 328-7500
www.co.olmsted.mn.us/OCPHS/Pages/default.aspx

Olmsted County Extension Service (University of Minnesota Extension)
1421 3rd Avenue SE
Rochester, MN 55904
Phone: (507) 328-6214
www.extension.umn.edu/county/template/index.aspx?countyID=55

Olmsted County Soil & Water Conservation District
1485 Industrial Drive NW, Room 102
Rochester, MN 55901
Phone: (507) 280-2850
Fax: (507) 280-2858
www.co.olmsted.mn.us/pw/oswcd/Pages/default.aspx

Rochester Building and Safety
2122 Campus Drive SE, Suite 300
Rochester, MN 55904
Phone: (507) 328-2600
Fax: (507) 328-2601
www.rochestermn.gov/departments/bldgsafety

Rochester-Olmsted Planning Department
2122 Campus Drive SE, Suite 100
Rochester, MN 55904
Phone: (507) 328-7100
Fax: (507) 328-7958
www.co.olmsted.mn.us/planning/Pages/default.aspx

Rochester Park & Recreation Department
201 4th Street SE
Rochester, MN 55904
Phone: (507) 281-6160
Fax: (507) 281-6165
www.rochestermn.gov/departments/park/index.asp

US Army Corp of Engineers – St. Paul District
180 East 5th Street, Suite 700
St. Paul, MN 55101
Phone: 1-651-290-5807
www.mvp.usace.army.mil

USDA Natural Resource Conservation Service
1485 Industrial Drive NW
Rochester, MN 55901
Phone: (507) 289-6239
Fax: (507) 280-2858
www.nrcs.usda.gov/wps/portal/nrcs/site/mn/home

Subjects by Responsible Organization

General Topic	Specific Topics	Organization
Boating Information	public water access locations, canoe routes, invasive species, watercraft registration	MN Department of Natural Resources - Parks and Trails Division
Chester Woods Park	use, history	Olmsted County Parks
Construction Site Erosion & Sediment Control	inspections and enforcement	Rochester Public Works Department
Dam Safety	regulations, inspection	MN Department of Natural Resources - Ecological and Water Resources Division
Fertilizer and Chemical Management	lawn care	Olmsted County Extension Service
Fish Consumption Advisories	consumption limitations	MN Department of Health
Fish Kills	reporting	MN Pollution Control Agency
Fish Stocking	species, schedule, locations	MN Department of Natural Resources - Fish and Wildlife Division
Fishing Education	MinnAqua, Fishing in the Neighborhood, I Can Fish, Take-a-Kid Fishing, Take-A-Kid Ice Fishing	
Fishing Regulations	season, limits, licensing, spawning times	
Floodplain Management	regulations, zoning, boundaries, Flood Insurance Rate Maps	Rochester-Olmsted Planning Department
Land Use	Regulations, planning, enforcement and geographic information system management	Rochester-Olmsted Planning Department
Leaks and Spills	reporting (MN Duty Officer, 1-800-422-0798) and responding	MN Department of Public Safety
Local Water Management	long range planning and project implementation	Olmsted County Environmental Resources
		Rochester-Olmsted Planning Department
Mosquitoes	personal protection strategies	Olmsted Environmental Health Services
Non-Municipal Community Wells	water testing results and water quantity data	MN Department of Health
Plumbing Regulations	Permits/inspections to enforce plumbing code	Rochester Building Safety
Private Water Wells	water system review and permitting, construction and sealing inspections	Rochester-Olmsted Planning Department
Rochester's Flood Control Rervoirs	use, history	Rochester Park and Recreation Department
Rochester's Flood Control Rervoirs	flood protection standards, water level monitoring, maintenance	Rochester Public Works Department
Rochester's Municipal Water Supply	wells, water mains, storage facilities, water testing results, water quantity data, water conservation, wellhead protection	Rochester Public Utilities
Rochester's Flood Control Project	use, history, maintenance	Rochester Public Works Department

General Topic	Specific Topics	Organization
Septic Systems	user education	Olmsted County Extension Service
	construction and repair permits, septage pumping and disposal requirements	Rochester-Olmsted Planning Department
	regulations	MN Pollution Control Agency
Shoreland Management	regulations and enforcement	Rochester-Olmsted Planning Department
Silver Lake and Lake Zumbro Dams	operations and maintenance, lake levels	Rochester Public Utilities
Storm Water Management	planning, policies and ordinances, public education and complaint intake/response, illicit discharge/dumping and drainage/grading investigations, erosion and sediment control inspections, grading and drainage approvals, infrastructure construction and maintenance, funding, system mapping	Rochester Public Works Department
Storm Water Management	construction, industrial, and municipal storm water permit administration	MN Pollution Control Agency
Stream and Lake surveys	aquatic life monitoring	MN Department of Natural Resources - Fish and Wildlife Division
Wastewater Conveyance	sanitary sewer construction, operations, and maintenance	Rochester Public Works Department
Wastewater Treatment	sanitary sewage processing, RV dump station, pretreatment industrial permits	Rochester Water Reclamation Plant
Water Appropriations	regulations and permits for surface and groundwater withdrawals	MN Department of Natural Resources - Ecological and Water Resources Division
Water Studies & Reports	local long term monitoring projects	Olmsted Environmental Health Services
	regional monitoring projects	MN Pollution Control Agency
Water Supply Regulations	drinking water standards, health risk information	MN Department of Natural Resources - Ecological and Water Resources Division
Water Treatment	recommendations to address undesirable water conditions, like hardness, excess iron, or iron bacteria	MN Department of Health
Wetland Management	Wetland Conservation Act administration	Rochester-Olmsted Planning Department
Wetland Regulations	state rule development, wetland mitigation approvals, general wetland information	Board of Water and Soil Resources
Work in Public Waters	water body alterations, shoreline stabilization	MN Department of Natural Resources - Ecological and Water Resources Division

Chapter 9 – Rochester's Water Learning Activities

There are a number of local activities listed below that can help individuals, families, and groups learn more about water in Rochester. The activity ideas are grouped by Chapter topics. Some of them could form the basis of a service learning project.

Chapter 1 - Rochester's Water Cycle

- **Cascade Meadow Wetlands & Environmental Science Center – Exhibits:**
  - Visit the indoor "Water Connections" and "All About Aquifer" exhibits.
  - Using the Zumbro Watershed floor map, trace the flow of water through the watershed.
- **Cascade Meadow Wetlands & Environmental Science Center – School Field Trip:**
  - **"Watershed Stewards with Solutions"** for elementary and secondary students (90-120 min.): Through several sequential activities, students will explore the Zumbro River Watershed, discover how its health is threatened, and encounter best practices and behaviors to protect the watershed.
- **Classroom Activity – Individual Action Demonstration:**
  - Help students visualize the impact their actions can have on the environment. At the beginning of class each day for at least a week, ask students to write down any dollar amount less than $1 on a small piece of paper, which the teacher will collect (the longer the time period for this step, the bigger the impact will be). After the money collection phase, ask students if they would pay $1 or less each day to have an environment with clean, safe water. Ask why or why not. After the discussion, take all the papers the students have turned in and add the amounts together. Now have the same discussion about paying for clean water with the total dollar amount and relate the total to the small actions of individuals. By itself, a small act such as sweeping up grass clipping and disposing of it properly does not seem like much. If the act is done (or not done) by everyone, however, it has a large impact.
- **Quarry Hill Nature Center – Karst Geology & Wild Caving:**
  - Over two days in the classroom students are introduced to: the basics of karst geology, common underground and above ground karst features, why kasrt is found in SE Minnesota, and why understanding karst geology is critical in protecting groundwater sources. During day-long trips, students visit a private, underground natural cave system to witness what karst geology looks like first hand. Contact Quarry Hill Nature Center for more information.

Chapter 2 - Rochester's Water History

- **History Center of Olmsted County:** Research more about water topics. Call (507) 282-9447
- **Water Travel Activity:** Trace a drop of water as it might have moved through Rochester's water history, water cycle, and watershed. Present your research in one of the following forms or create your own product: graphic novel, poem, video, poster, short skit, diorama, Glog, Prezi, or

Chapter 3 - Rochester's Natural Water Features

PowerPoint.

- **Cascade Meadow Wetlands & Environmental Science Center – Exhibits:**
  - Visit the Wetlands exhibits: "Cascade Meadow Wetlands Contour Map", "Wetland Mechanical Theater", and "Living with Wetlands".
  - Using the Zumbro Watershed floor map, try to find rivers and wetlands.
- **Cascade Meadow Wetlands & Environmental Science Center – School Field Trip:**
  - **"Wetland Services"** for elementary students (60-90 min.): After covering the three "ingredients" that define a wetland, students will explore what wetlands do for us through a series of hands-on activity tables. A more involved series of activities on wetland ingredients can extend this to 120 minutes.
  - See 7 of the 8 different wetland types found in Minnesota under restoration here.
- **DNR's Adopt – A – River Program** (for litter collection): www.dnr.state.mn.us/adoptriver/index.html
- **Encourage Others:** Encourage neighbors, developers, and state and local governments to protect the function and value of wetlands in your watershed.
- **Federal Duck Stamps:** Purchase federal duck stamps from your local post office to support wetland acquisition.
- **MPCA's Citizens Stream Monitoring Program**: Check this map www.rochesterstormwater.com/docs/Citizens/CSMP%20Inventory_Rochester.pdf to see if there are unmonitored streams in Rochester that need turbidity levels monitored. Then contact the MPCA to register your site: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/citizen-stream-monitoring-program/index.html.
- **Quarry Hill Nature Center:** Contact the staff to develop a service learning project using the Park's natural water features, such as:
  - Turbidity monitoring of Silver Creek or Quarry Hill Creek,
  - Macro-invertebrate sampling of Silver Creek or Quarry Hill Creek, or
  - Frog and toad calling surveys of the hillside wetland.
- **World Water Monitoring Challenge**: An international education and outreach program that builds public awareness and involvement in protecting water resources around the world by engaging citizens to conduct basic monitoring of their local water bodies between March 22nd and December 31st. http://www.worldwatermonitoringday.org/.

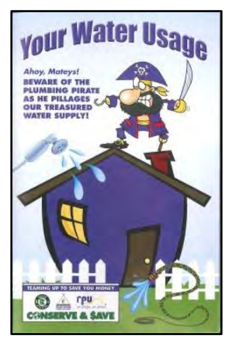
Chapter 4 - Rochester's Constructed Water Bodies

- **MPCA's Citizens Lake Monitoring Program:** If you have access to a canoe, kayak or other type of boat, volunteer to monitor the clarity of one of Rochester's artificial lakes. Sign up at MPCA's web site: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/citizen-lake-monitoring-program/index.html?menuid=.

- **Quarry Hill Nature Center:** Quarry Hill Park is home to several constructed water bodies: an educational/recreational pond, a wet storm water pond, an infiltration storm water basin, and an infiltration storm water basin. Contact the staff to develop a service learning project using the Park's constructed water features, such as:
    - Conducting wildlife research, like fish tagging, turtle trapping, or macro-invertebrate sampling, or
    - Establishing long term trends for chemical water data from any of the wet ponds.

Chapter 5 - Rochester's Water Supply

- **Cascade Meadow Wetlands & Environmental Science Center – Exhibits:**
    - Visit the "Water Footprints" and "Wells & Wellheads" exhibits.
- **Rochester Public Utilities Water Usage:** Obtain RPU's free brochure "Your Water Usage" and choose water conservation techniques that your family can adopt. Use the non-toxic dye tablet to check a toilet tank for leaks. Review the kid pages in the back for more ideas.



Chapter 6 - Rochester's Wastewater Treatment System

- **Cascade Meadow Wetlands & Environmental Science Center – Exhibit:**
    - Visit the "Down the Drain" exhibit.
- **Rochester Water Reclamation Plant:** Take a school field trip to learn how wastewater is treated in Rochester. Contact David Lane at 328-2656.

Chapter 7 - Rochester's Storm Water Management System

- **Cascade Meadow Wetlands & Environmental Science Center - Exhibits:**
  - Visit the indoor "From Streets to Waterways" exhibit and the outdoor "Storm Water Trail".
- **Quarry Hill Nature Center:** Volunteer to maintain their raingarden.
- **Rochester Public Works (contact Megan Moeller, 328-2440, mmoeller@rochestermn.gov):**
  - **Adopt-A-Storm Water Pond:** This program allows interested groups, businesses, and individuals to improve water quality by adopting a public storm water pond, agreeing to collect litter and watch for burrowing animals and broken structures; http://www.rochesterstormwater.com/Full%20Text%20Packet.pdf.
  - **Host a Raingarden Party**: Residential raingardens are designed to collect storm water from an owner's roof, sidewalk or driveway. You can help others learn about the value of raingardens by hosting a "Raingarden Party" at your home, either led by you or a trained volunteer host; www.rochesterstormwater.com/citizens/citizens_hostaraingardenparty.asp.
  - **Create a Residential Raingarden**: Rochester has a cost-share grant program to help homeowners install raingardens; http://www.rochesterstormwater.com/r_r_r.asp.
  - **Invite a Speaker:** Invite a City staff member to an upcoming neighborhood association, scout or service group, church or other meeting to learn how your neighborhood is connected to water and take home ideas for becoming better stewards of our watery resources! Topic areas for speaking opportunities include:
    - Solutions to Storm Water Pollution,
    - Proper Downspout, Sump, or Swimming Pool/Spa Discharge Practices,
    - Installing a Rain Barrel,
    - Planting a Raingarden or Native Plants,
    - Trees and Storm Water,
    - Water-Friendly Lawn Care, or
    - Residential Snow and Ice Management.
  - **Storm Drain Marking:** Help prevent illegal dumping by applying markers to storm drain inlets.
  - **Door Hanging:** place door hangers in your neighborhood to educate neighbors about clean water. Sample topics include pet waste and clean streets.
  - **Short-term or One-time Commitments:** Opportunities for single-time or short-term volunteer projects exist, such as native seed collecting, pocket cigarette butt receptacle distribution, handout preparation and more.
  - **Special Events:** Sign up at www.rochesterstormwater.com to receive emails about upcoming water-related events or look at the Upcoming Activities page.

Marking Storm Drains

Source: Deb Las

Rochester's Water in General

- **Cascade Meadow Wetlands & Environmental Science Center:** The center is open Thursday, Friday, and Saturday from 10 am to 4 pm. Check the website for special programs. There are opportunities for volunteering. Staff will help educators develop custom experiences, including support for inquiry and project-based water studies, such as
    - Invasive species monitoring and removal,
    - Biological survey and monitoring (insects, plants, mammals, birds, aquatic inverts),
    - Water sampling (physical, chemical, biological) from around the site in different settings (swamp, creek, lake, storm water pond, etc.),
    - Wetland ecological communities investigation and community interpretive media projects, or
    - Community outreach education projects on importance of wetlands (esp. flood control, ecological diversity).
- **Litter Collection**: Keep water clean by picking up litter at an adopted location, alone or with others. You can register for an adoptable area in each of the following programs by contacting them directly:
    - **MnDOT District 6, Adopt – A – Highway:** www.dot.state.mn.us/adopt/, 507-286-7509.
    - **Rochester Park and Recreation Department, Adopt – A – Park:** http://www.rochestermn.gov/departments/park/activities/community/Adopt-a-Park.asp, 507-328-2525.
    - **Help Make Rochester A Litter Bit Better!** *(*April): http://rneighbors.org/litterbitbetter.
- **Minnesota Marine Art Museum:** This museum is home to works by many well-known artists, all centered on the theme of water. http://www.mmam.org/
- **Quarry Hill Nature Center:**
    - Develop your own summer independent study program.
- **Rochester City Council:** Attend a City Council Meeting to find out how decisions affecting water are made. Check City Council agendas at www.rochestermn.gov .
- **Water Environment Federation:** Check out the multiple water activities: http://www.wef.org/coloringbooks/.
- **Zumbro Watershed Partnership Water Ways Speakers Series:** ZWP hosts a water-related presentation on the second Thursday of each month at the Cascade Meadow Wetlands & Environmental Science Center. Speakers include: researchers, government officials, farmers, and natural resource professionals who discuss a variety of topics important in our watershed.