Watershed Management Plan 2021-2031

4.0 MWMO Resource Inventory

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4.0 MWMO Resources Inventory

4.1 Introduction

The MWMO resource section reviews land, water, and human resources within the MWMO boundaries and assesses the need for management of these resources based on the current knowledge of the watershed. This resource assessment section influences what, why, when, where, and how the public comments and issues in Appendix G of this Plan are addressed.

The Physical Environment section includes information on topography and geomorphology, geology, and soils. The Biological Environment section includes information on vegetation and wildlife. The Human Environment section includes information on land use and growth patterns, population dynamics, recreation, and potential environmental hazards. The Hydrologic System section includes information on climate, precipitation, surface water resources, groundwater resources, water quantity, water quality, impaired waters, and surface water appropriations.

4.2 Physical Environment

4.2.1 Potential Limitations to Infiltration

A map of potential limitations to infiltration is shown in **Figure 2**. Information from this resource inventory was used to better understand where infiltration limitations may exist in the watershed. While helpful from a planning level perspective, any information required for development purposes requires a site scale review. **Table** 7 provides more information on limitations analyzed and the data sources.

Table 7: Infiltration Limitations and Data Sources

Limitation[1]	Data Source	Data Source Confidence Interval	Year of Data Source
Rough terrain may exist where slopes are steeper than 20%	Light Detection and Ranging	+/- 6 inches	2011
Hotspots and groundwater contamination may exist	Minnesota Pollution Control Agency "What's in my backyard"	See Note 6	2014
Shallow groundwater may exist between ground level and a depth of 20 feet[2]	Minnesota Department of Health Well Data	+/- 5 feet vertical accuracy Horizontal Accuracy[5]	2014
The Minnesota Department of Health recommends no infiltration within the 1-year 3travel zone (Emergency Response Area) of Drinking	Minnesota Department of Health Source Water Protection Unit	Minimum scale requirement for data and/or maps is 1:24,000.	2014

Limitation[1]	Data Source	Data Source Confidence Interval	Year of Data Source
Water Supply Management Area (DWSMA)[4]			
A minimum of a 50-foot setback is required from water supply wells[3]	Minnesota Department of Health Well Data	+/- 5 feet vertical accuracy Horizontal Accuracy[5]	2014
Karst conditions may exist between ground level and a depth of 20 feet	Minnesota Department of Health Well Data	+/- 5 feet vertical accuracy Horizontal Accuracy[5]	2014
Low infiltration potential may exist due to hydrologic soil group D consisting of clay, silt and organics with an infiltration rate of < 0.2 in/hr.	Natural Resources Conservation Service County Soil Survey and Minnesota Geological Survey[7]	Minnesota Geological Survey shows the material expected to be encountered approximately 3-feet below the surface; however, the level of accuracy of data does not account for up to 20-feet of fill in urban areas and is mapped at 1:100,000 scale[8]. County Soil Survey applicable to the first 6-feet of soil and is mapped 1:24,000.	2006 – Soils Data 2007 – Geology Data
Shallow bedrock may exist between ground level and a depth of 20 feet[2]	Minnesota Department of Health Well Data	+/- 5 feet vertical accuracy Horizontal Accuracy[5]	2014

1) Based on Minnesota Pollution Control Agency limitations to meeting Minimum Impact Design Standards
2) National Pollution Discharge Elimination System Construction General Permit requires 3-feet minimum separation. 20' used as buffer to account for site grading
3) Per Minnesota Rule 4725.4350
4) Minnesota Department of Health recommends no infiltration within 1-year travel zone of DWSMA and limited infiltration within 10-year travel zone
5) Horizontal Accuracy depends on the location method for each well
Accuracy of each well location can be viewed in the GCM_CODE - Geographic Method Code (identifies location accuracy).
*A = Digitized - scale 1:24,000 or larger
*B = Digitized - scale 1:100,000 to 1:24,000
*DN1 = Digitization (screen) - Map (1:24,000) - NOT Field checked
*DN2 = Digitization (screen) - Map (1:12,000) - NOT Field checked
*DS1 = Digitization (Screen) - Map (1:24,000)
*DS2 = Digitization (Screen) - Map (1:12,000)
*G3 = GPS Code Measurements (Pseudo Range) Differentially Corrected
*G6A = GPS Code Measurements (Pseudo Range) Standard Positioning Service Selective Availability On (averaged)
*G6O = GPS Code Measurements (Pseudo Range) Standard Positioning Service Selective Availability Off (averaged)

*I = GPS; accuracy 3 to 12 meters (+6 to 40 feet)
*PQ6 = Public Land Survey - QQQQQQ Section
6) Coordinates for these features were collected using a variety of methods of varying accuracy. The 'COORD_METH' column in the attribute table describes the method used to determine the coordinate for each feature.
7) In areas that show up as urban fill on the Soil Survey (approximately 50% of the MWMO) the Geological Survey was used to determine
the soil characteristics.
8) Scale refers to the frequency of sampling. The larger the second number, the larger the ground area and less detail. For instance, 1:12,000 scale depicts a sample taken
approximately every 1/4 acre. Whereas a 1:100,000 scale depicts a sample taken every 2 acres.

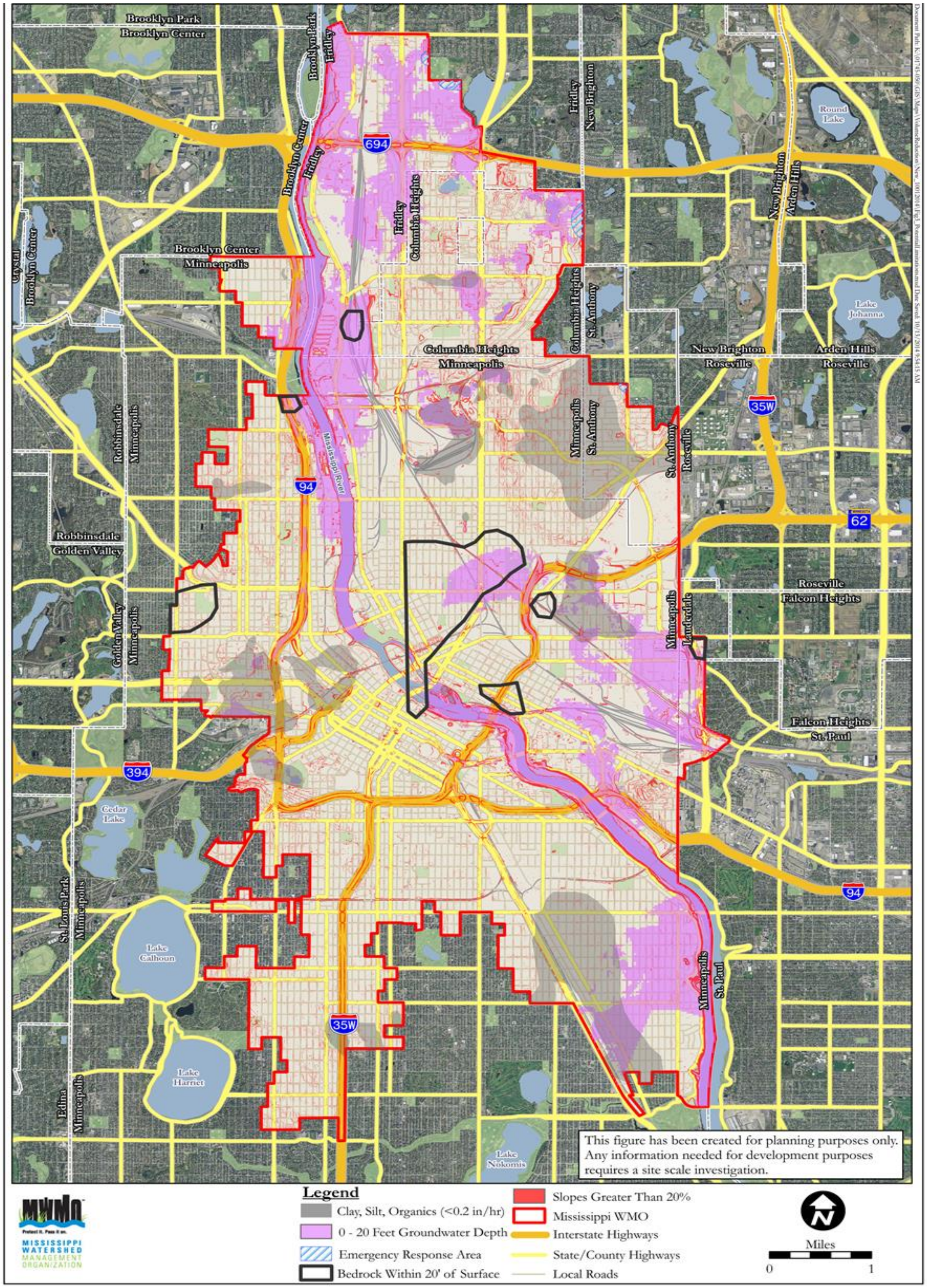


Figure 2: Potential Limitations to Infiltration

4.2.2 Topography and Geomorphology

The topography of the MWMO influences the way resources respond to events such as precipitation and urban development. The topography of the MWMO varies greatly, from rolling terrain at higher elevations distant from the Mississippi River to nearly flat terraces close to the river. Total relief in the MWMO is roughly 300 feet from high points in the Saint Anthony Village area, which has an elevation of 1,020 feet above sea level, to low points of 725 feet along the shores of the Mississippi River (**Figure 3**).

Geomorphology is the study of landform and the processes that lead to varying landform shapes. The topography of the MWMO was created by geomorphic processes such as glaciation, fluvial transport (sediment transport by water), eolian processes (sediment transport by wind), mass wasting (gravity-driven sediment transport), and weathering. These processes created nearly all the current landscapes visible throughout the watershed. In addition to geologic processes, influences from humankind have drastically shaped the landform of the MWMO. Significant grading has flattened rolling hills for the creation of flat roadbeds and building pads. In addition, some portions of the MWMO that were peat-filled wetlands prior to European settlement in the Twin Cities Metropolitan Area have since been artificially filled to promote the development of these areas.

Figure 3 illustrates the topography of the MWMO. Four prominent colors are visible as elevations above mean sea level. These prominent regions are due to the geomorphic processes that shaped these areas. Topographically high regions—visible as brown/red in Saint Anthony Village and west of I-94—are glacial depositional highs formed by the advancement of the Des Moines lobe glaciation. These depositional highs are above 900 feet and consist of clay rich till. Adjacent tan/yellow hues located at lower elevations toward the Mississippi River, between 850 and 900 feet, are terrace deposits known as the Richfield Terrace. Terraces are platforms of land created by past higher levels of the Mississippi River. As the Mississippi River down cuts, removing material and lowering the river bed, these flat areas become prominent past indicators of river floodplain elevations. Terrace deposits are typically sequences of sand and silt. Green/blue hues located at an even lower elevation toward the Mississippi River, between 800 and 850 feet, represent a different and younger terrace known as the Langdon Terrace. Finally, the reddish-tan color prominent west of 35-W and in the vicinity of Lyndale Ave and 46th Street in Minneapolis represents an area formed by glacial outwash. This area was formed by sand and gravel deposited by melting along a glacier's ice margin.

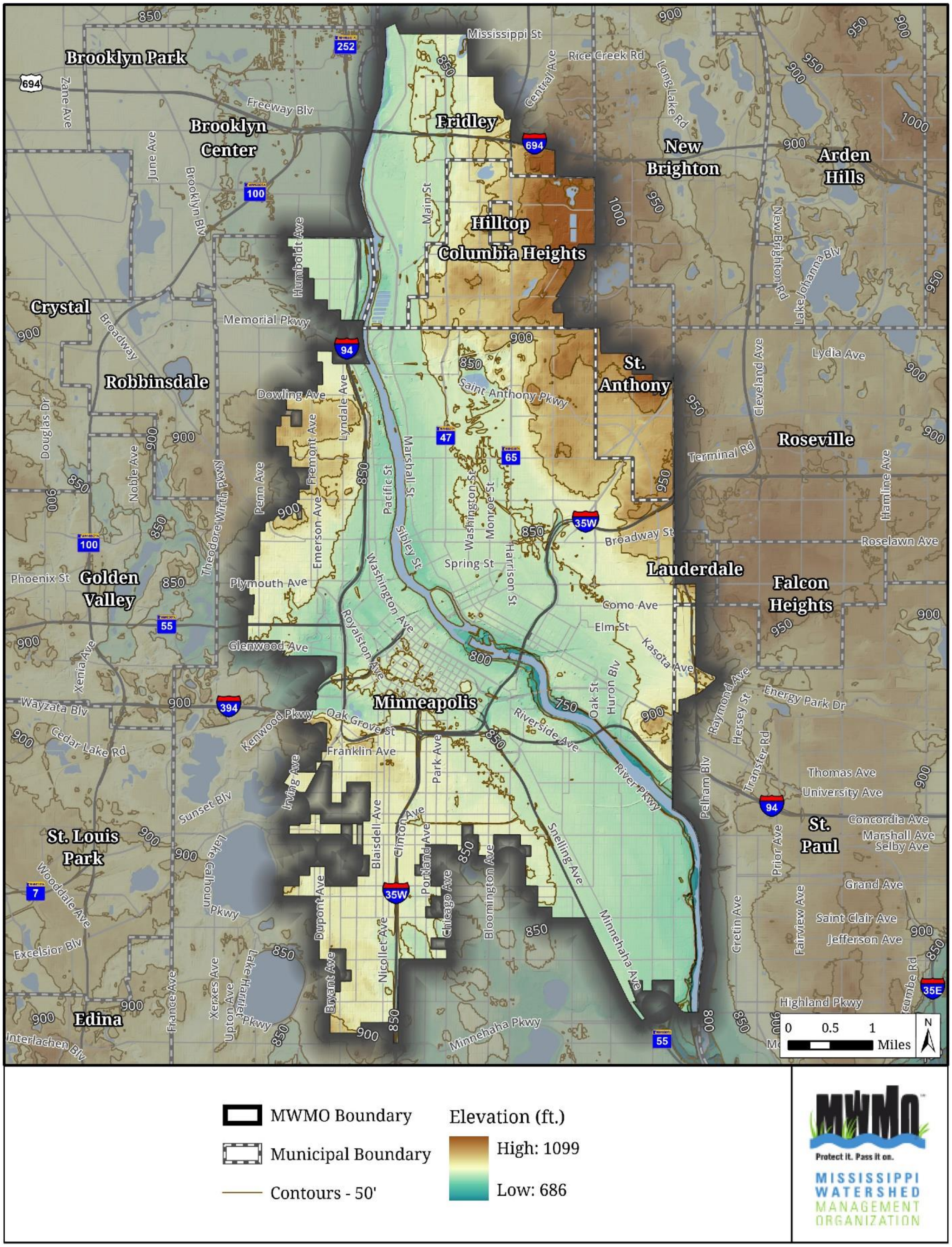


Figure 3: Topography of the MWMO

The landscape topography and the geomorphic domain of regions within the MWMO influences water quality and quantity by affecting the dynamics of the hydrologic cycle. Influences of these factors include:

- Topography directly affects the direction and rate of water flow, and the retention of water
- Geologic strata influence characteristics of MWMO soils and groundwater flow through the subsurface
- Soil type determines the ability of subsurface materials to attenuate pollutants
- Together topography and geology affect detention and retention of water, runoff rates, and infiltration rates
- Infiltration rates, aquifer properties, and groundwater flow paths influence flow of pollution from a spill site and throughout aquifers once pollution has reached the water table

Understanding the dynamics of these factors assists resource managers in identifying sites that are appropriate for infiltration practices or water storage as well as understanding sites that are sensitive to disturbances like construction.

It is important to note that soil structure is irreplaceable, and damaging it reduces soil function including infiltration. Decompaction techniques only have a short-term effect and cannot restore soil structure. In addition to soil texture classification, soil structure should be assessed and/or an infiltration test should be performed to verify design infiltration rates to prevent infiltration basin failure. In an urban watershed, where much of the developed areas have brought in fill, the MWMO uses monitoring instrumentation like an infiltrometer to gather site specific data to help determine if infiltration can occur.

4.2.3 Geology

The geology of the MWMO influences the watershed greatly. Unconsolidated geologic material deposited by glaciation and subsequent processes created the landforms visible in the watershed. Chemical and physical weathering of the geologic materials deposited influences soil type, soil properties, and shallow groundwater storage and movement. Consolidated geologic material, known as bedrock, acts as either aquitards (geological formations that are not capable of transmitting significant quantities of groundwater under normal hydraulic gradients) or aquifers (underground beds or layers of earth, gravel, or porous stone that yield water) depending on whether or not water is easily transmitted through the rock.

Aquifers are specific types of bedrock units which, because of their unique properties, are used for drinking water and industrial water use. These aquifers are important to member organizations and industries located in and near the MWMO. Understanding the properties and lateral distribution of the unconsolidated and bedrock geology of the watershed is imperative to identifying areas where there is potential for contamination, where infiltration may be a viable stormwater management practice, and where unique groundwater-dependent plant communities could be present or restored. Maintaining groundwater recharge areas in this highly impervious watershed is important to protect groundwater baseflow to surface waters.

The surficial geology (or uppermost geologic formations) within the MWMO consists of Quaternary deposits associated with the Des Moines Lobe (Grantsburg Sublobe) and Superior Lobe of the Wisconsin Glaciation, and also with terrace deposits and post-glacial stream and peat deposits (**Figure 4**). The distribution of the surficial deposits varies dependent upon the source of the original material and the erosional and depositional processes affecting them. Directly along the Mississippi River are stream deposits (alluvial fan deposits and floodplain alluvium) and one area of exposed bedrock. Depth to bedrock along the tops of the bluffs lining the Mississippi River is typically 10 feet or less. Two relatively flat platforms, the Langdon and Richfield river terrace deposits, are at separate elevations above sea level bordering each side of the Mississippi River. The river deposits and terrace consist of sand and gravel with some silty deposits.

Moving further away from the Mississippi River and above the terrace deposits are regions of glacial outwash and till. The southwest portion of the watershed includes the outwash deposits and the northeast and northwest portions include loamy till. There are also sand faces in the northern portion of the watershed. Surficial deposits vary in depth throughout the MWMO, from less than 10 feet along the Mississippi River bluffs to about 200 feet over areas where the Prairie du Chien is the first encountered bedrock.

Bedrock geologic units underlie the surficial deposits of the MWMO. The bedrock geologic units are of early Paleozoic age (525 – 400 million years old) and were originally deposited as marine sedimentary rocks (Mossler and Blomgren, 1990). Shallow seas covered southeastern Minnesota and parts of adjacent states during most of this period. The five bedrock groups of the watershed which outcrop (are exposed directly at the surface) or subcrop (are exposed in the subsurface directly below surficial sediments) are, from youngest to oldest, the Decorah shale, Platteville-Glenwood Formation, Saint Peter Sandstone, and the Prairie du Chien Group (**Figure 5**). See **Figure 6** for a schematic of all the bedrock groups of the region.

The uppermost bedrock unit underlying the Quaternary deposits is the Decorah Shale. This unit is discontinuous through the watershed. Where it is present, it acts as a confining layer, protecting lower units from contamination. The Decorah Shale is green calcareous shale with thin limestone interbeds. This unit crops out along the bluffs of the Mississippi River.

The Platteville and Glenwood Formations underlie the Decorah Shale. The Platteville consists of fine-grained dolostone and limestone. The Glenwood consists of thin green sandy shale (3-5.5 feet thick). This formation also crops out along the Mississippi River bluff line and is discontinuous throughout the watershed.

The Saint Peter Sandstone underlies the Platteville and Glenwood Formations. The Saint Peter is divided into two parts in this area of the metro. The upper two-thirds consists of fine- to medium-grained quartz sandstone. The lower third is known as the basal Saint Peter and acts as a confining unit where present. It consists of mudstone, siltstone, and shale with interbeds of coarse sandstone. This formation is exposed in areas along the Mississippi River bluffs.

The Saint Peter is underlain by the Prairie du Chien Group. The upper two-thirds is sandy with thin bedded dolostone and often fractured. The lower part consists of massive or thick bedded dolostone. The Prairie du Chien is present continuously within the MWMO and exhibits solution enhanced flow characteristics where fractures and joints are present.

Below the Prairie du Chien Group are the Jordan Sandstone, Saint Lawrence Formation, Franconia Formation, Ironton-Galesville Sandstone, Eau Claire Formation, and the Mount Simon Sandstone. These bedrock units are regionally important aquifers and confining layers.

Also visible in **Figure 5** are the trends of deep buried bedrock valleys. Deep valleys were cut into the bedrock of the watershed by erosional processes related to glaciation. Scouring and weathering of bedrock surfaces by glaciers and glacier meltwater created deep and broad bedrock valleys that cut deep through the top of the bedrock surface. These valleys were subsequently filled in by sediments from later glacial activity. Although they are not visible at the surface, they influence groundwater flow patterns in some regions of the Twin Cities Metropolitan Area. The most prominent of these valleys runs in a northeast-southwest trend in Minneapolis and Columbia Heights.

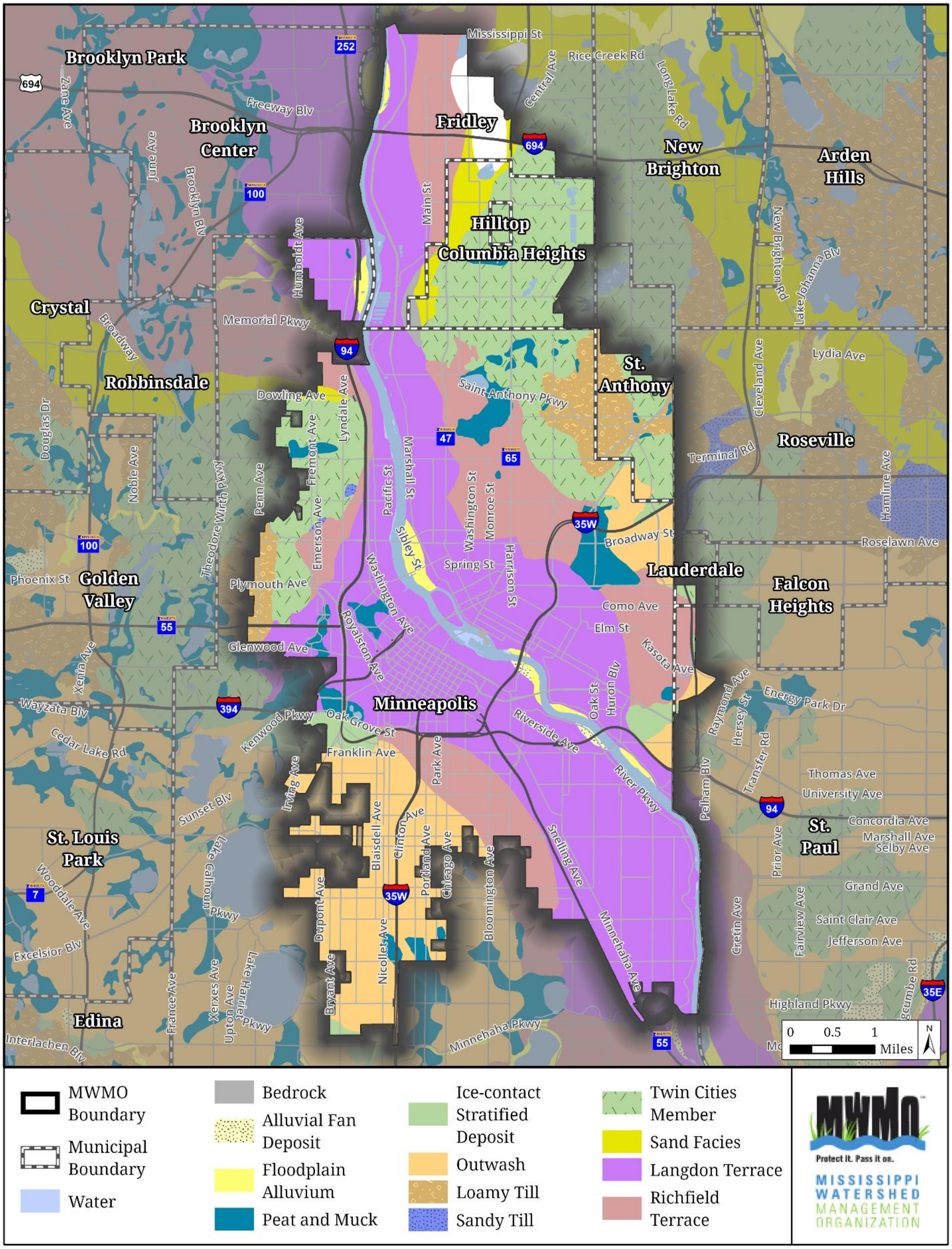


Figure 4: Surficial Geology of the MWMO

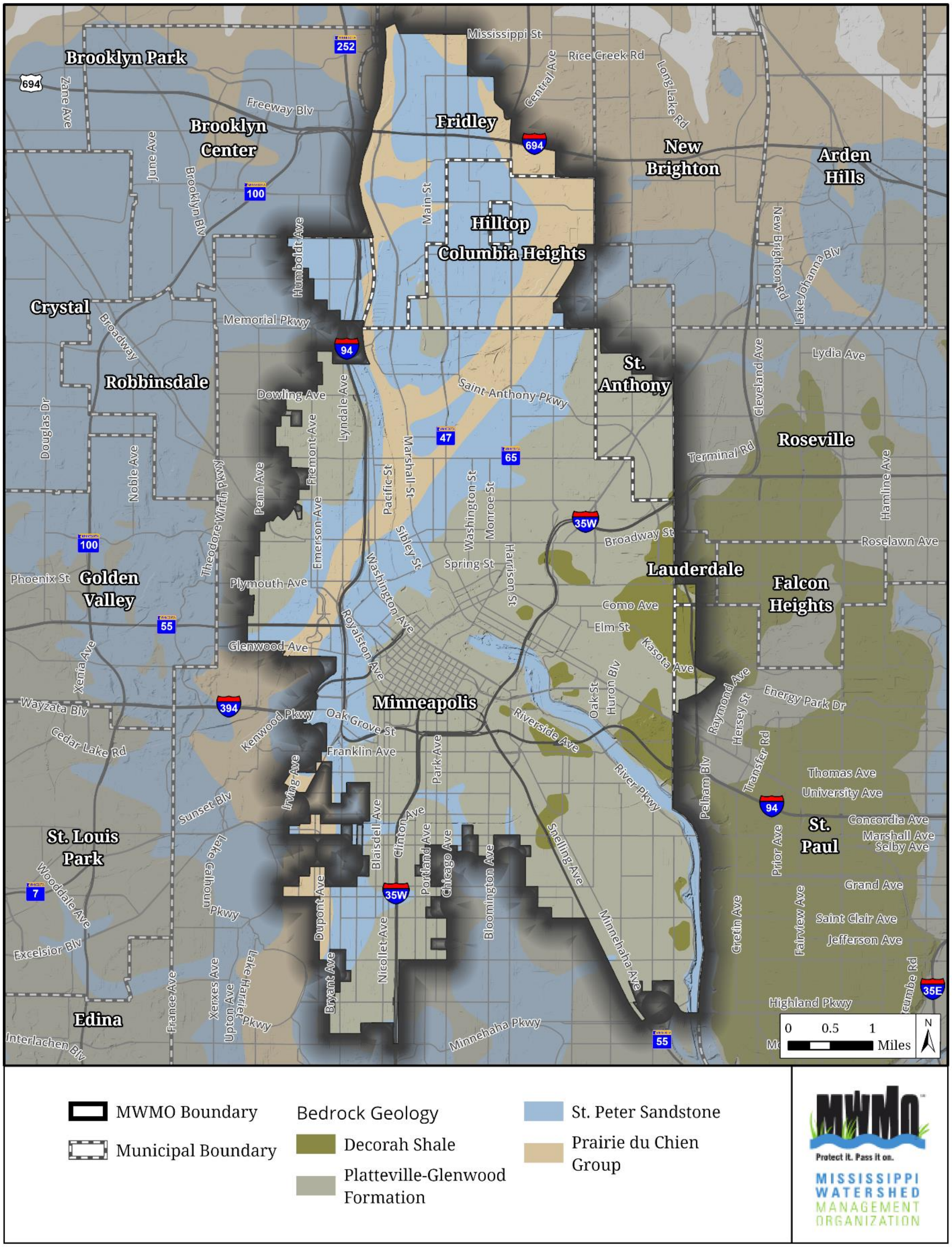


Figure 5: Bedrock Geology of the MWMO

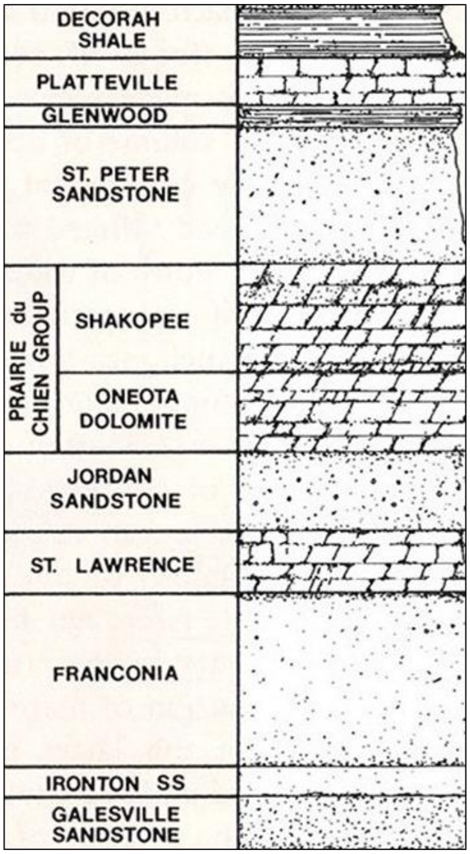


Figure 6: Bedrock units (Ojakangas and Marsh, 1982)

4.2.4 Soils

The properties of soils in the MWMO impact the water and natural resources of the watershed in a variety of ways. Soil properties impact the capacity for growth of vegetation, the likelihood for erosion to occur, the feasibility for rainfall to recharge groundwater, the potential for contaminants to move through the soil, and the possibility of transport of soil-bound nutrients and other pollutants to waterbodies.

As stated in the *Historic Waters of the MWMO (*MWMO, 2011), soil characteristics are the result of physical, chemical, and biological interactions that take place over time. Natural soils are influenced by the weathering of parent material—the biological, chemical, and mechanical activity that takes place in the oxygen-rich environment of the earth's surface. The characteristics of soils, by extension, reflect the interaction between climate, plant, and animal community life, surface and subsurface hydrology, and the base parent materials of the underlying geologic formations.

The soils of the MWMO project area are largely a reflection of the previously discussed surficial geology and the formative processes of the ancient Mississippi River Valley. Additionally, the soils of the MWMO reflect plant community relationships with the physical world since the retreat of the glacial epoch approximately 10,000 years before the present. During the current epoch, soils have developed in conjunction with advancing and retreating vegetation communities. The establishment, disruption, reestablishment, and shifting of vegetation communities in concert with the physical landscape provide the underlying basis of the pre-settlement Twin Cities landscape.

Soil composition played a significant role in the development of the Twin Cities Metropolitan Area. This region lies at the interface between major continental biomes, each with a different set of ecological characteristics and soil qualities. The economic growth of the Twin Cities was first and foremost based on the presence of the Mississippi River. Secondly, the Twin Cities had a vast supply of timber to supply its own growth and drive the growing national economic booms of the 19th Century. Following the establishment of the Twin Cities based on timber, the vast prairies with deep rich soils provided the basis for the ongoing economic growth based on agriculture. In each case, regional soils based on the presence of post-glacial shifting vegetation communities provide an additional pathway to reconstructing the pre-European settlement landscape. Without these diverse pre-settlement vegetation and soil types, the Twin Cities may not have remained the continuously thriving metropolis that it has over the past century and a half.

As in most urbanized areas, soil mapping in the MWMO area has been seriously affected by the early and rapid urbanization of the area. Soils surveys were published for Ramsey County in 1916 and for Hennepin County in 1929. These maps have been georeferenced from the original soil surveys and are shown in **Figure 7**. Soil surveys are based on field data collection of soil plots and mapped with a taxonomic description developed by the Natural Resources Conservation Service (NRCS). NRCS soil surveys were, historically, created primarily to identify suitable soils for agricultural uses, and urbanized lands were typically lumped into categories that reflected the disturbed nature of the land. To a significant degree, the urban soils of the MWMO have been largely disrupted and moved to accommodate development and industry.

Though developed largely as a tool for agriculture and protection against overuse, soils maps today are used for a range of applications, from mineral extraction, wetland identification, buildability, and climate analysis among others. In 1916, Ramsey County was rapidly developing, but large areas of native soils remained intact, and the soil survey was quite extensive, providing mapping units for nearly the entire county. Unfortunately, only a very limited area of the MWMO lies within the Ramsey County survey area. By the time the first Hennepin County Soil Survey was published in 1929, the Minneapolis urban core was largely built-out, so most of the central portion of the MWMO area was labeled “unclassified”. Mapped exceptions in the 1929 survey are confined largely to the extremities of the MWMO area, where roads had been developed, but lot scale build-out was not fully complete. By the 1974 publication of the soils surveys for Hennepin and Ramsey Counties, urban lands dominated virtually all polygons within the MWMO boundary.

At first glance, the 2008 soil survey of the MWMO project area continues to describe the soils of the urban core as “Urban Land” since much of the land has been moved, and soils disrupted. The most recent (modern) soil surveys for Hennepin and Ramsey Counties have reincorporated more refined data into the urban mapped areas. **Figure 8** shows the extent to which the NRCS has determined the MWMO area to be predominantly urban or disturbed soils. Very few areas are mapped to the natural soil series level. The NRCS recommends that, in these disturbed soils where soil analysis for site-based work is required, borings and soils tests are required, as it is assumed that the natural soil properties may no longer be present.

As **Figure 8** (Map 15A, MWMO, 2011) depicts, the majority of soils in the watershed are disturbed and classified as "Urban Land." Updates to the 2007 NRCS Soil Survey now include data collected in the urban core to provide soil "complexes" (Appendix D) within the predominant (often "urban") soil types. A soil complex is a mapped soil unit with a mix of soil series: in this case, areas with a predominant urban matrix with substantial "inclusions" of natural soils. According to the Hennepin County NRCS, where urban soils have been mapped as a complex with other soil series these can be read as an interpretation by the NRCS of the likely dominant series prior to disruption (telephone conversation with NRCS office staff). Using the interpretation of the most prevalent soil within an urban complex as the likely pre-settlement matrix, soil attributes that assist in understanding general landscape characteristics provide additional insight into pre-settlement conditions.

Figure 9 (Map 15B, MWMO, 2011) shows areas in the most recent surveys where "urban lands" are mapped as soil complexes (light green). Where map units are described as urban lands and udorthents (undifferentiated soil fill) with a more in-depth description (complex or substratum), new fields have been added to the GIS layers to piece together an interpretation of possible pre-settlement conditions. In addition, many of the soils mapped as "urban land" in the MWMO area are associated with a more detailed "soil complex". Soil complexes are mapped units that contain two or more recognizable units. In urban soils settings, the author has made the assumption that highest level natural soil in the complex was considered by the author of the Soil Survey as the dominant pre-settlement soil, confirmed by the Hennepin County NRCS (Telephone conversation with NRCS office staff). Using this methodology, soils descriptions can be used to assist in piecing together pre-settlement vegetation, wetlands, and drainage class among other characteristics. While this information may not be useful on a site-specific scale, it can be used to develop pre-settlement baseline conditions on a neighborhood or regional level. This new mapping provides the potential for more refined landscape scale interpretations of pre-settlement vegetation and hydrological characteristics than previously available.

Figure 10 shows the combined historic and modern data available for the MWMO area. Only those areas depicted in gray contain no information on natural soil characteristics.

Combining the attributes from different mapping periods, **Figure 11** (Map 15D, MWMO, 2011) shows the synthesis of soil series data. Where a modern soil complex is described for a soil map unit, the most common inclusion is shown, presuming the pre-settlement soil matrix. In the northeastern portion of the MWMO, the large area of Hayden soils mapped in 1929 is shown within boundaries of the modern soil survey units. Within the northeast portion of the MWMO, Udorthents with a wet substratum are shown as such, but were described as either peat or Webster silty loam in the 1929 survey. Appendix D, excerpted from the *Historic Waters of the MWMO (*MWMO, 2011), provides detailed NRCS soil series descriptions of soils shown on

Figure 11 (Map 15D, MWMO, 2011). For descriptions of the Hayden and Webster soils from the 1929 Hennepin County Soil Survey, see the *Historic Waters of the MWMO (*MWMO, 2011).

Using the synthesized data described above, **Figure 12**, **Figure 13**, and **Figure 14** (Maps 16A, 16B and 16C, consecutively, MWMO, 2011) provide a synthesis of data provided in modern and historic soils survey to assist in establishing an image of the pre-settlement landscape of the MWMO.

Figure 12 (Map 16A, MWMO, 2011) shows the soil orders associated with the map units in **Figure 11** (Map 15D, MWMO, 2011). Soil orders are the major categories of soil types largely defined by large scale landscape characteristics where these soils formed. The formative soils of the MWMO fall into four major orders, each typical of distinct vegetation communities that formed at the surface. The four major orders of the MWMO are described briefly here, and shown on **Figure 12**:

- **Mollisols -** This order of soils covers a large area of western Minnesota and provides the deep rich soils of the agricultural regions of the state. Most significantly, these soils have a nutrient rich surface layer of dark colored thick material occurring throughout the grassland pre-settlement prairie regions of the state. These soils typically have a surface layer that is low density and loose.
- **Alfisols -** The other major order in the MWMO area, the Alfisols are typically forest soils. These soils are generally found along and east of the Mississippi River, with high accumulations of aluminum (Al) and Iron (Fe). These fertile soils formed in loam or clay. Alf is the formative element and is coined from a soil term, pedalfer. The surface layer typically has less clay than the subsurface. These soils usually also contain a leached zone of eluviation, or E horizon. This layer is typical of forest soils where this E horizon has been washed of some mineral content through the percolation of water down the horizon. These soils often remain moist throughout the year. These are the soils of Maple Basswood Forests and are found west of the MWMO area.
- **Histosols -** These soils are formed of organic materials from the remains of plants found in marshes and bogs. The soils are comprised of the dead and decaying matter of leaf and root tissue of plants growing in wet environments. The soils range from Saprists (most material is decomposed and original constituents are unrecognizable) to Hemists (moderately decomposed soils where some recognizable plant material is distinguishable) to Fibrists (plant materials remain distinguishable).
- **Entisols -** These are soils of recent origin, often developing in river bottom alluvium and sand. They are defined by the combination of being comprised of parent material not easily weathered (quartz) and being in a relatively early stage of development. The Entisols most commonly found in the MWMO area are confined to the Mississippi River floodplain, the highly urbanized downtown of Minneapolis, the area of the old Bassett Creek tunnel, and the base of steep moraine slopes in the northeast portion of the watershed.

The Soil Orders Map clearly corresponds with the Surficial Geology Glacial Phase Map presented as Map 11 in the *Historic Waters of the MWMO (*MWMO, 2011). Note the highlands of the Grantsburg Lobe in North and Northeast Minneapolis, here mapped distinctly as Alfisols. Entisols, the still-developing soils of the Mississippi River floodplain and the well-drained prairie soils of the Mississippi River terraces, are each represented by refining the information provided in the most recent Hennepin County soil survey. Udorthents are a disturbed soil. Where these units were mapped with the "wet substratum" qualifier, these were added as wetland soils. These soils correspond very closely with the historic wet features mapping (see Map 9 in the *Historic Waters of the MWMO (*MWMO, 2011).

Figure 13 represents the vegetation communities listed as typical for each of the NRCS Soils Series Descriptions. These descriptions are provided by the NRCS for every soil series at: http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi. While these descriptions do not entirely correspond with the soil orders, they are a reflection of the mosaic of vegetation communities that would have existed at the time of settlement, and indicate shifting patterns of vegetation during the postglacial period. Of note here is the extent to which the communities described are significantly dominated by the transitional savanna community. Only in the moraine region of the northeast portion of the MWMO are soils described as fully typical of forests, and likewise, specifically prairie soils are limited mostly to the river terrace area of the Seward, Cooper, Howe, and Longfellow neighborhoods of Minneapolis.

Figure 14 (Map 16C, MWMO, 2011) shows the Hydrologic Soil Group (HSG) for the map units from the synthesized soil survey. The hydrologic soil groups presented are based on an estimate of the historic native soils in the MWMO and are used in developing the MWMO Standards to determine the hydrologic soil group. The hydrologic group designation is used to describe the runoff potential of soils and is divided into four groups (A to D). HSG A soils generally have the least runoff potential, and HSG D soils the greatest. According to the 'Urban Hydrology for Small Watersheds' published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55, the soil groups are described as follows:

- **Group A** soils are sand, loamy sand, or sandy loam types of soils. They have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels, and have a high rate of water transmission.
- **Group B** soils are silt loam or loam. They have a moderate infiltration rate when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
- **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with moderately fine to fine structure and a layer that impedes downward movement of water and soils.
- **Group D** soils are clay loam, silty clay loam, sandy clay, silty clay, or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a clay pan or clay layer at or near the surface and shallow soils over nearly impervious material.

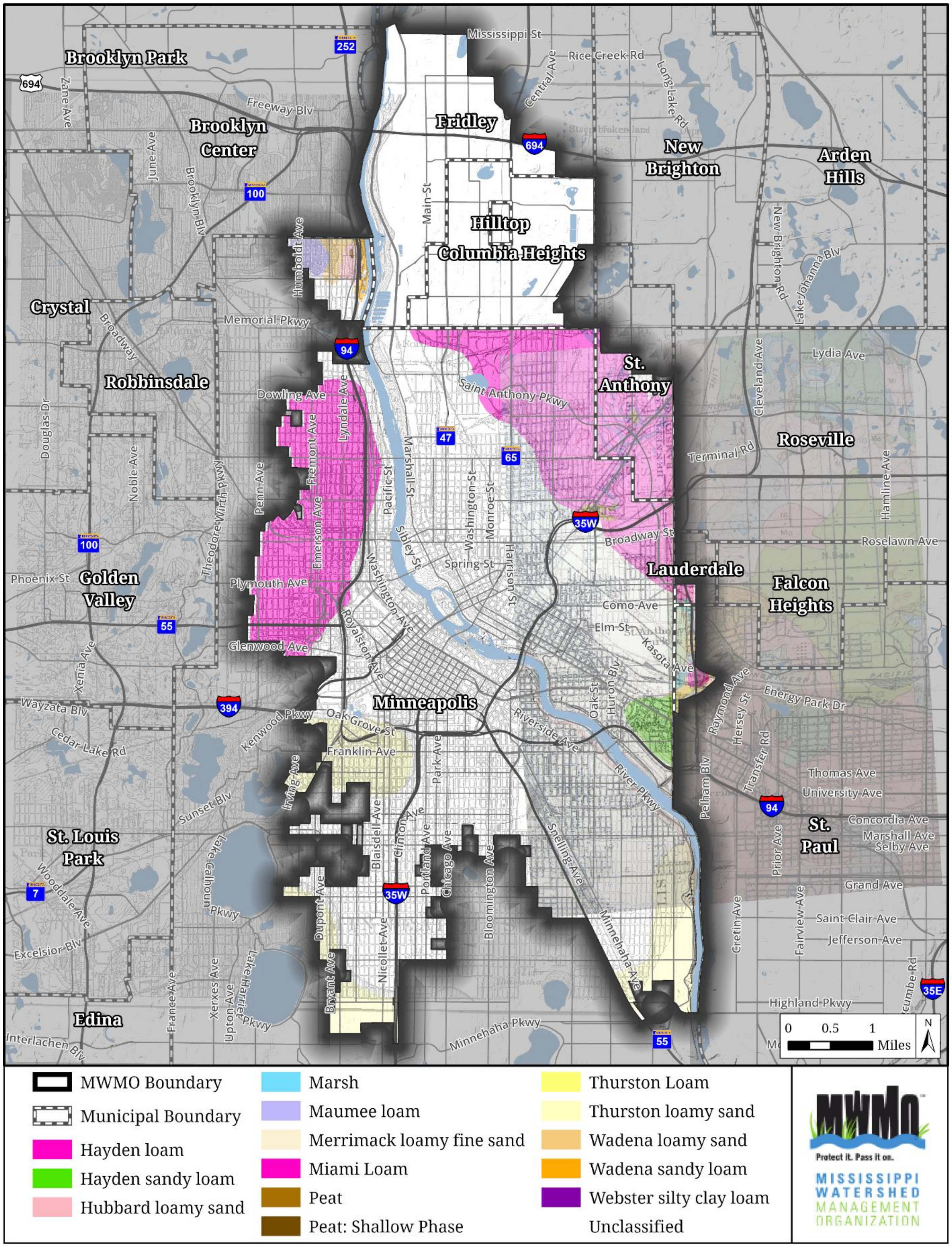


Figure 7: Historic Soils Orders of the MWMO

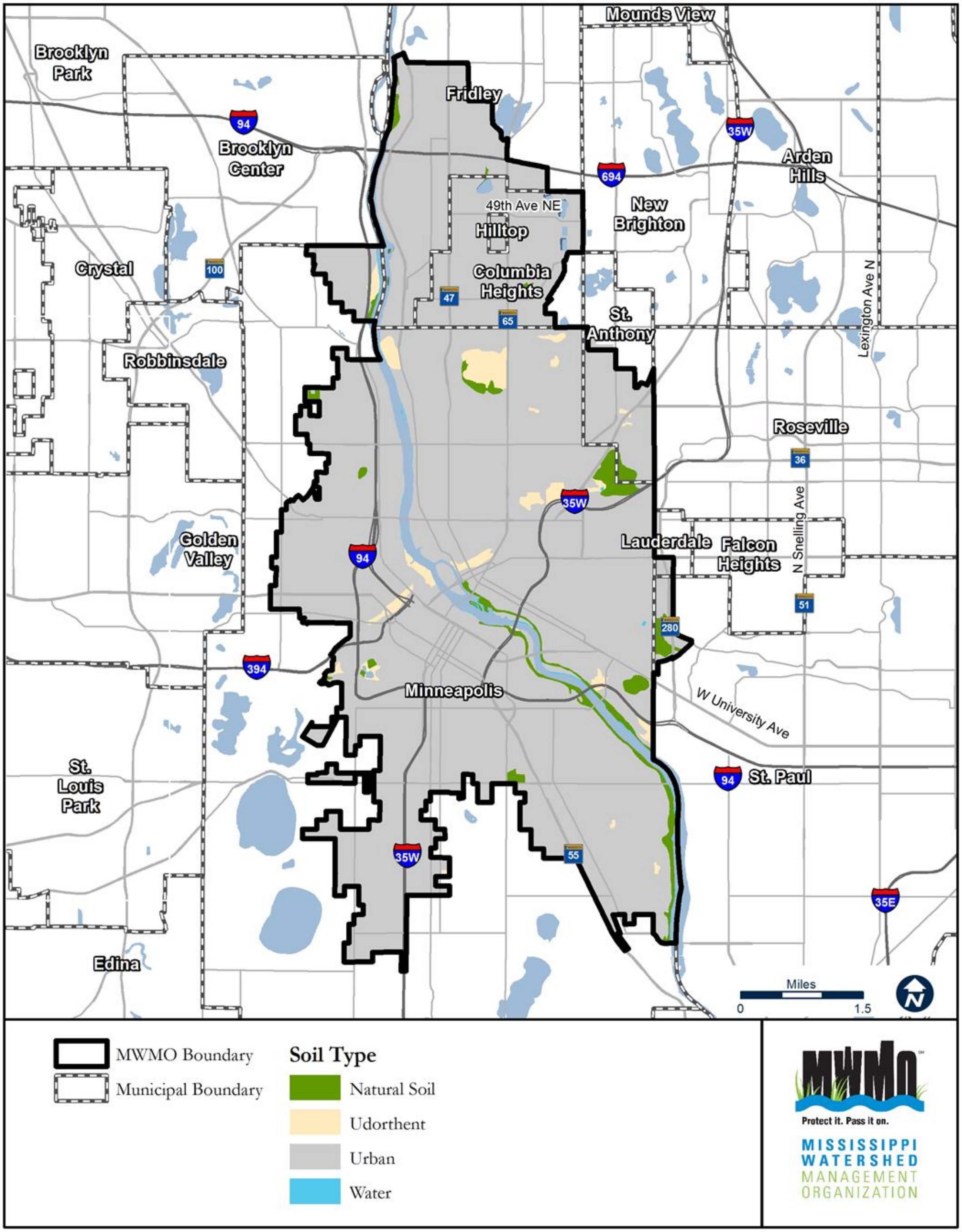


Figure 8: Present Day Urban Soils

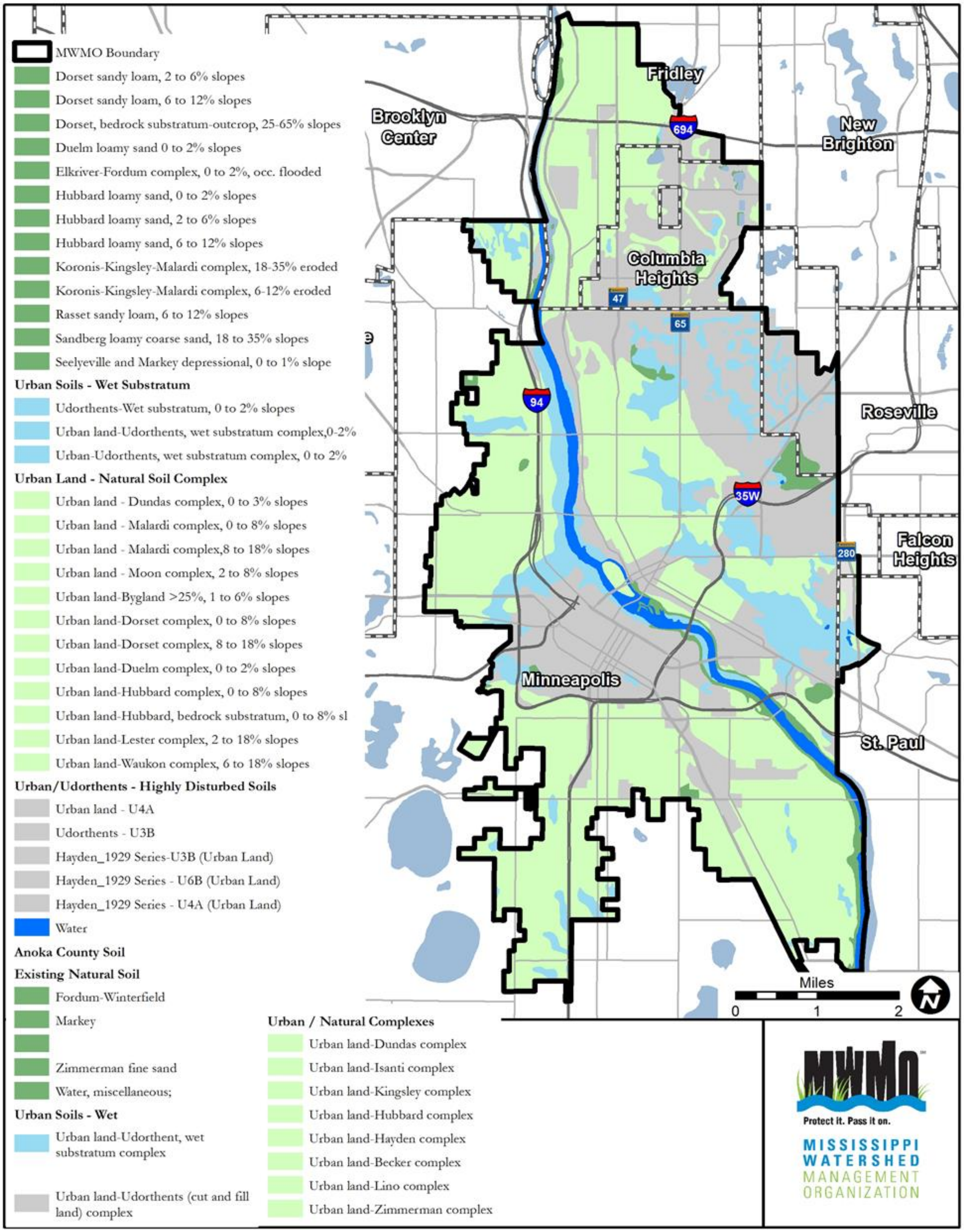


Figure 9: Modern Secondary Soil Information

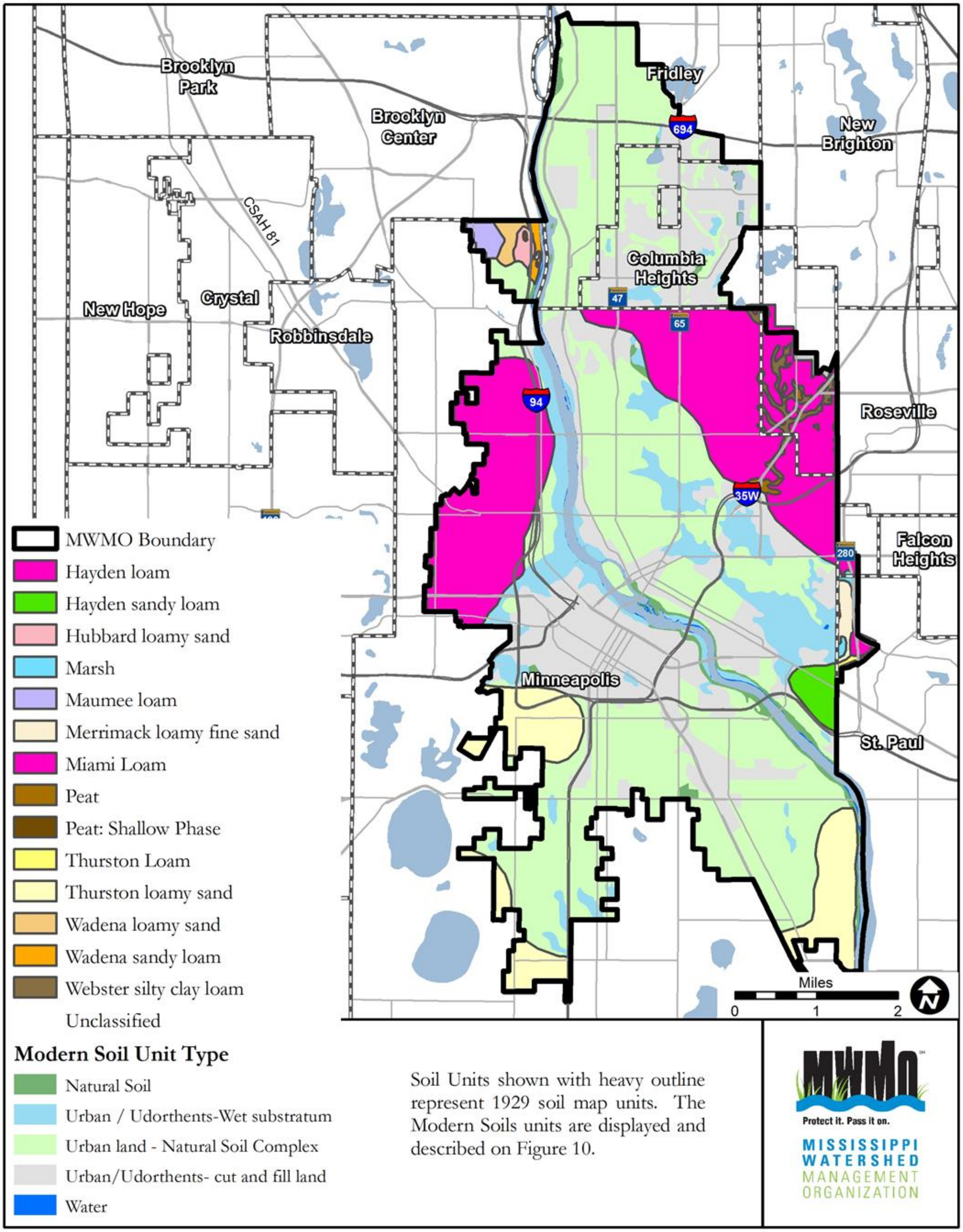


Figure 10: Combined Historic and Modern Soil Information

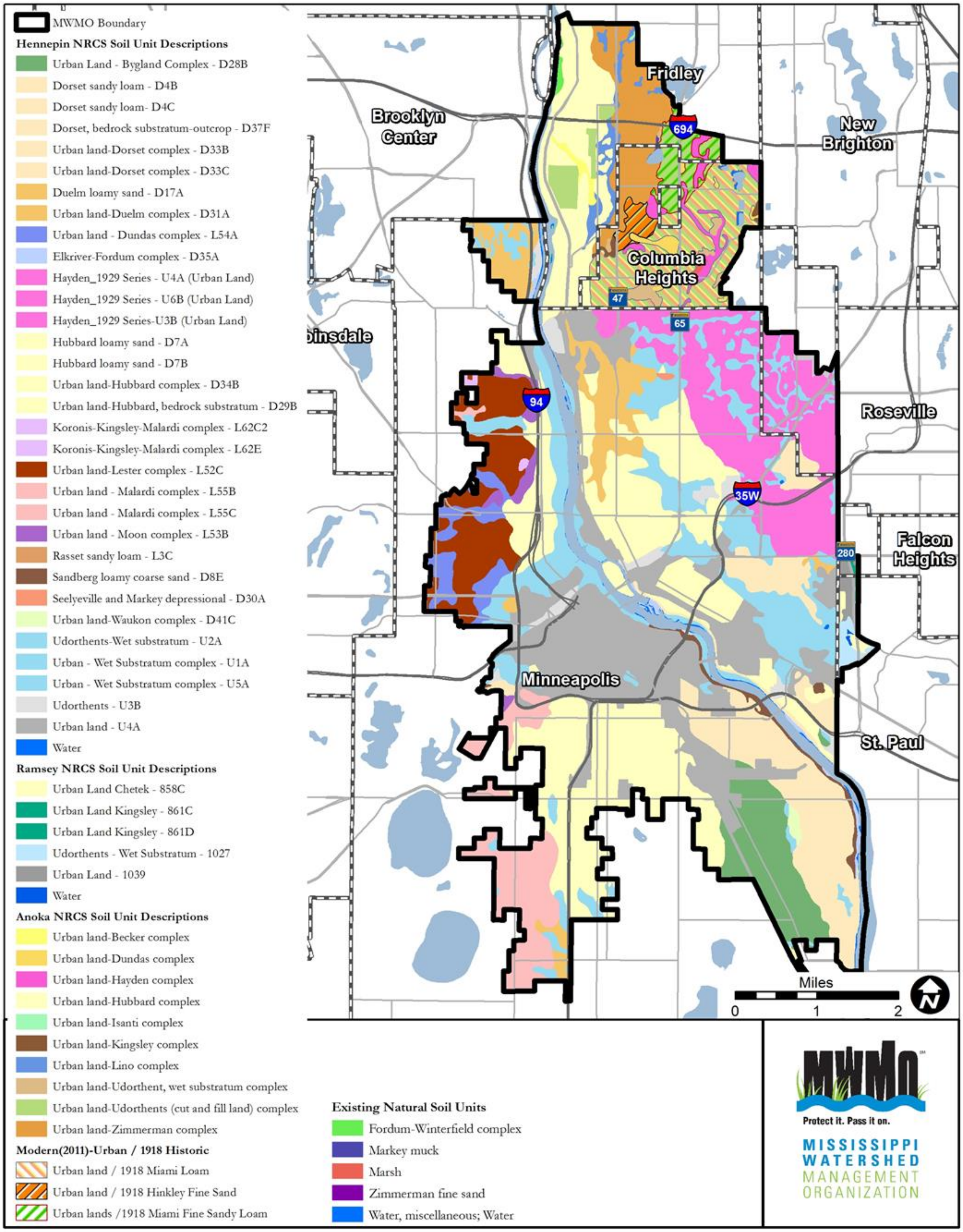


Figure 11: Soil Series

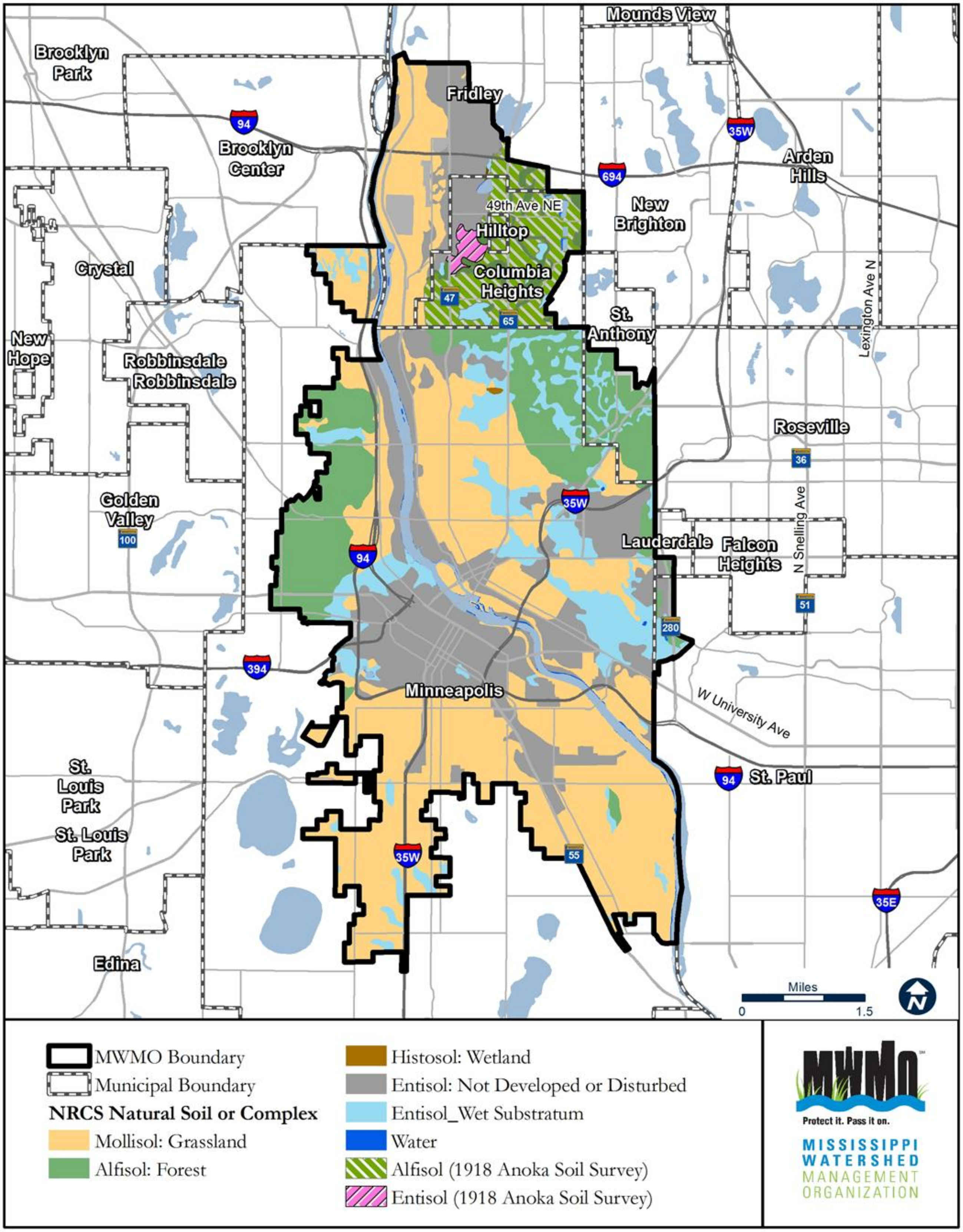


Figure 12: Soil Orders

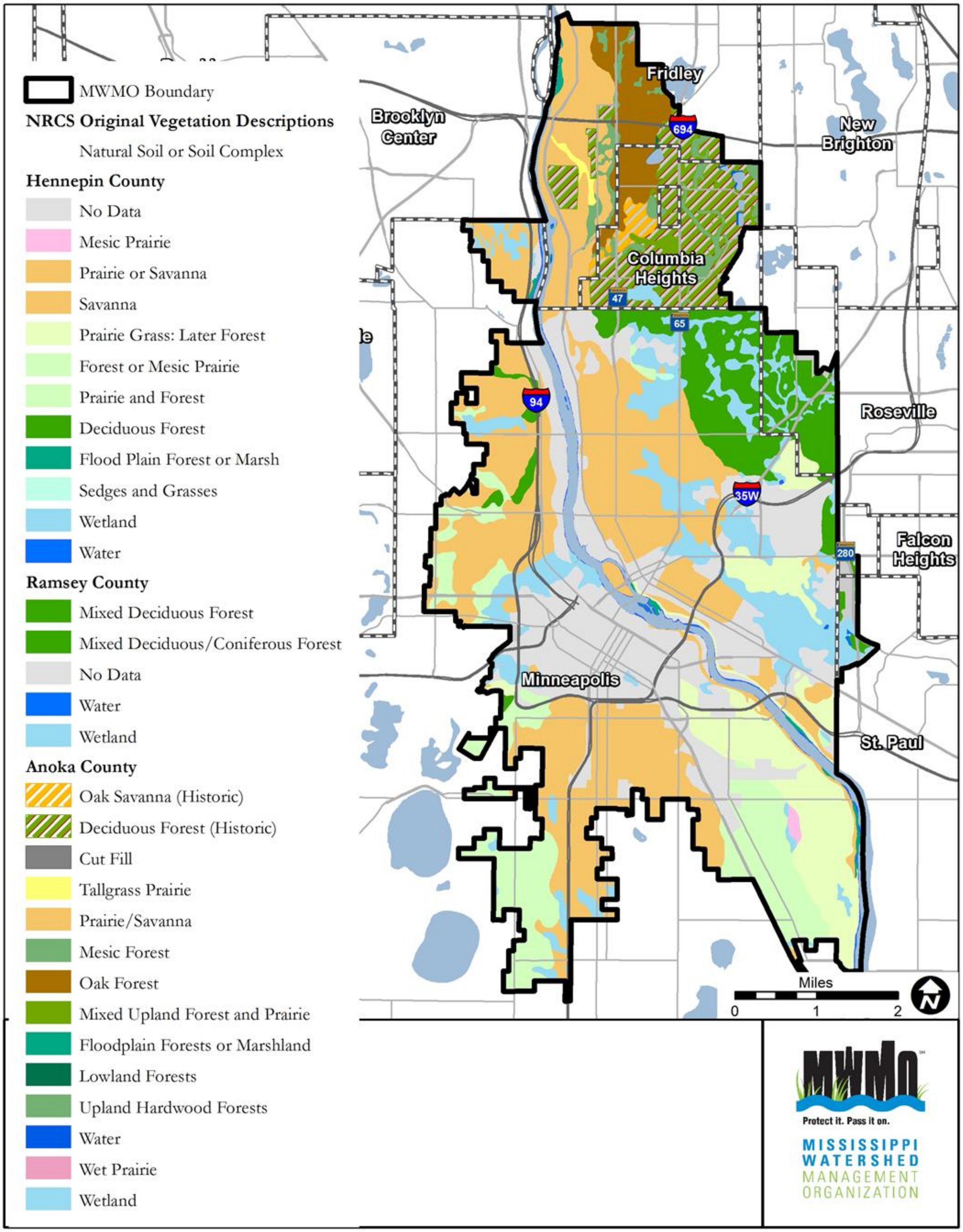


Figure 13: NRCS Based Vegetation

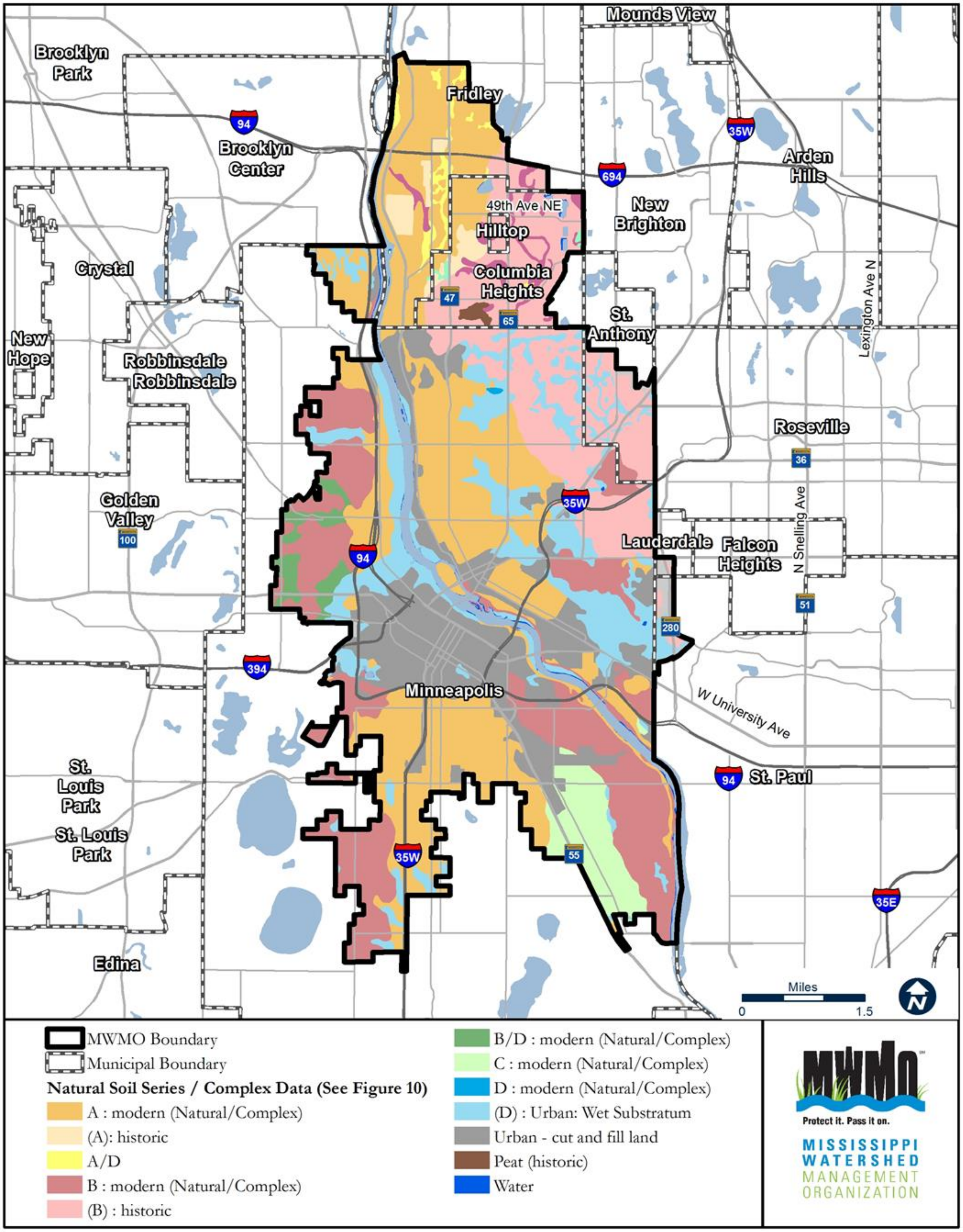


Figure 14: A Historic Estimate of Soil Hydrologic Group

4.2.5 Unique Features and Scenic Areas

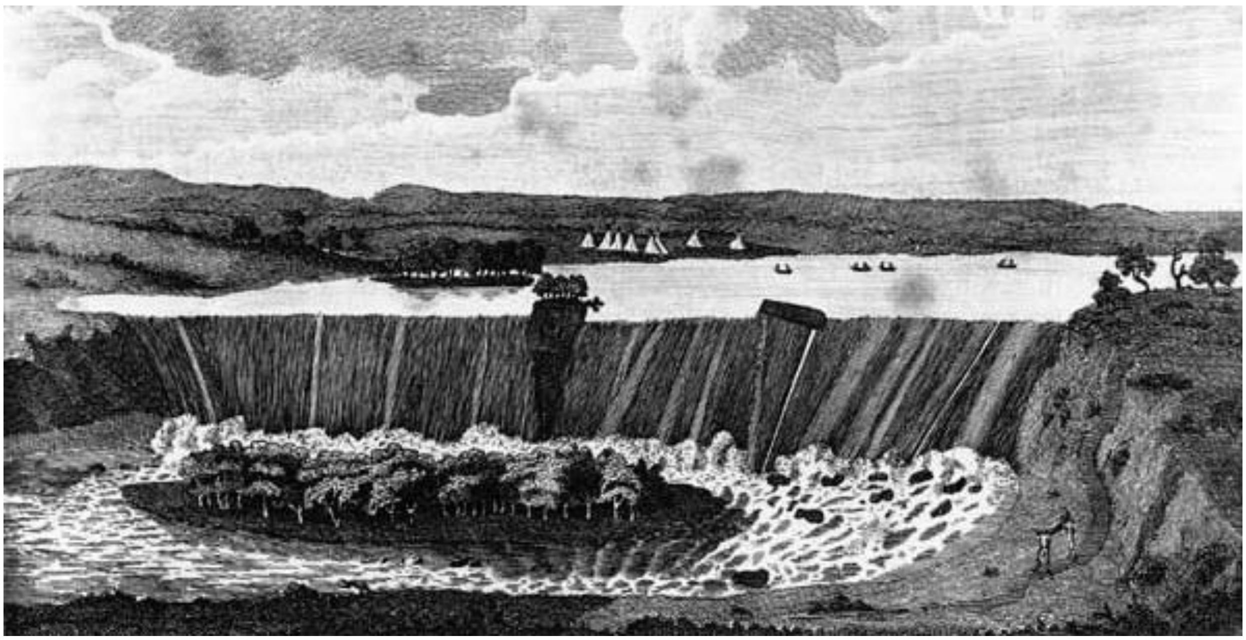
The watershed contains many scenic areas and unique features. The regional and municipal parks located within the watershed have preserved scenic views of the Mississippi River Valley and other water resources within the watershed. These parks and open spaces often allow recreational access to these resources.

As a result, many of the metropolitan area's cultural features are found within the watershed. Some of these features within the City of Minneapolis include:

- Hall's Island: an island located just north of the Plymouth Avenue North bridge on the Mississippi River. It was destroyed by industrial development in the 1960s and reconstructed with funding support from MWMO in 2018; the site was excavated to create a new back channel that re-separated the island from the mainland. The riverfront property was formerly owned by Scherer Brother Lumber Company and purchased by the MPRB in 2010.
- Mill City Museum: a museum built in the ruins of the Washburn "A" Mill on the west bank of the Mississippi River by St. Anthony Falls focusing on the history of flour milling and other industries using hydropower
- Minneapolis Institute of Art: a free museum, opened in 1915 and expanded in 1974, south of downtown Minneapolis on 3rd Avenue South across from the Washburn Fair Oaks Park
- Mississippi River Gorge: runs approximately eight miles from Saint Anthony Falls in downtown Minneapolis to the Minnesota River confluence in Mendota, Minnesota. It is the only true gorge along the Mississippi's entire 2,350-mile length. Geologic layers of the gorge include Glacial Till (soil), Plateville Limestone, the Glenwood Formation (shale), and Saint Peter Sandstone. From 45,000 to 12,000 years ago, during the last ice age, glaciers advanced and retreated many times over this area to slough away all the younger or top layers of rock formations. The glaciers melted 12,000 years ago, leaving a large amount of water. Saint Anthony Falls was formed 12,000 years ago near what is now downtown Saint Paul. The estimated size was nearly 200 feet high and a mile across. Year after year, the waterfall cut a path through layers of sedimentary bedrock. As soft, underlying Saint Peter Sandstone eroded beneath the force of falling water, the limestone caprock was undermined and crumbled. The falls receded upstream about 6.8 miles to their current location near downtown Minneapolis (Brewer 1998). The River Gorge is important for birds, fish, and native plants. Stressors include invasive species, erosion caused by foot and bike traffic, and stormwater pollution.
- Nicollet Island: an island crossed by the Hennepin Avenue Bridge in the Mississippi River north of St. Anthony Falls
- Saint Anthony Falls: the only major waterfall on the entirety of the Mississippi, these falls were once a major gathering place and landmark to the native tribes who frequented the area. The area holds cultural, spiritual, and political significance today to the Dakota and Ojibwe. The falls no longer retain their natural appearance as an immense waterfall with limestone bedrock covering soft sandstone. With the development of power extraction for the mills via diversion of upper-level water into waterwheel-equipped vertical shafts, the migration of St. Anthony Falls accelerated quickly. A concrete overflow spillway was installed after the falls partially collapsed in

1869. The river was dammed several times (with the Upper St. Anthony Falls dam completed in 1963 by the USACE) for power and navigation purposes.

- Stone Arch Bridge: a former railroad bridge, now open to pedestrians and cyclists, crossing the Mississippi River and offering views of St. Anthony Falls
- University of Minnesota Campus: a public research university with campuses in Minneapolis (both east and west bank of the Mississippi River within blocks of I-35W and I-94) and St. Paul
- Walker Art Center and Sculpture Garden: an art center and sculpture garden park (a partnership between the Walker and the MPRB) west of Loring Park and the Basilica of Saint Mary



Artistic rendition of the falls, prior to damming (brittanica.com)

The Mississippi River through the metropolitan area was designated a Critical Area by the State of Minnesota in 1979 and was designated the Mississippi National River and Recreation Area (MNRRA) of the National Park Service in 1988 by the United States Congress. In addition, the Mississippi River from Minnesota to Missouri was designated as an American Heritage River in 1998 allowing greater coordination of river-related efforts. The cities of Minneapolis and Saint Paul have developed Critical Area Plans and management plans to protect the natural, cultural, historic, commercial, and recreational values of the corridor.

4.2.6 Discussion of Challenges, Gaps, and Next Steps

The MWMO will continue to partner with the City of Fridley, the City of Minneapolis, the Minneapolis Park and Recreation Board, and the National Park Service in maintaining the water quality, habitat, and natural aesthetics of the Mississippi River and Critical Area.

Many studies done on natural resources by federal, state, and local levels of government pass over urbanized areas. As such, MWMO started with a scant amount of information on the characteristics and quality of water and natural resources in the watershed. This is problematic because effective watershed management is based on a thorough scientific understanding of the unique physical characteristics and complex ecosystems that make up a watershed. In addition, plants, soils, water, and air are a part of natural systems that do not acknowledge political boundaries. So, when managing natural resources, organizations many times need to consider a scale that goes beyond their individual city or watershed area. Thus, the MWMO will continue to conduct appropriately-scaled studies that inventory, characterize, and assess the condition of water resources and related natural and human resources within the watershed.

4.3 Biological Environment

4.3.1 Natural Communities

The majority of the MWMO has been developed for commercial, industrial, or residential uses and covered in impervious surfaces. However, some areas of natural and semi-natural vegetation remain (**Figure 15**). Most natural and semi-naturals areas are located within close proximity of the Mississippi River. **Table 8** summarizes the acreage of remaining natural and semi-natural areas within the watershed.

Table 8: Natural and Semi-natural Areas of the MWMO Planning Area

Natural and Semi Natural Areas	Acres	% Watershed Area
Disturbed Forested Wetlands	243.90	0.955%
Disturbed Forests	0.56	0.002%
Disturbed Grasslands	239.92	0.939%
Disturbed Shrublands	11.16	0.044%
Disturbed Woodlands	6.09	0.024%
Native Forested Wetlands	175.70	0.688%
Native Forests	73.24	0.287%
Native Grasslands	41.72	0.163%
Sparse Vegetation	1.21	0.005%
Water	907.40	3.552%
Totals	**1,700.90**	**6.659%**

Source: MnDNR Natural and Semi-Natural Areas dataset

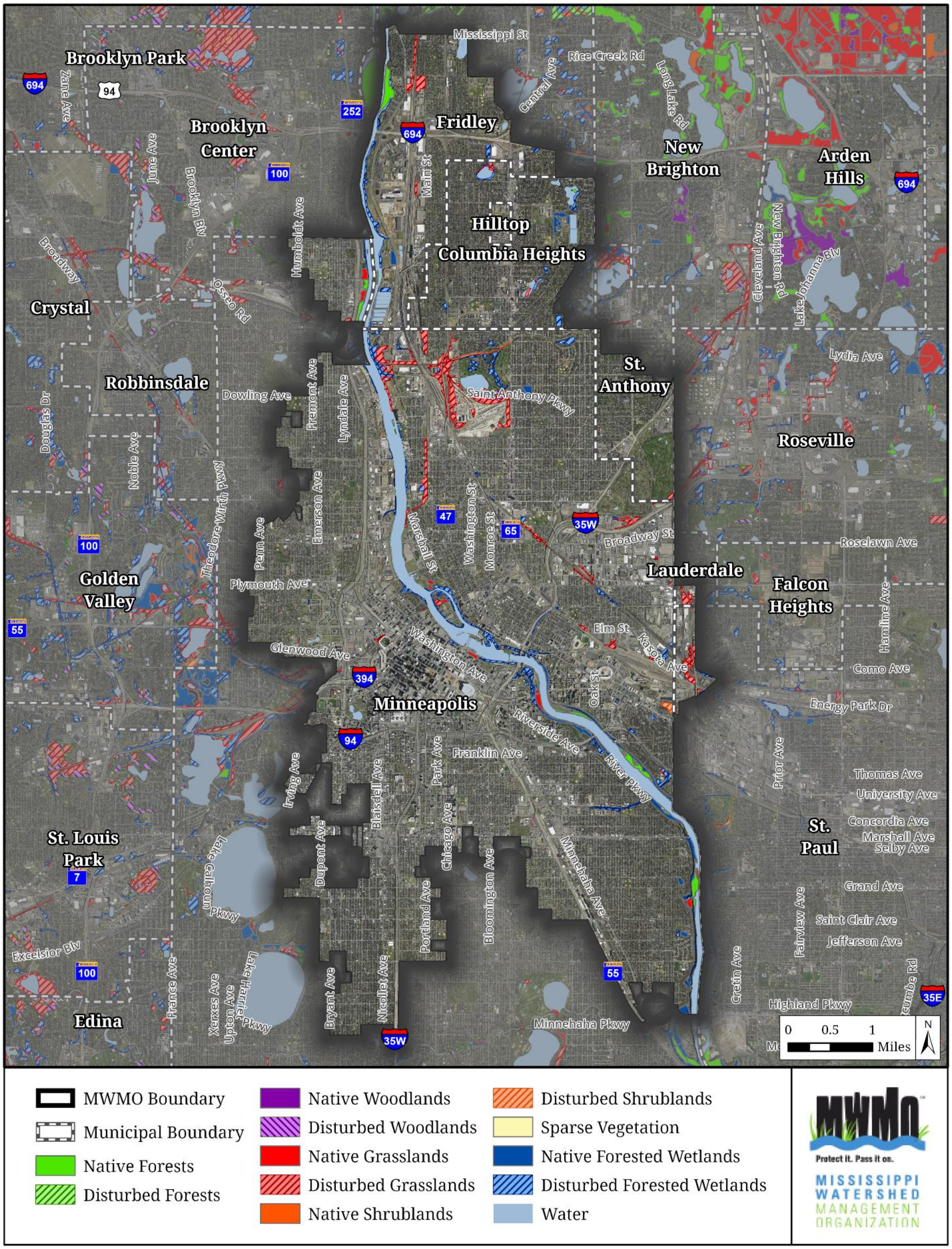


Figure 15: Natural and Semi-natural Area of the MWMO

4.3.2 Rare Biological Features

The Minnesota County Biological Survey identifies significant native plant communities throughout the State of Minnesota. Native plant communities typically appear where there is little alteration by humans and development. Native plant communities are named for the characteristic plant species within them or for characteristic environmental features. The Minnesota County Biological Survey program completed a survey of remaining areas of natural vegetation in Hennepin County from 1995-1997 and in Ramsey County from 1989-1990, identifying several intact native plant communities. The native plant communities identified in the survey are located along the Mississippi River and include Mesic prairie, Red oak/sugar maple/basswood forest, and Silver maple floodplain forest.

The Minnesota Department of Natural Resources queried the Minnesota Natural Heritage Information System Rare Features Database to find all records of rare species and other significant natural features within one mile of the watershed. **Table 9** summarizes the records of federal- and state-listed species—plants or animals that are listed as Endangered, Threatened, or Special Concern status in the State of Minnesota Department of Natural Resources Natural Heritage Program. The habitats where these species have been located need to be protected and potentially enhanced. The MWMO will give special consideration and protection to these areas during planning.

Because these rare features data are not based on a comprehensive inventory, there may be additional rare or otherwise significant natural feature occurrences in the MWMO that were not reported and therefore not entered into the database or the table below. Additional information on rare species can be found on the Minnesota Department of Natural Resources website's Rare Species Guide at http://www.dnr.state.mn.us/rsg/index.html. The index report of rare features and additional information on Blanding's Turtles can be found in Appendix E.

Table 9: Rare, Sensitive, and Endangered Species within the MWMO

Common Name	Genus and Species	Status
A Species of Fungus	*Psathyrella rhodospora*	Minnesota - Endangered
Acadian Flycatcher	*Empidonax virescens*	Minnesota - Special Concern
American Burying Beetle	*Nicrophorus americanus*	Minnesota - Watchlist
Autumn Fimbry	*Fimbristylis autumnalis*	Minnesota - Special Concern
Beach Heather	*Hudsonia tomentosa*	Minnesota - Threatened
Black Huckleberry	*Gaylussacia baccata*	Minnesota - Threatened
Black Sandshell	*Ligumia recta*	Minnesota - Special Concern
Blanding's Turtle	*Emydoidea blandingii*	Minnesota - Threatened
Eastern Hognose Snake	*Heterodon platirhinos*	Minnesota - Watchlist
Fawnsfoot	*Truncilla donaciformis*	Minnesota - Threatened
Ghost Tiger Beetle	*Cicindela lepida*	Minnesota - Threatened
Handsome Sedge	*Carex formosa*	Minnesota - Endangered
Higgins Eye	*Lampsilis higginsii*	Federal - Endangered

Common Name	Genus and Species	Status
		Minnesota - Endangered
Kentucky Coffee Tree	*Gymnocladus dioica*	Minnesota - Special Concern
Lance-leaf Violet	*Viola lanceolata var. lanceolata*	Minnesota - Threatened
Late Hawthorn	*Crataegus calpodendron*	Minnesota - Special Concern
Leadplant Flower Moth	*Schinia lucens*	Minnesota - Special Concern
Mucket	*Actinonaias ligamentina*	Minnesota - Threatened
Mudpuppy	*Necturus maculosus*	Minnesota - Special Concern
Peregrine Falcon	*Falco peregrinus*	Minnesota - Special Concern
Plains Hog-nosed Snake	*Heterodon nasicus*	Minnesota - Special Concern
Prairie Vole	*Microtus ochrogaster*	Minnesota - Special Concern
Rusty-patched Bumble Bee	*Bombus affinis*	Federal - Endangered Minnesota - Watchlist
Slender Naiad	*Najas gracillima*	Minnesota - Special Concern
Spike	*Eurynia dilatata*	Minnesota - Threatened
Swamp White Oak	*Quercus bicolor*	Minnesota - Special Concern
Tall Nutrush	*Scleria triglomerata*	Minnesota - Endangered
Tricolored Bat	*Perimyotis subflavus*	Minnesota - Special Concern
Wartyback	*Quadrula nodulata*	Minnesota - Threatened

Source: MDNR Natural Heritage Information System: Rare Features Database

4.3.3 Fish and Wildlife

The MWMO is a highly developed watershed with limited viable fish and wildlife habitat. The areas within the watershed that do foster fish and wildlife populations are important to preserve, monitor, and enhance. These areas provide economic, aesthetic, and recreational benefits. In addition, natural systems directly impact water quality. Preserving aquatic, riparian, and upland wildlife habitats can increase the overall ecological integrity of the watershed. While most of the upland areas of the MWMO are developed, habitat patches also help preserve remnants of local ecosystems and improve water quality. For example, residents in many neighborhoods have transformed their yards and boulevards to create better habitat for pollinators by installing native plant gardens, bee lawns, and infiltrative stormwater management practices like rain gardens. The following section introduces Mississippi River fish and wildlife.

Fish and Invertebrates

The Mississippi River is the major source of viable fish and wildlife habitat in the watershed. Approximately 123 fish species were historically found downstream of Saint Anthony Falls and 63 above the falls, which served as a natural migration barrier (Eddy et al., 1963). Dam construction, land use changes, and sewage and industrial contamination, led to dramatic fish species declines. By 1926, fish survey data found only two living fish between St. Anthony Falls and Hastings (Weller and Russell, 2016). Periphyton densities generally increased from upstream to downstream, whereas benthic invertebrate densities decreased from upstream to downstream in the upper Mississippi River as urban and agricultural land use became more prevalent. Upstream of the twin cities metropolitan area (TCMA), the Mississippi River contains more diverse habitat including riffles, runs, and pools; the channel then becomes wider, warmer, and deeper with slower velocities and fine-grained substrate. Due to a series of impoundments for navigation within and downstream of the TCMA, the river is more lentic (lake-like). The result is conditions favoring lake species and larger river species that prefer deep-water habitat (ZumBerge et al., 2003). Restoration of boulder and cobble bed substrate, reestablishment of sediment transport via a free-flowing river, and restoration of native plant communities and in-channel features such as islands, sandbars, and mudflats have been identified as strategies to restore the Mississippi River Gorge. Most fish and mussels are blocked from reaching their historic spawning/nesting grounds and the substrate is buried with sediment (Lenhart, 2012). Improvements in wastewater management, particularly following the passage of the Clean Water Act in 1972, have helped fish populations recover. It is estimated that 129 or more species of fish (120 native, nine introduced) inhabit the Mississippi River up to St. Anthony Falls and 86 species above the falls (Weller and Russell, 2016). Within the MWMO watershed, biological monitoring data available from the MPCA Surface Water Data Access tool reflects impaired conditions. For example, Station 13UM001 adjacent to Boom Island Park has 2013 data indicating an index of biological integrity (IBI) rating of 26 (poor) for fish and 31 (fair) for invertebrates; fish species with the highest counts included smallmouth bass, common carp, and black darter (tolerant of pools and still water). Invasive Asian carp are also a growing concern; although not known to be currently reproducing in Minnesota, two silver carp were caught between the Hastings Dam and Dam No 1 in 2014. The health and dispersal ability of the Mississippi River's native fish populations is key to the success of mussel populations, since mussels reproduce by releasing larvae that attach to a host, usually fish. However, removal of fish migration barriers must be coordinated with efforts to prevent the spread of Asian carp (Weller and Russell, 2016).

An estimated 30 native fish species remain in the Mississippi River gorge, which extends from the original mouth of the Minnesota River at Fort Snelling to the upper Saint Anthony Falls Lock and Dam. Konrad Schmidt compiled a list based on literature, stream survey reports, specimens at the James Ford Bell Museum of Natural History, and communication with Minnesota DNR fisheries biologists. A total of 74 species representing 19 families were historically reported in the gorge. This includes 72 native species, two introduced (exotic), one threatened and three special concern species (Schmidt, 2005).

Freshwater mussels are highly sensitive to water quality impairments (e.g. low dissolved oxygen, altered flow regimes, chemical contaminants, and increased siltation) and their populations have fluctuated due to these environmental disturbances in the metro area. Historically, 41 native species of mussels were documented within the MNRRA corridor. However, populations were nearly wiped out in the early 1900s due to pollution, particularly the discharge of untreated waste, and no live species found above Lock and Dam No 1 to just above the St. Anthony Falls (Fuller 1980). Mussel populations have begun to recover due to improvements to sewage treatment, including the separation of storm sewers from sanitary sewers, and other water quality improvement efforts. A 2002 report documented 15 species within Pool 1 (extending from

Dam No 1 upstream to St. Anthony Falls) including the Wartyback (*Quadrula nodulata*), a threatened species in Minnesota described as being fairly common in Pool 1. Mussels were also found to be expanding their range above St. Anthony Falls (historically a dispersal barrier), with 16 species collected in the St. Anthony Falls pool, 10 of which had not been previously reported including the round pigtoe (*Pleurobema sintoxia*), a threatened species in Minnesota (Kelner and Davis, 2002). Upstream of St. Anthony Falls, there are now 18 reported native mussel species (Weller and Russell, 2016). Native mussels are highly sensitive to exotic invasive species invasions such as zebra mussels. Although the invasive zebra mussel was not found within Pool 1, they were noted to likely be present as they had been observed within the lock chambers at St. Anthony Falls (Kelna and Davis, 2002). The entire stretch of the Mississippi River within the watershed is designated by the MN DNR as infested with Eurasian watermilfoil, zebra mussels, or both (MN DNR, 2017). Boaters can play a key role in helping prevent the spread of invasive species. Boat launches, such as at the University of Minnesota launch at East River flats and at Boom Island Park, have zebra mussel exotic species alert signs.

Birds

Migratory, resident, and breeding birds reply upon the diverse habitats provided by the Mississippi River corridor. Millions of migratory birds travel along the Mississippi Flyway during spring and fall migrations; this corridor is used by 40 percent of North America's waterfowl and shorebirds. A total of 298 bird species are known to regularly occur within the Twin Cities metro area, 163 of which are breeders or permanent residents; the others are migrants or winter/summer visitors (Audubon Minnesota, 2012). Protected and managed areas within highly developed areas provide important habitat. For example, a list of observations by Dave Zumeta compiled between May 1998 and July 2020 includes 191 species of birds along the west side of the Mississippi River Gorge, 58 of which are confirmed or likely breeding species (Zumeta, 2020). Many American Bald Eagles also utilize the Mississippi River for nesting and fishing; the metro River has about 55 active nesting sites (Weller and Russell, 2016).

The metro area is recognized as being critical to the conservation of resident and migratory birds. The Audubon designated Mississippi River Twin Cities Important Bird Area (IBA) includes the River and its floodplain forest and upland habitat extending 38 river miles from Minneapolis to Hastings. Given the densely populated and urban nature of the IBA, conserving and managing the remaining native plant communities along the shoreline, wetlands, and adjacent upland areas is key to conservation success. The areas adjacent to the River provide vegetative cover for birds to nest and feed. Recognizing the need for conservation of bird habitat within the metro area, Minneapolis and St. Paul were recognized in July 2011 as members of the Urban Conservation Treaty for Migratory Birds (Urban Bird Treaty Program) developed by the United States Fish and Wildlife Service. Efforts under the treaty include habitat restoration (emphasizing native plants), invasive species management, and development of educational materials to support conservation of birds spending a portion of their lifecycle within the metropolitan area (Audubon Minnesota, 2012).

Mammals

The Mississippi National River and Recreation Area corridor is home to aquatic or semi-aquatic mammals including the American Beaver, River Otter, mink, and muskrat (Lafrancois et al., 2007). Within the MNRRA, natural sign surveys found otter in the corridor after decades of being absent. However, no reliable data or estimates of local river otter abundance or population size currently exist. There are seven species of bats within the MNRRA corridor, including big and little brown, northern myotis, tri-colored, eastern red, hoary, and silver-haired. Bats use natural and manmade caves along the River. While there is no evidence of white-nose syndrome in the corridor yet, it is thought to likely be on its way (National Park Service, 2013).

Amphibians and Reptiles

Lists by The National Park Service Great Lakes Inventory and Monitoring Network as of March 2006 include 14 frog and salamander species (present or probably present), 8 turtle species, and the Northern Water Snake within the MNRRA (Nerodia sipedon sipedon) (Lafrancois et al., 2007). Frog populations are currently low because breeding habitat within the MNRRA corridor is scarce with few wetlands. While toads and chorus frogs are doing fairly well within the corridor, other species such as leopard frogs are declining due to Batrachochytrium dendrobatidis fungus, pollutants and other stressors. Salamanders are also struggling. Turtle populations in MNRRA are stable but at much lower numbers than in pools immediately below the boundary (National Park Service, 2013). Spiny softshell turtles were observed by MWMO staff in June 2020 sunning themselves on logs at the reconstructed Hall's Island.

4.3.4 Discussion of Challenges, Gaps, and Next Steps

As discussed above, natural plant communities and wildlife are scarcer in the terrestrial upland areas of the MWMO, while the Mississippi River corridor is the major source of viable fish and wildlife habitat in the watershed. Yet all these fish and wildlife resources provide economic, ecological, and social benefits for residents living in the watershed. The MWMO can use this information to guide its restoration, land conservation, and multifunctional corridor planning efforts to improve native plant diversity and wildlife habitat.

4.4 Human Environment

4.4.1 Demographics

Population and demographic data can impact the reach and effectiveness of MWMO's projects and programs. To maximize its impact, the MWMO considers such data in its approach to water and natural resource management and the design and implementation of specific projects and programs.

The MWMO is an urban watershed with high population density. **Figure 16** presents population density within the MWMO based on Census Bureau block data from 2014-2018 maintained by the

Metropolitan Council. Population density for census blocks wholly or partially within the MWMO averages approximately 11 people/acre (7,200 people per square mile), but varies widely across the watershed and between neighborhoods (**Figure 16**). The total population of census blocks within the MWMO is approximately 330,000; population is broken down by community in **Table 10**. The Metropolitan Council forecasts population growth within all MWMO cities between 2020 and 2040 (**Table 10**). Increased population within the MWMO may lead to increased high-density redevelopment opportunities and challenges within the watershed. Additional population data is available in the 2040 Comprehensive Plan of each city.

Table 10: Population projections for cities within the MWMO

City	2014-2018 Population[1]	2010 Population[2]	2020-2040 Forecast Population Growth[3]
Columbia Heights	18,154	17,867	12.7%
Fridley	8,312	8,407	10.9%
Hilltop	862	744	29.8%
Lauderdale	350	344	18.5%
Minneapolis	250,997	226,050	11.2%
Saint Anthony Village	3,747	3,464	2.0%
Saint Paul	740	969	9.2%
Totals	283,162	257,844	--

(1) Based on 2014-2018 US Census Block Group and the percent area within MWMO (this does not distinguish between residential and non-residential areas).
(2) Based on 2010 US Census Block Group and the percent area within MWMO (this does not distinguish between residential and non-residential areas).
(3) Based on Metropolitan Council Thrive 2040 forecasts (this does not distinguish between areas within or outside the MWMO).

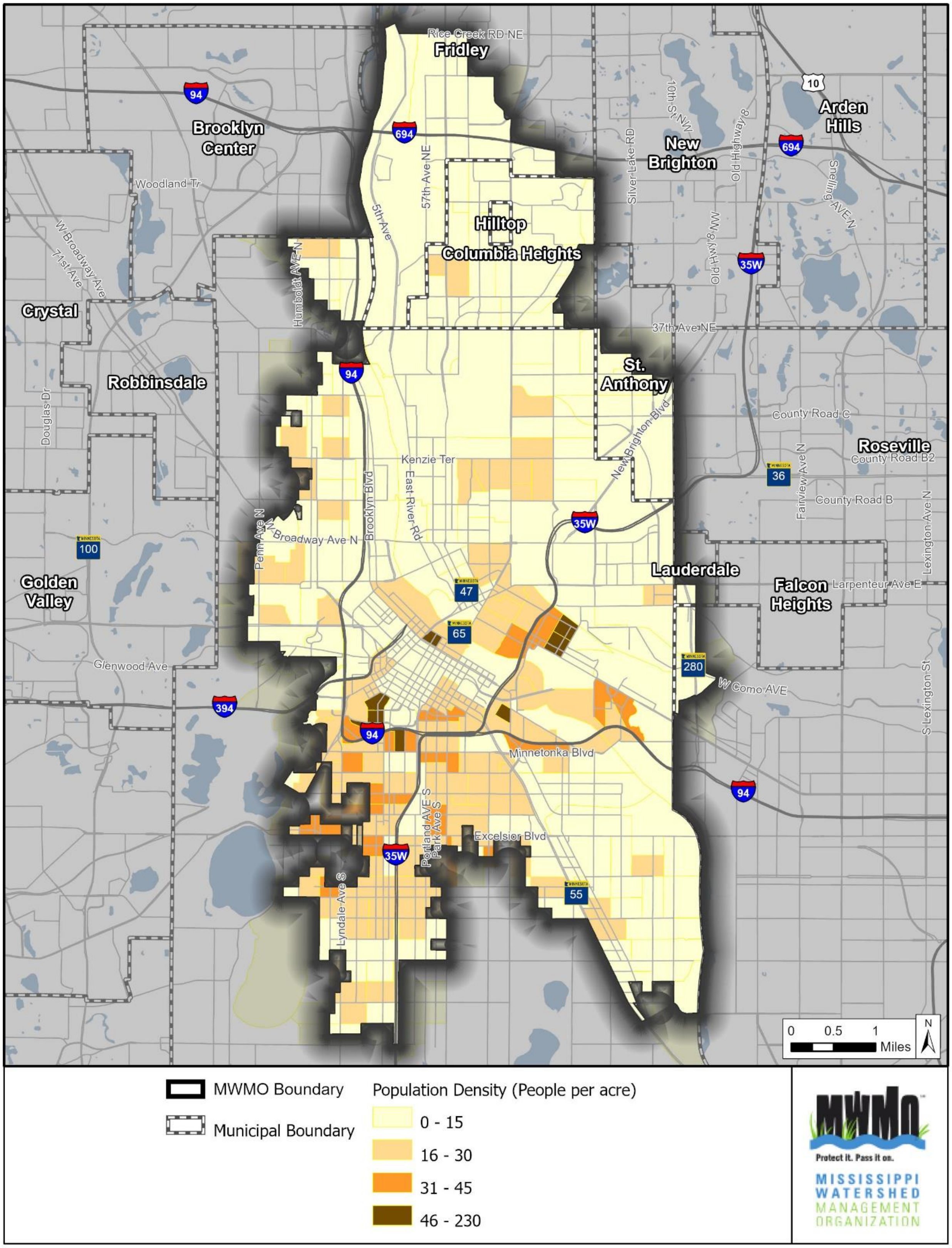


Figure 16: Population density in the MWMO

The communities within the MWMO are diverse in many ways. MWMO understands that recognizing this diversity is key to engaging populations of residents with differing values and ideas about water and natural resources, and varying capacity for action. For example, the MWMO and the City of Minneapolis Department of Public Works developed with Katherine Barton the *Hmong Water Research Project (Kev Cob Qhia Zej Tsoom Hmoob Txog Dej): Assessing Attitudes, Perception and Behavior about Water in Minnesota's Hmong Community* (Barton, 2007). The *Hmong Water Research Project* takes an important look at the Hmong community to learn and understand how the community communicates and receives information, its knowledge, behavior, and attitudes about water issues, and its worldview and cultural context. The Hmong community served as a pilot group for this thorough cultural analysis with respect to water resources management. The information in the report informs the design and implementation of focused stewardship campaigns about water. The MWMO and its partners may repeat and adapt this approach for other communities in the MWMO.

Over time, the MWMO's population has grown more racially and ethnically diverse. Over 40% of residents within the MWMO are non-white (2014-2018 Census Block data). Minneapolis has the largest urban population of Native Americans in the United States. Recent increases in diversity are due to new residents from Mexico, Latin America, and Asia, as well as African countries like Somalia and Ethiopia (Minneapolis has the largest Somali population of any city in the United States). Many of these new residents are children and working-age adults. In fact, the city boasts that over 90 languages are spoken in its households. While Minneapolis was once a major source of diversity in the MWMO, such diversity is now observed across most MWMO cities (**Table 11**).

Table 11: Race and ethnicity within the MWMO

Race or Ethnicity (percent of population identifying as)[1]									
	Person of Color	**Hispanic**	**Black**	**American Indian**	**Asian**	**White**	**Pacific Islander**	**Other**	**Multi-racial**
Totals	44.9%	10.4%	21.8%	1.3%	7.0%	55.1%	0.0%	0.2%	4.1%
Columbia Heights	40.0%	10.8%	17.2%	0.8%	6.0%	60.0%	0.1%	0.9%	4.2%
Fridley	42.0%	10.4%	20.3%	1.0%	7.5%	58.0%	0.0%	0.1%	2.7%
Hilltop	68.6%	45.1%	10.1%	2.7%	2.6%	31.4%	0.0%	0.0%	8.1%
Lauderdale	48.6%	2.4%	17.2%	2.6%	23.7%	51.4%	0.0%	1.4%	1.5%
Minneapolis	45.8%	10.4%	22.6%	1.4%	7.1%	54.2%	0.0%	0.2%	4.1%
Saint Anthony Village	14.5%	4.9%	1.4%	2.2%	2.1%	85.5%	0.0%	0.2%	3.7%
Saint Paul	15.6%	2.3%	0.8%	0.0%	10.8%	84.4%	0.0%	0.4%	1.3%
(1) Based on 2014-2018 Census Block data and percent area within MWMO.									

Beyond race and ethnicity, demographic factors such as age, education level, and language can impact a community's interest and ability to engage in water and natural resources stewardship actions. **Table 12** and **Table 13** present breakdowns of age and education level within the MWMO, respectively. In addition, income disparity and economic stress can be a significant barrier by limiting one's financial ability to implement practices, time available to become aware of and participate in stewardship practices or MWMO programs, and property ownership that is often critical for siting BMPs.

Table 12: Age groups for cities within the MWMO

Percent of population in MWMO[1]				
	Under 18 years	**18-39 years**	**40-64 years**	**Over 65 years**
Totals	18.9%	46.8%	24.8%	9.5%
Columbia Heights	21.5%	32.2%	31.0%	15.3%
Fridley	20.4%	37.3%	29.0%	13.3%
Hilltop	28.2%	34.1%	30.6%	7.1%
Lauderdale	16.2%	59.5%	15.8%	8.5%
Minneapolis	18.6%	48.6%	24.0%	8.8%
Saint Anthony Village	23.0%	22.3%	32.1%	22.5%
Saint Paul	20.7%	36.5%	27.0%	15.9%
(1) Based on 2014-2018 Census Block data and percent area within MWMO.				

Table 13: Highest education level achieved for cities within the MWMO

Race or Ethnicity (percent of population identifying as)[1]						
	Less than High School	**High School**	**Some College**	**Associate's Degree**	**Bachelor's Degree**	**Graduate Degree**
Totals	13.5%	18.8%	18.8%	7.1%	25.4%	16.4%
Columbia Heights	11.2%	32.1%	21.6%	11.3%	16.8%	6.9%
Fridley	11.4%	32.0%	20.1%	10.1%	18.8%	7.6%
Hilltop	27.9%	40.9%	17.6%	4.0%	8.7%	0.9%
Lauderdale	6.0%	9.2%	9.8%	4.5%	34.8%	35.8%
Minneapolis	13.9%	17.4%	18.5%	6.7%	26.2%	17.3%
Saint Anthony Village	3.9%	17.6%	21.2%	6.7%	28.5%	22.1%
Saint Paul	4.4%	12.9%	15.3%	2.4%	33.4%	31.7%
(1) Based on 2014-2018 Census Block data and percent area within MWMO.						

The Metropolitan Council has identified Areas of Concentrated Poverty (ACP) – census tracts where at least 40% of the residents live below 185% of the federal poverty guideline – as well as areas of concentrated affluence (ACA) (**Figure 17**). The Metropolitan Council has further identified areas where this income disparity disproportionately impacts communities of color (i.e., greater than 50% of residents are people of color) (**Figure 17**). The Metropolitan Council maintains additional datasets that provide more information about the root causes of concentrated poverty and income inequality. The Minneapolis 2040 Comprehensive Plan also contains detailed information about income disparity and economic stress within the city. The datasets contain more information about housing and transportation to identify more specific needs of neighborhoods. The MWMO considers these datasets to promote the equitable delivery of programs and projects across the watershed. Additional context about the ACP and ACP50 datasets is available from the Metropolitan Council at: https://storymaps.arcgis.com/stories/e61c8e0e54e24485b956601fdc80b63e

Understanding the diverse nature of the population within the watershed will help MWMO staff design, target, and implement relevant infrastructure projects, information, and stewardship campaigns for its different populations, and promote equitable distribution of services across all communities.

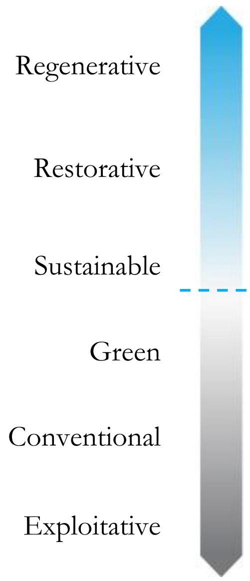
In an effort to improve equity within the watershed the MWMO is continuing an initiative started 2016 to study how restorative development design could lead to more equitable social, environmental, and economic outcomes within the watershed. The premise of a restorative approach is to assure that infrastructure supporting redevelopment sites is designed in a manner that it contributes to a net positive social, environmental, and economic outcome for the community it is in. This a part of a larger systems-based strategy where cities start to manage their waste streams as material inputs for other goods and services in the city.

Restorative development magnifies the benefits of green infrastructure work the MWMO is doing by tying improvements in air, water and soils to social needs related to food, housing, jobs and energy. In 2019, a Restorative Development Partnership was established to begin a Minneapolis wide feasibility study that will assess the viability of piloting a restorative development concept in Minneapolis.

The scale depicted below illustrates the shift that will need to occur in urban redevelopment to support climate change and equity goals sought within the watershed. As a member of the Restorative Development Partnership, the MWMO is learning how to model, measure, and track equity gained or lost from proposed developments and the infrastructure supporting them.

As shown below, the midpoint on the restorative development scale is the zero point, above which a development effort yields net positive equity, and below which it has net negative equity. The levels on the restorative development scale are: Regenerative, restorative, sustainable, green, conventional, and exploitative.

Table 14: Shift in Urban Redevelopment Scale Needed to Address Climate Change and Equity Goals



+ Positive
Restorative performance is a net-positive position. There are measurable positive impacts at the system level. Equity is <u>gained</u> at this performance level.

0 Neutral
Sustainability is a neutral position. There are no negative or positive impacts measurable anywhere in the system. Equity is neither gained nor lost at this performance level.

- Negative
Conventional performance is a net-negative position where impact is negative. Equity is <u>lost</u> at this performance level.

Source: Yorth Group 2020: Benchmarking Sustainability

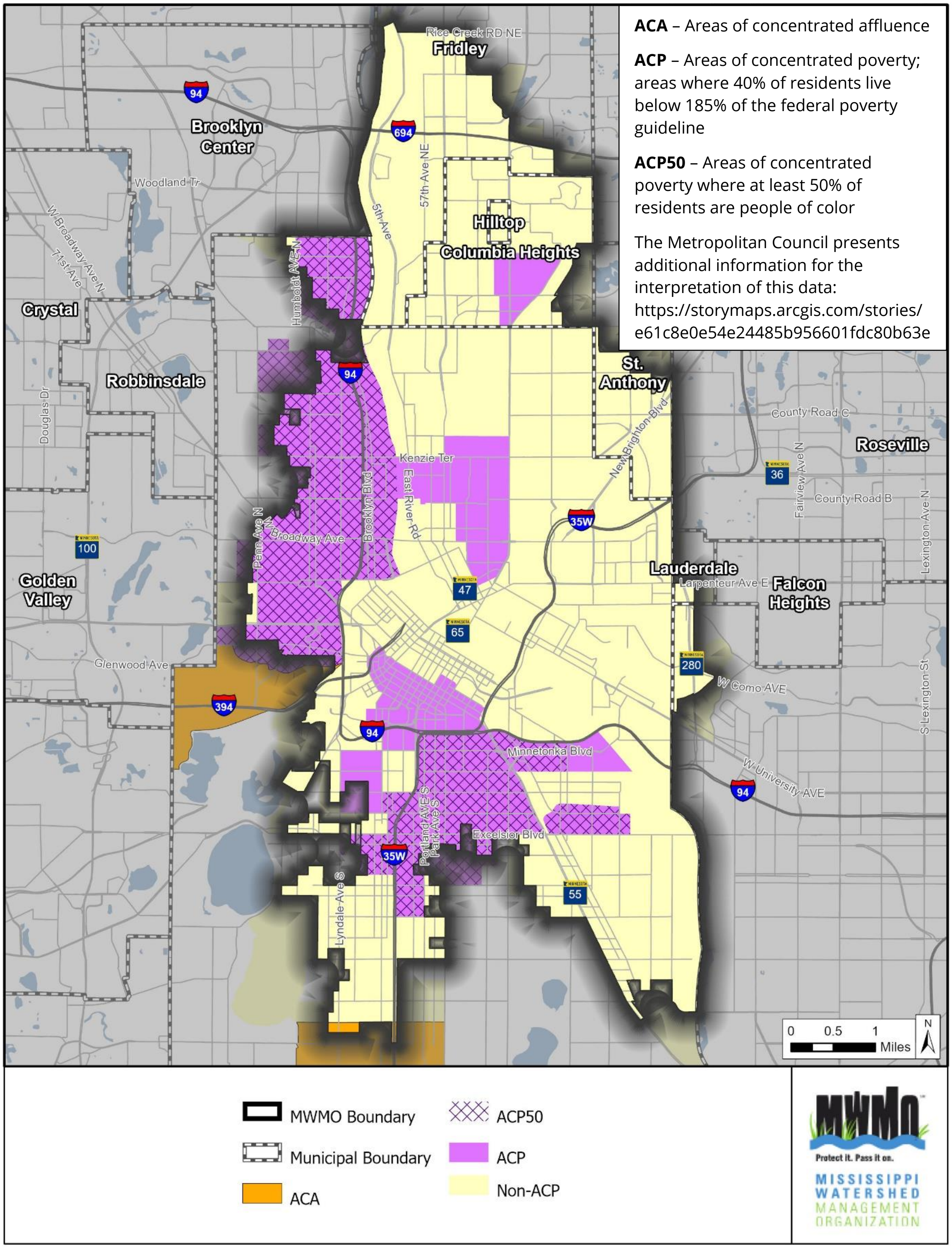


Figure 17: Areas of Concentrated Poverty and Affluence in the MWMO

Current population and population trends inform the direction of MWMO's natural resource management toward any use or combination of the following: preservation, protection, restoration, recreation, or acquisition. Population density in the MWMO in the year 2010 census is found in **Figure 18**. Each of the neighborhoods within the MWMO is identified in **Figure 19**. The population of the watershed based on the 2010 census is estimated at 257,844 people (**Table 15**). The Metropolitan Council has shown notable population growth in the Urban Center and Suburban Edge communities (Metropolitan Council, 2018). The Twin Cities Regional Forecast to 2040 (2019 update) indicates continued expected growth as well as major demographic shifts, towards a population that is more racially and ethnically diverse, older, and more likely to live alone or in larger households that may include extended family and multigenerational living arrangements (Metropolitan Council, 2019). Based on Metropolitan Council demographic forecasts as of May 28, 2014, it is projected that the overall population of cities within the MWMO will increase by 2040. The anticipated population growth indicates that higher density redevelopment within the already urbanized watershed is likely to occur.

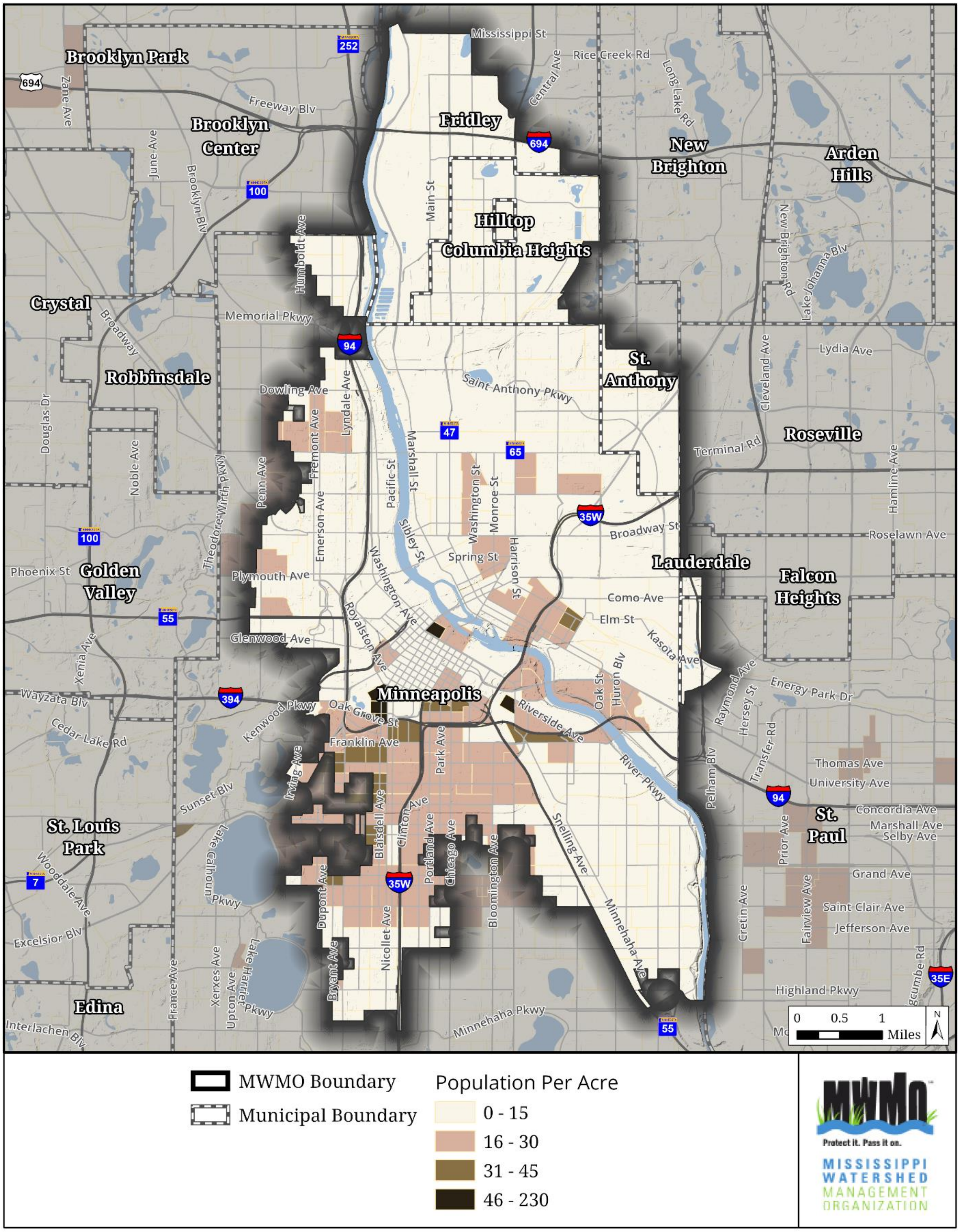


Figure 18: Population Density of the MWMO Based on the 2010 Census

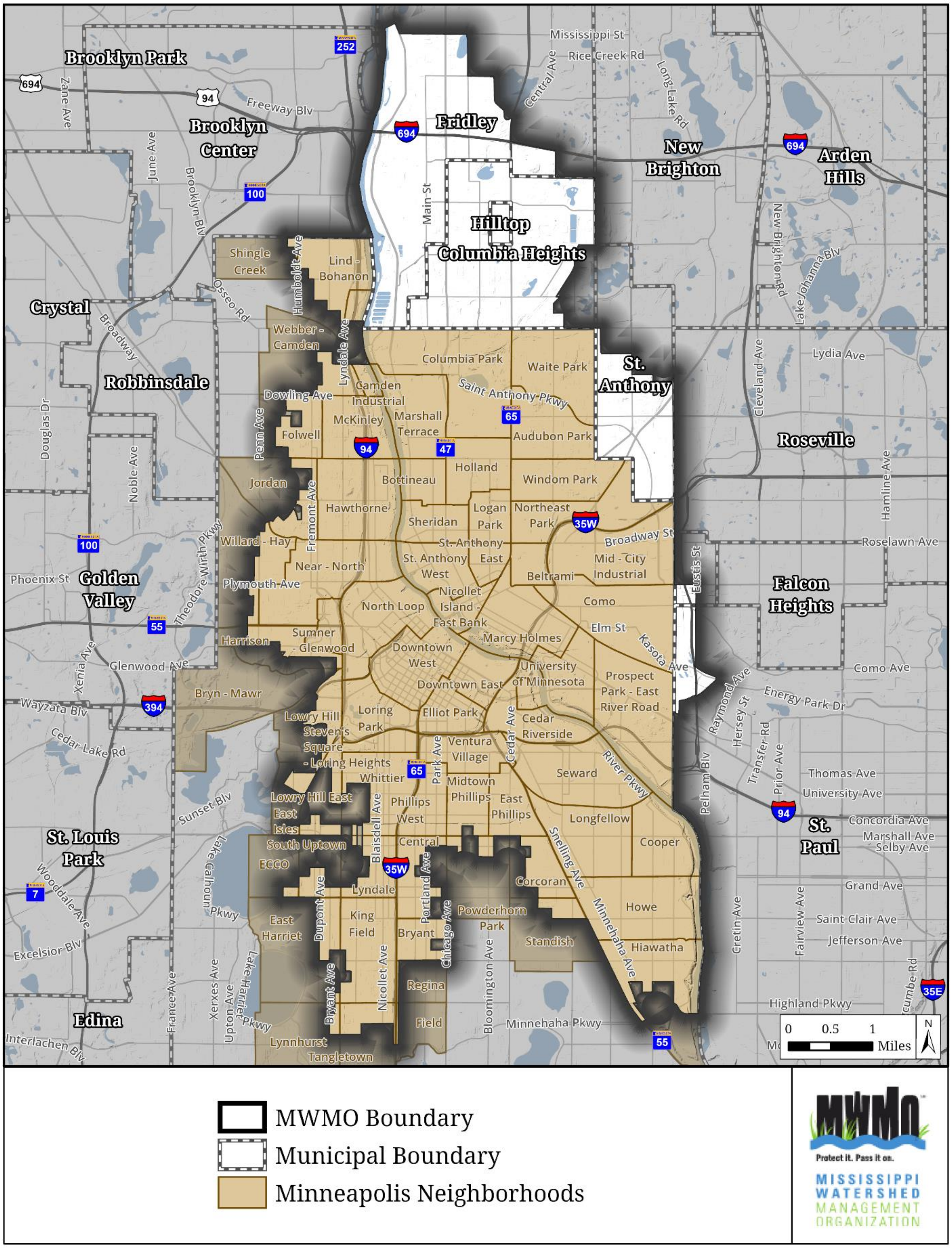


Figure 19: Minneapolis Neighborhoods in the MWMO

Table 15: Population Projections for Cities within the MWMO

City	2010 Population*	2019 Forecast**	2040 Forecast**
Columbia Heights	17,867	19,496	21,700
Fridley	8,407	27,208	29,400
Hilltop	744	744	1,100
Minneapolis	226,050	382,578	466,400
Saint Anthony Village	3,464	3,070	4,300
Saint Paul	969	285,068	334,700
Lauderdale	344	2,379	2,400
Totals:	**257,844**	**720,543**	**860,000**

Source: (Metropolitan Council Thrive MSP 2040 Forecasts, Metropolitan Council, 2014)

*Based on 2010 US Census Block Group. For the portion of the city that is within the MWMO.

** With the exception of Saint Anthony Village, Population forecasts are for the full city as estimated by Metropolitan Council, (2014) rather than the portion of the city's population that is within the MWMO. Population estimates do not differentiate among residential and non-residential areas.

The City of Minneapolis is a source of significant diversity within the MWMO. **Table 16** summarizes the estimated population within the City for seven major categories of race. In 1950, only 1.6% of the City was non-white; by 2006, the City was 36% non-white. Minneapolis has the largest urban population of Native Americans in the United States. Recent increases in diversity are due to new residents from Mexico, Latin America, and Asia, as well as African countries like Somalia and Ethiopia. Many of these new residents are children and working-age adults. In fact, the city boasts that over 90 languages are spoken in its households.

Table 16: Minneapolis 2006 Population by Race

Race	Estimated % of Total Population
White	64 %
Black or African American	18 %
Hispanic or Latino (of any race)	9 %
Asian and Native Hawaiian	5 %
Two or more races	3 %
American Indian and Alaska Native	1 %
Some other race	0 %
Total	**100%**

4.4.2 Historical Land Use

Understanding the effects of human settlement on MWMO resources is important for understanding water quality trends and guiding water resource management. The historic landscape of the MWMO consisted of a mosaic of streams, lakes, wetlands, and plant community types as a result of areas of shallow groundwater flow, soil characteristics, hydrology, and varying sun exposure. Dramatic springs and waterfalls were common.

Urbanization of the region resulted in filled, buried, drained, dammed, or otherwise altered water resources. In order to make way for development, surface waters were confined into a series of pipes and tunnels to convey streams, wetlands, and stormwater into the Mississippi River. Early planning led to some river corridor areas being left undeveloped. For example, Landscape Designer H.W.S. Cleveland created a vision in 1883 for a network of roads and parks linked to drives along both sides of the Mississippi River and presented this plan to the cities of Saint Paul and Minneapolis. Footpaths, such as the Winchell Trail on the west bank of the River between Franklin Avenue and 44th Street allow visitors close access to the River and undeveloped park space. However, the few areas that have not been developed along the River are often overgrown with invasive species like European buckthorn and have been altered by historic logging, aggregate and bedrock mining, and manmade access points. Fire sensitive maples, elms, and basswood were able to establish along the River (Brewer 1998). Despite these impacts, areas such as the Mississippi Gorge Regional Park (extending south of Bridge No. 9 to the north edge of Minnehaha Regional Park) help retain a semi-wild character along the River and showcase hardwood forests and prairie on steep limestone bluffs with bottomlands. The only true gorge along the Mississippi River, it was formed as St. Anthony Falls migrated slowly upriver and eroded a steep channel. Sections of the Mississippi Gorge Regional Park, such as the "Oak Savanna," containing remnant prairie at 36th Street and West River Parkway, have been carefully maintained and managed by MPRB staff, partnering organizations, and local volunteer groups.

The banks and bed of the Mississippi River were altered over time by filling and dredging activities. Subwatersheds in the region that were previously defined by topography are now defined by extensive underground stormwater tunnel and pipe networks. Historic subwatersheds, as identified in the *Historic Waters of the MWMO* report (MWMO, 2011), are shown in **Figure 20**. In the *Historic Waters of the MWMO* report *(*MWMO, 2011), these historic subwatersheds were aggregated into six Historic Planning Areas based on hydrologic association (also in **Figure 20**). Each Historic Planning Area is described by landscape, historic water features, pre-settlement vegetation, and major landscape alterations. In some instances, the historic hydrology of the watershed still affects land use today. With the addition of portions of three new cities to the MWMO, two additional planning areas have been added (see **Figure 20**).

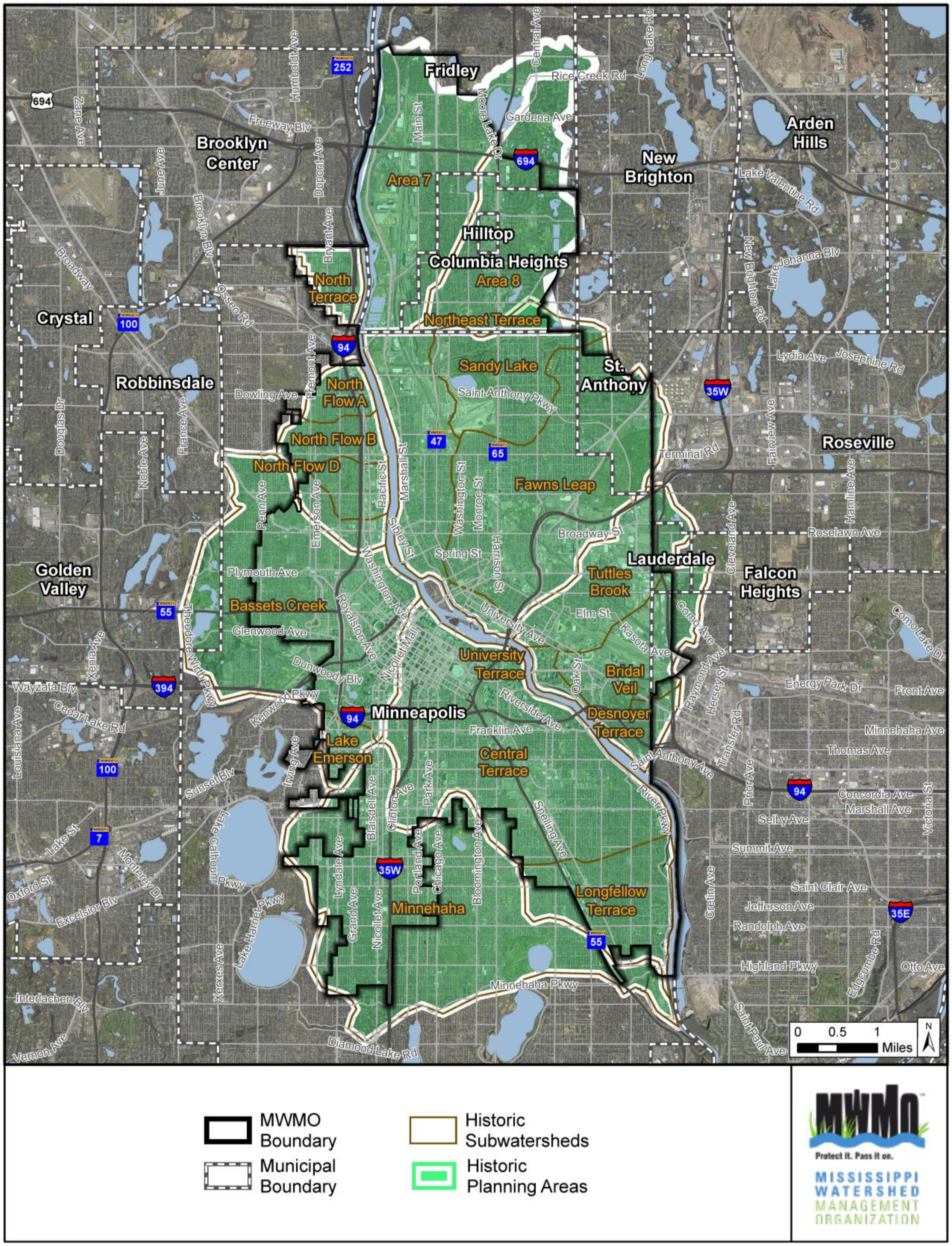


Figure 20: Historic Subwatersheds and Planning Areas of the MWMO

4.4.3 Present Land Use

The watershed is entirely developed and contains the central business district of Minneapolis (**Figure 21**). The dominant land use is single family residential, covering approximately 39.5% of the watershed. Commercial and multi-family land uses are concentrated near downtown Minneapolis and along major roadways. Industrial land uses are generally located along major transportation routes: roadways, railways, and along the Mississippi River. Parks are distributed throughout the watershed and range in size from small neighborhood parks to large regional parks located along the Mississippi River. **Table 17** summarizes acreage of the various land uses found in the watershed. The entire watershed is within the Metropolitan Urban Service Area. The Metropolitan Urban Service Area is the area in which the Metropolitan Council ensures that regional services and facilities, such as sewers and major highways, are planned and provided.

Table 17: Present Land Use of the MWMO

Land Use	Acres	% Watershed Area
Agricultural	17.6	0.1%
Golf Course	360.0	1.4%
Industrial and Utility	3,165.4	12.4%
Institutional	2,127.6	8.3%
Major Highway	1,311.2	5.1%
Major Railway	760.9	3.0%
Manufactured Housing Parks	39.4	0.2%
Mixed Use Commercial	177.6	0.7%
Mixed Use Industrial	293.5	1.1%
Mixed Use Residential	255.2	1.0%
Multifamily	1,674.4	6.6%
Office	530.2	2.1%
Open Water	879.2	3.4%
Park, Recreational, or Preserve	1,567.5	6.1%
Retail or Other Commercial	1,498.4	5.9%
Seasonal/Vacation	0.0	0.0%
Single Family Attached	1,880.6	7.4%
Single Family Detached	8,180.4	32.0%
Undeveloped	823.9	3.2%

Land Use	Acres	% Watershed Area
Totals	**25,543.2**	**100%**

Source: Metropolitan Council, Generalized Land Use Data

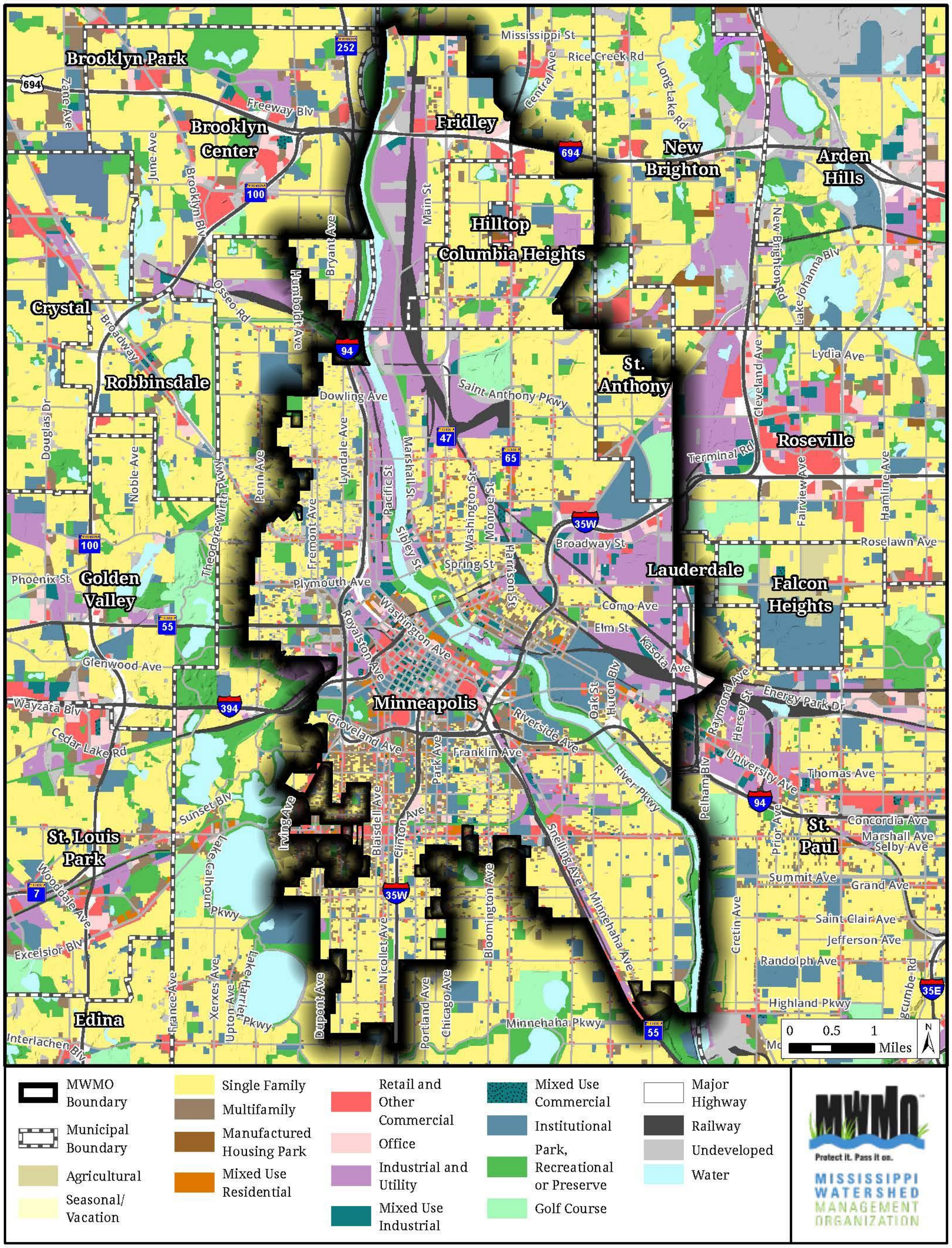


Figure 21: Present Land Use of the MWMO

4.4.4 2040 Land Use

Based on the cities' 2040 land use plans, a few major changes in land use are expected in the watershed. These include some large areas of redevelopment due to closure of Upper Saint Anthony Falls Lock, under developed areas within the watershed transitioning from warehouse to multistory and a significant shift of single-family housing to multifamily. **Table 18** summarizes acreage of the various land use forecast for the year 2040. Future land use as reported by Metropolitan Council is shown in **Figure 22**.

Table 18: Future Land Use of the MWMO

Land Use	Acres	% Watershed Area
Commercial	330.9	1.3%
Industrial	2,388.4	9.4%
Institutional	1,747.5	6.8%
Mixed Use	490.2	1.9%
Multi-Optional Development	5,921.7	23.2%
Multifamily Residential	1,895.2	7.4%
Open Water	887.2	3.5%
Parks and Recreation	2,127.7	8.3%
Railway (including Light Rail Transit)	728.6	2.9%
Rights-of-Way (i.e. Roads)	1,205.6	4.7%
Single Family Residential	7,820.2	30.6%
Totals	**25,543.2**	**100%**

Source: Metropolitan Council Regional Planned Land Use

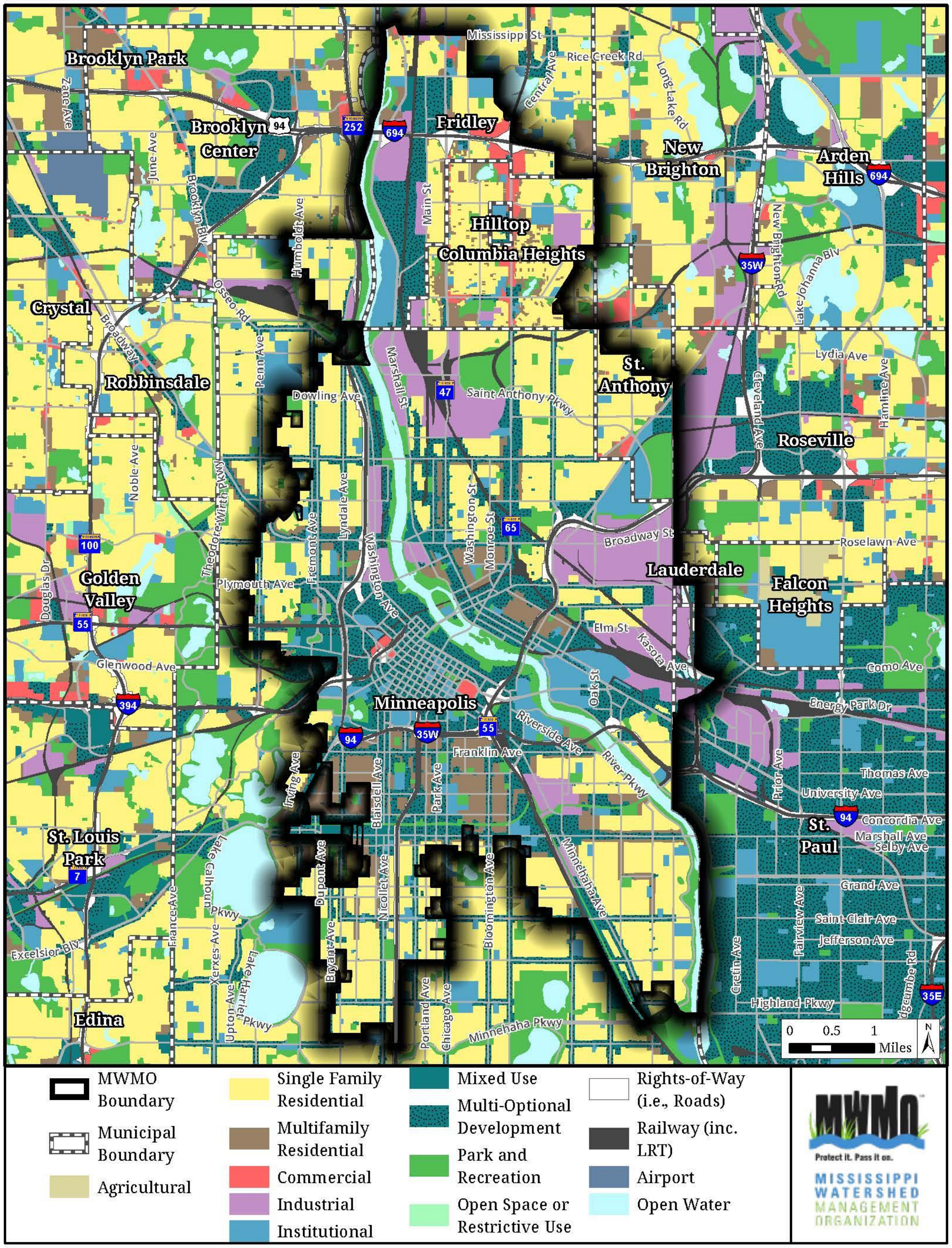


Figure 22: 2040 Future Land Use of the MWMO

4.4.5 Redevelopment Opportunities

During recent local water planning processes, the MWMO worked with its member cities to identify locations where significant shifts in the future land use is being shown. These areas of redevelopment over the next 10 years are opportunities for the cities to collaborate with the MWMO on district or regional stormwater systems, corridor planning, environmentally sensitive development techniques, or communication and outreach activities. The MWMO is willing to be a part of the early on planning and design stages of these redevelopment areas. Assisting the cities or developers with setting a green infrastructure framework for the development that will benefit both the public and private sector.

To prioritize and track these projects internally the MWMO is developing a watershed planning tool that we can utilize in house to identify where layered social, environmental, and economic benefits intersect. This will help us prioritize areas in the watershed where we will prefer to work on projects when redevelopment opportunities arise. All upcoming project areas are discussed with member cities during annual project check-ins. They also come to our attention as we work with staff and Board members from our member organizations on other planning and other project initiatives. Keeping in touch with the planning and economic development departments of member cities as well other neighborhood level organizations set up to track development is another great source of information. Regardless of the source, our goal is to meet with the landowner as soon as land is purchased or a landowner signals they are considering initial plans for redevelopment. For a current list of MWMO's capital projects see **Section 6.1 Capital Improvement Schedule**.

4.4.6 Surface and Groundwater Appropriations

Minnesota Department of Natural Resources Division of Ecological and Water Resources (EWR) regulates surface and groundwater appropriations based on daily and yearly withdrawal volumes. This management affects water supply for domestic, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes. A permit through the Water Appropriation Permit Program is required for all users withdrawing more than 10,000 gallons per day or 1 million gallons per year for consumptive or nonconsumptive use. A consumptive use is characterized by withdrawal of water that is not directly returned to its original source. All groundwater withdrawals are consumptive unless the water is returned directly to the aquifer from which it came. If surface water withdrawals are not directly returned to the source such that it is available for immediate further use, it is also considered consumptive. Currently there is not permitting in place for appropriations that draw less than 10,000 gallons per day or 1 million gallons per year.

Permit exemptions apply to certain domestic users, test pumping, water reuse from a permitted municipal source, and certain agricultural drainage systems. Permit exemptions may also apply to the demand from hydro-facilities. In certain cases where a hydro-facility does not take the water from its natural setting and the use is non-consumptive, the hydro-facility does not need an appropriation permit. As a result, these appropriations would not be on record with the

Minnesota Department of Natural Resources. Minnesota law also requires the Department of Natural Resources to limit appropriations during low flow conditions for the benefit of high priority downstream water users.

Figure 23 shows the locations and water source of the surface and groundwater appropriations within the MWMO. All the five main water use categories are currently found within the MWMO: power generation, industrial processing, public supply, irrigation, and additional uses categorized as *other*. *Other* appropriations include water withdrawn for air conditioning, water level maintenance, pollution confinement, or construction dewatering. A general permit authorizing temporary water appropriations might also include dust control, landscaping, and hydrostatic testing of pipelines, tanks, and wastewater ponds.

Three power generation appropriations are within the MWMO. Power generation appropriations typically withdraw surface water sources for cooling water resulting in non-consumptive use. Industrial processing is a water use category typically applicable to mining activities, paper mill operations, and food processing. Usually, withdrawals are from surface water sources. Many of the industrial processing appropriations are located along the Mississippi River as are public supply appropriations. Irrigation water can be withdrawn from either surface water or groundwater sources and is almost always a consumptive use. The other water use categories currently found in the MWMO include air conditioning, water level maintenance, and pollution confinement. Other withdrawals found in downtown Minneapolis are mostly for air conditioning. Other withdrawals in industrial areas are primarily for pollution confinement.

4.4.7 Open Space and Recreational Systems

Recreation is promoted by the MWMO through public involvement in land and water resource stewardship. Water-based recreation is an especially important part of the Minnesota lifestyle. The MWMO manages water quality to improve water-based recreation experiences and discourage water-based recreation that degrades water quality and surrounding habitat.

Multiple government entities and planning efforts have conducted open space, park, and recreational area mapping including the following: City Local Surface Water Management Plans and Comprehensive Plans, the Minneapolis Park and Recreation Board and its Comprehensive Plan, the National Park Service, Hennepin County, the State of Minnesota, and the Minnesota Department of Transportation. To the extent that mapping is available in report-size scale and format, **Figure 24** through **Figure 39** identify the open space, park, and recreational areas in the MWMO.

City parks, National Recreation Areas, State and County bicycle trails, and City greenways are just a few of the many open space and recreational offerings in the MWMO. In general, parks and open space in the MWMO are either associated with the Mississippi River corridor or are designated parcels within residential neighborhoods that serve as community centers with sports fields and play equipment.

The extensive network of parks in this highly urbanized watershed, specifically in Minneapolis, is the creation and activity of the Minneapolis Park and Recreation Board (MPRB). Established by an act of the Minnesota State Legislation and a vote of Minneapolis residents in 1883, it is an independently-elected, semi-autonomous body that governs, maintains, and develops the Minneapolis park system. The MPRB develops master plans to set a vision for long-term development and improvements of its parks or groups of parks, guide stewardship, ensure financial and ecological sustainability, and engage stakeholders. For example, MPRB worked with multiple stakeholders to develop a plan for the Mississippi River above Saint Anthony Falls in a report called *Above The Falls: A Master Plan for the Upper River in Minneapolis* (BRW et al., 1999). This plan was updated in 2013 (City of Minneapolis, 2013). The updated plan details a new implementation strategy to achieve the original vision for establishing a regional park along both sides of the Mississippi River all the way the City of Minneapolis' northern limits and supporting compatible new development in the northern part of the City. The plan incorporates the Minneapolis Park and Recreation Board's RiverFirst Vision for the development of parks and trails within the Above the Falls Regional Park (Tom Leader Studio et al., 2011).

Efforts were focused in North and Northeast Minneapolis for many reasons, including the increasing conflict between heavy industry and the adjacent neighborhoods striving to provide environmental quality that attracts new investment, and the fact that the Upper River is the best potential large-scale amenity awaiting development in the City of Minneapolis (and the MWMO).

The Upper River Master Plan ultimately seeks to provide the following:

- 98.6 acres of new park
- 3.9 miles of bike and pedestrian trails
- 3.4 miles of restored riverbank
- 2 miles of parkway and boulevard
- Over 1,000 housing units in new riverfront neighborhoods
- Over 3,000 net additional jobs
- Over $10 million in additional annual tax revenue

Since the original plan was written, most of the Phase I priorities have been completed:

- Upper River Development Corporation: The Minneapolis Riverfront Partnership was formed and is generally tasked with plan implementation
- Grain Belt redevelopment: located in the Sheridan Neighborhood of Northeast Minneapolis and includes the Grainbelt Brewery Complex and a varied mix of land uses such as commercial services, residential uses, arts related uses (e.g. galleries and studios), and improvements at a public riverfront attraction, Sheridan Memorial Park
- Trails along both banks of the river between Plymouth Avenue and the Burlington Northern Bridge
- West River Road North trail extension to 26th Avenue North: provides an important link from North Minneapolis to the riverfront, and specifically to the West River Road connection to Downtown

- Development projects, e.g. Standard Heating and Air Conditioning and Stremel Manufacturing (acquired by Chandler Industries), in the North Washington Industrial Park located along Washington Avenue in the warehouse district

The MPRB has undergone many additional planning efforts in addition to the Upper River Master Plan. The MPRB also developed a Park Master Plan for the Central Mississippi Riverfront Regional Park, which includes 350 acres of riverfront along the River and runs through the historic Mill District and the Downtown Minneapolis core (MPRB, 2016a). Beyond Park Master Plans, the MPRB also develops Service Area Master Plans, such as for East of the River, encompassing the Northeast/Southeast service area (MPRB, 2019a), North, covering parks north of I-394 and west of the Mississippi River (MPRB, 2019c), South, including parks south of downtown and east of I-35W (MPRB, 2016b), Downtown (MPRB, 2017), and Southwest (covering parks south of I-394 and west of I-35W). The MPRB also develops system-wide plans such as an Ecological System Plan, which was written in conjunction with the MWMO and addresses how MPRB approaches the quality, improvement, and continued protection of water, air, land and life within the Minneapolis park system (MPRB, 2020).

Recreational opportunities within the watershed include activities like boating, fishing, hiking, and biking, among others. There are four public sites to access the Mississippi River in the MWMO:

- Mississippi River Boat Ramp / Camden Boat Ramp: located on the west side of the River on Soo Avenue North in North Minneapolis (immediately west of the MWMO's boundary in the Shingle Creek watershed).
- Boom Island Park: boat dock on the east side of the River.
- Mississippi River Access, University of Minnesota: launch near the boathouse at the east end of the MPRB's East River Flats Park near the Irene Claudia Kroll boathouse. Signage indicates that this is an emergency boat launch only.
- Anoka County Riverfront Regional Park: boat launch with parking area located immediately south of Interstate 694.

There is an extensive network of bike trails through the watershed, including the Mississippi River Regional Trail in Anoka County and the Grand Rounds Scenic Byway, which nearly circumscribes the City of Minneapolis.

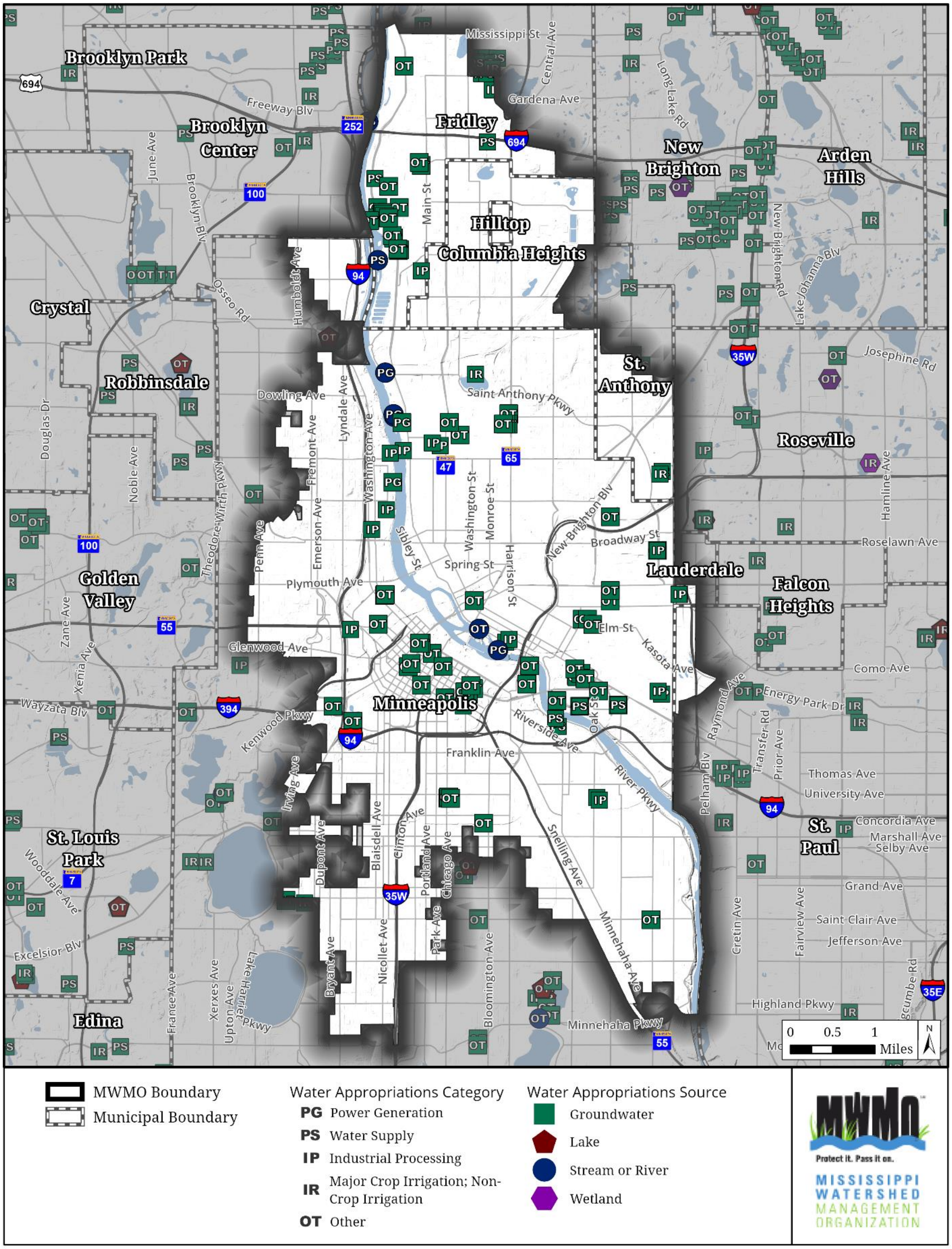


Figure 23: Surface and Ground Water Appropriations in the MWMO

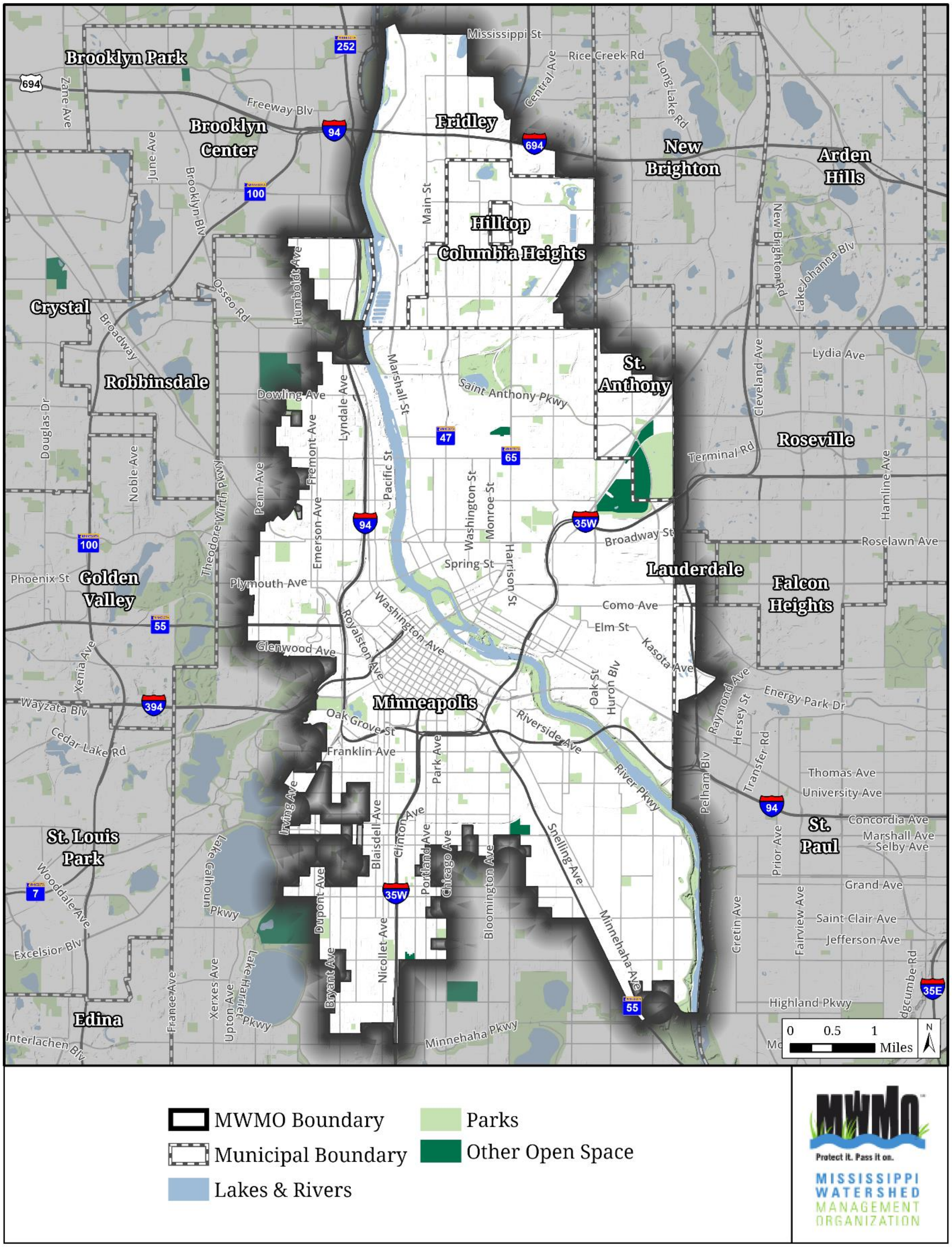


Figure 24: Parks and Open Space

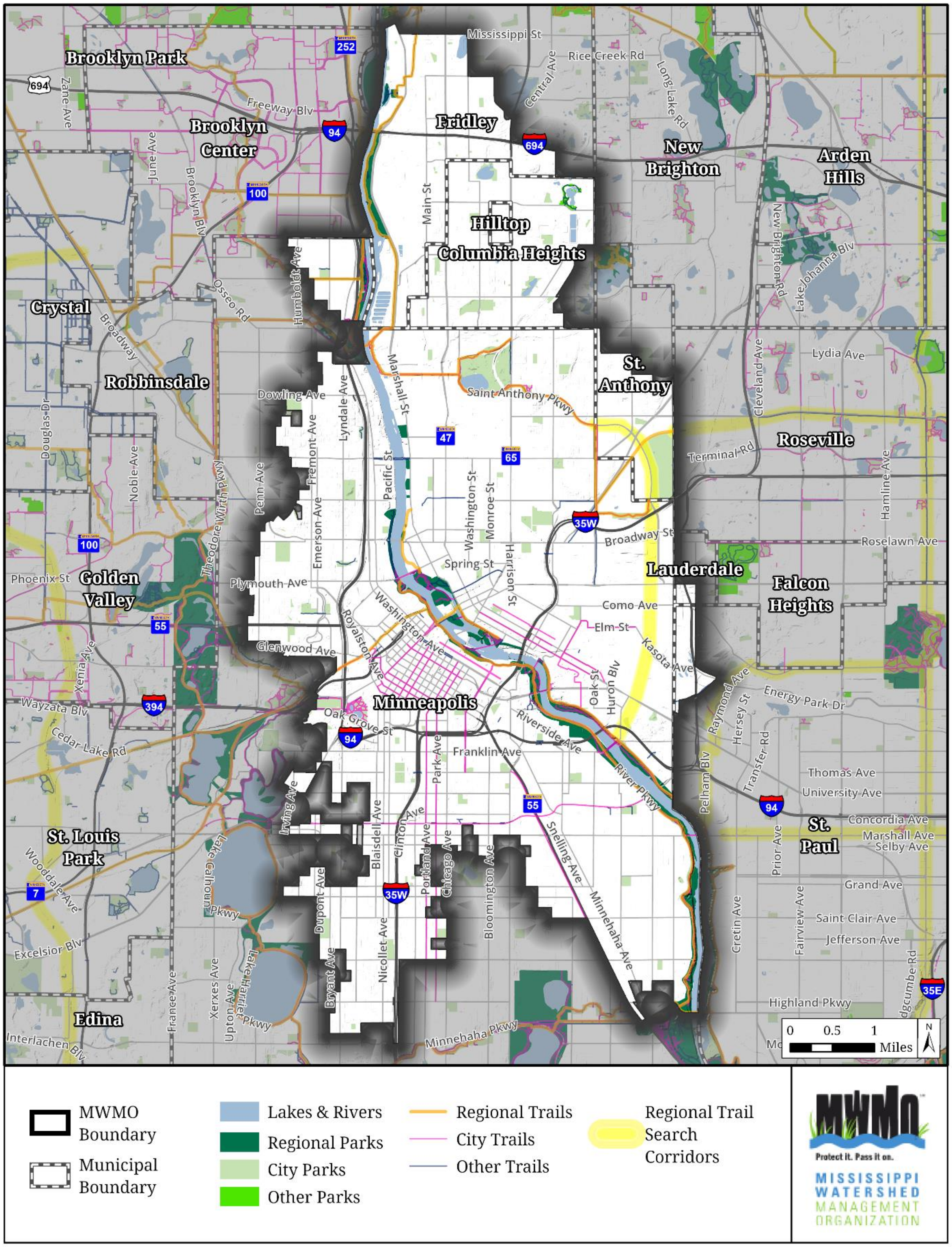


Figure 25: Regional Parks and Trails

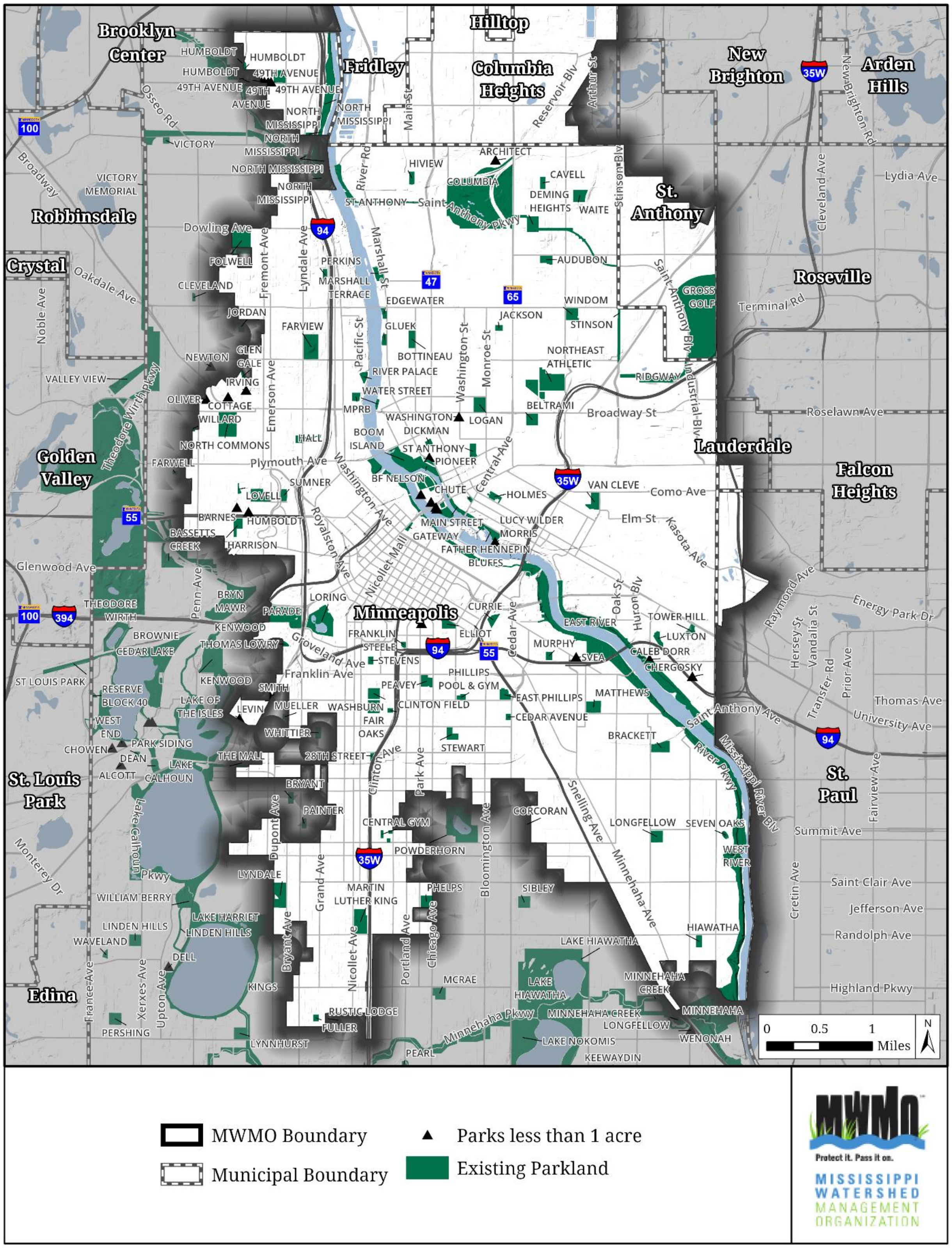


Figure 26: Existing Minneapolis Park System Map from Minneapolis Park and Recreation Board Comprehensive Plan (MPRB, 2015)

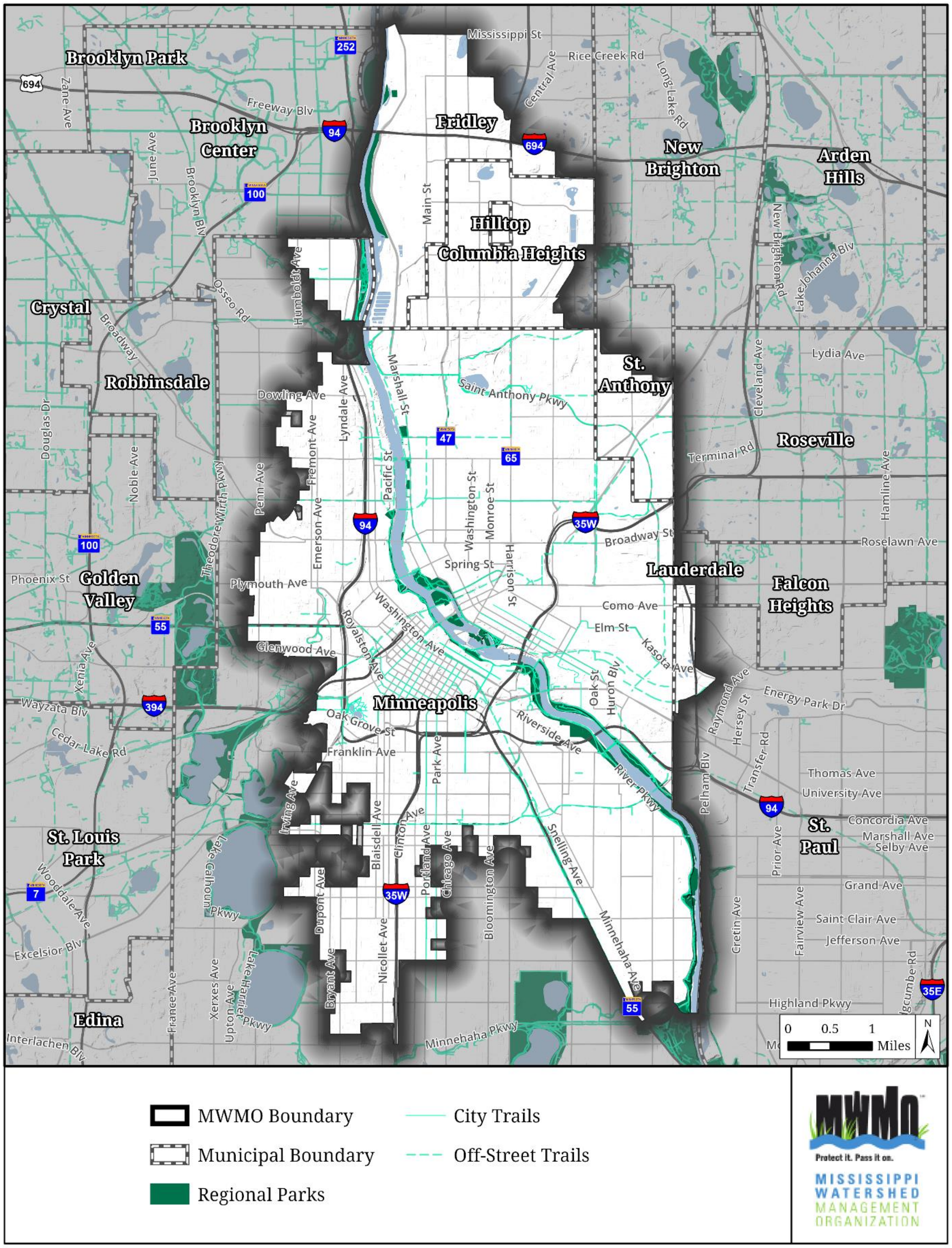


Figure 27: Minneapolis Trail System Map from Minneapolis Park and Recreation Board Comprehensive Plan (MPRB, 2015)

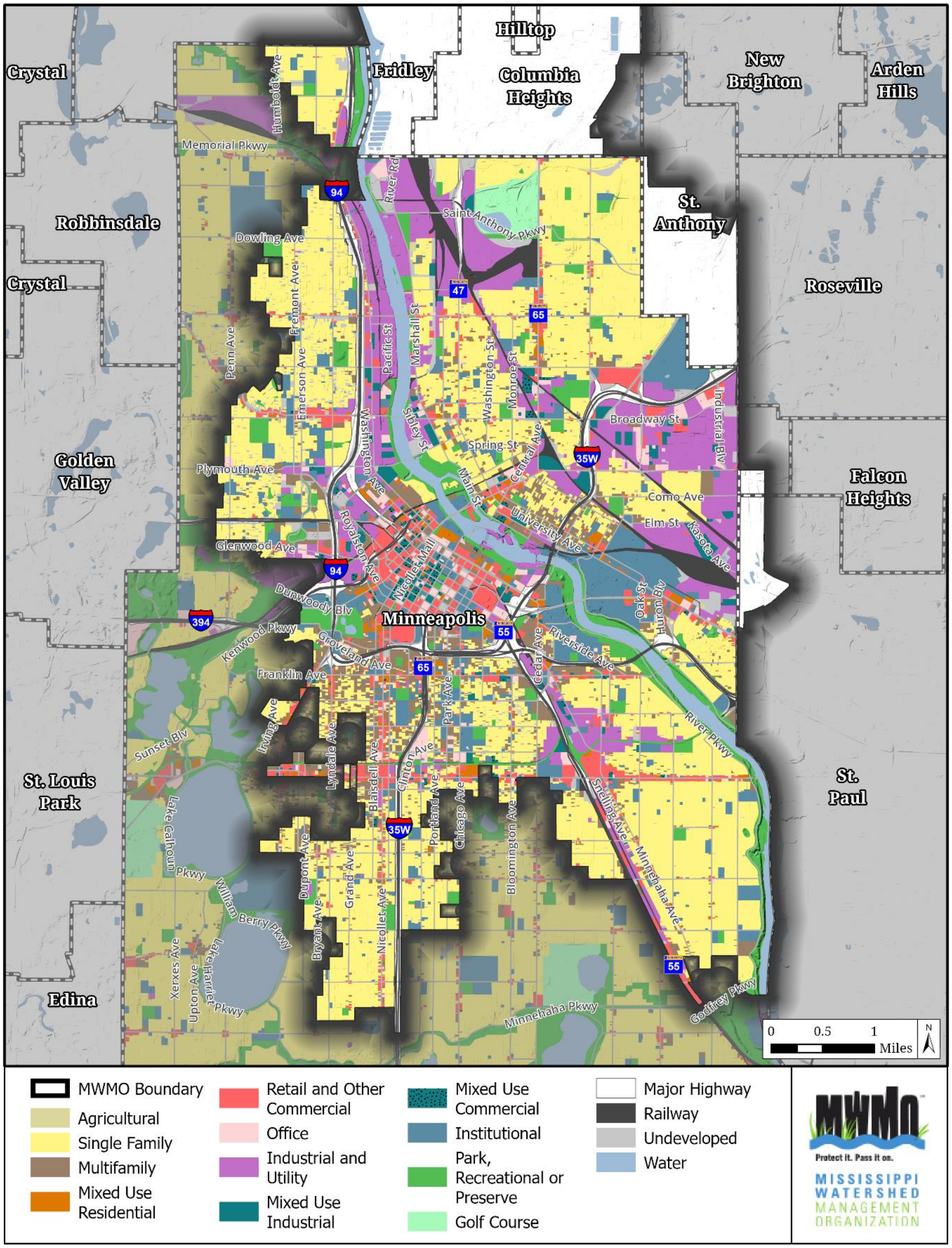


Figure 28: City of Minneapolis Existing Land Use Map from The Minneapolis Plan for Sustainable Growth (City of Minneapolis, 2017)

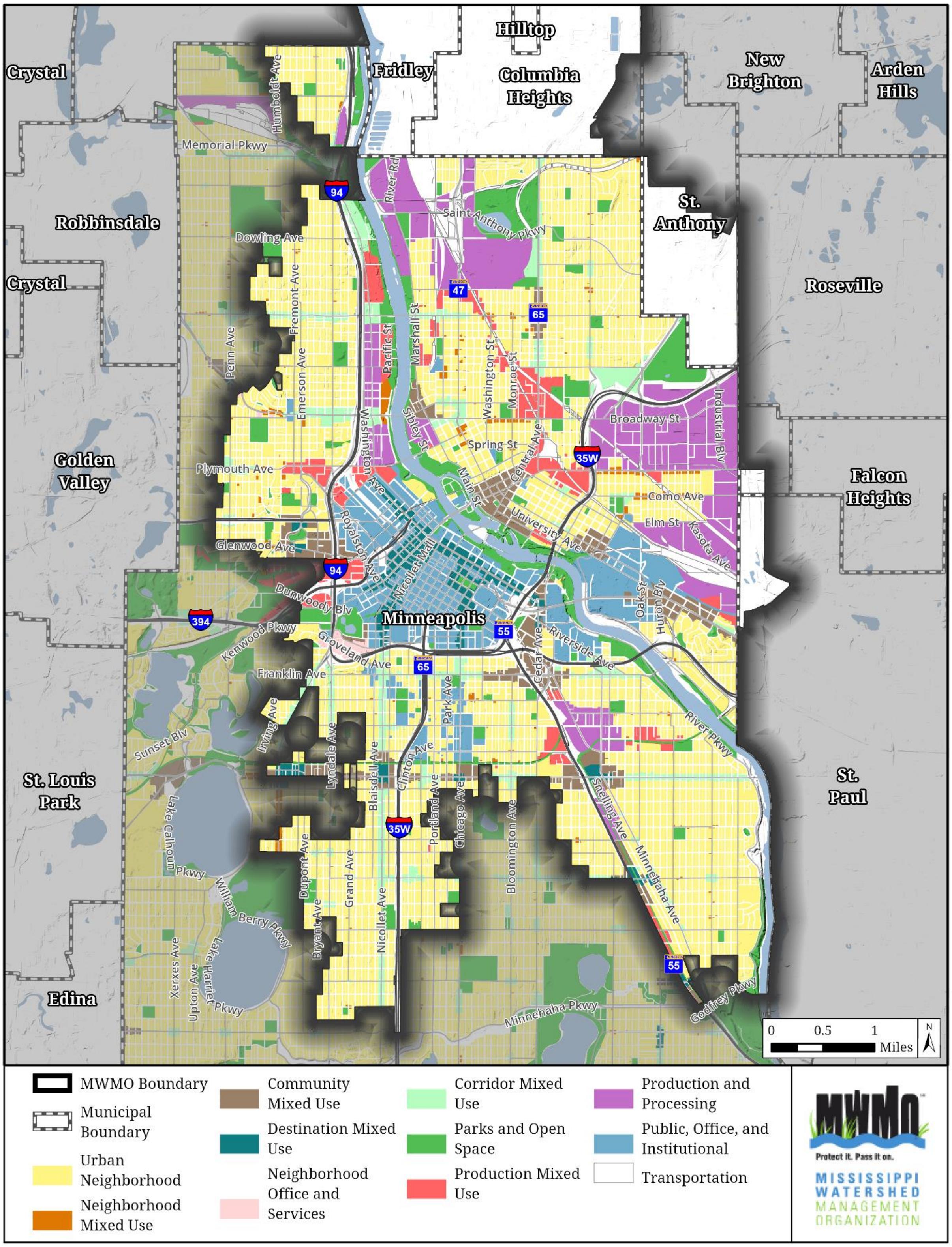


Figure 29: City of Minneapolis Future Land Use Map from The Minneapolis Plan for Sustainable Growth (City of Minneapolis, 2019)

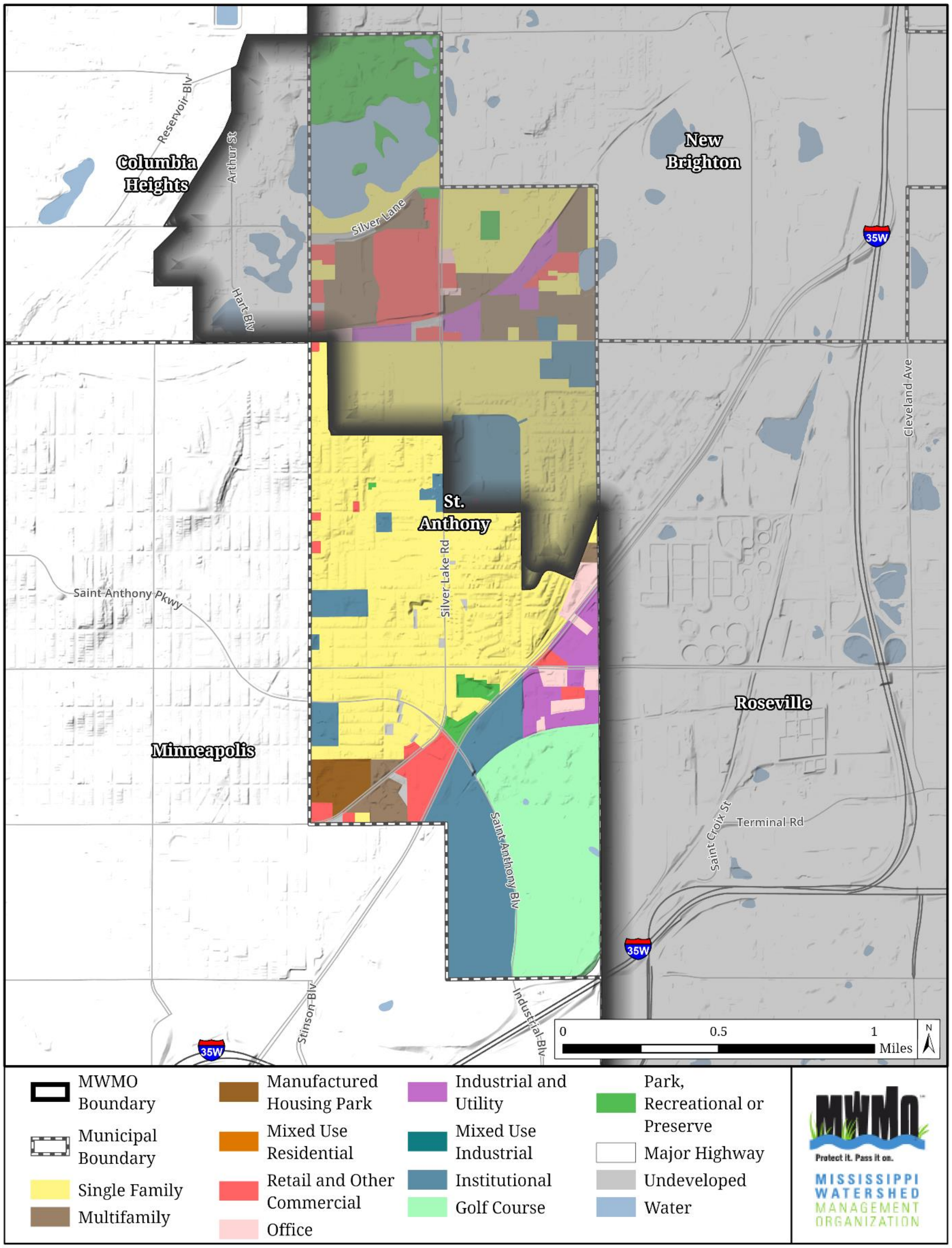


Figure 30: City of St. Anthony Village Existing Land Use Map (City of St. Anthony, 2010)

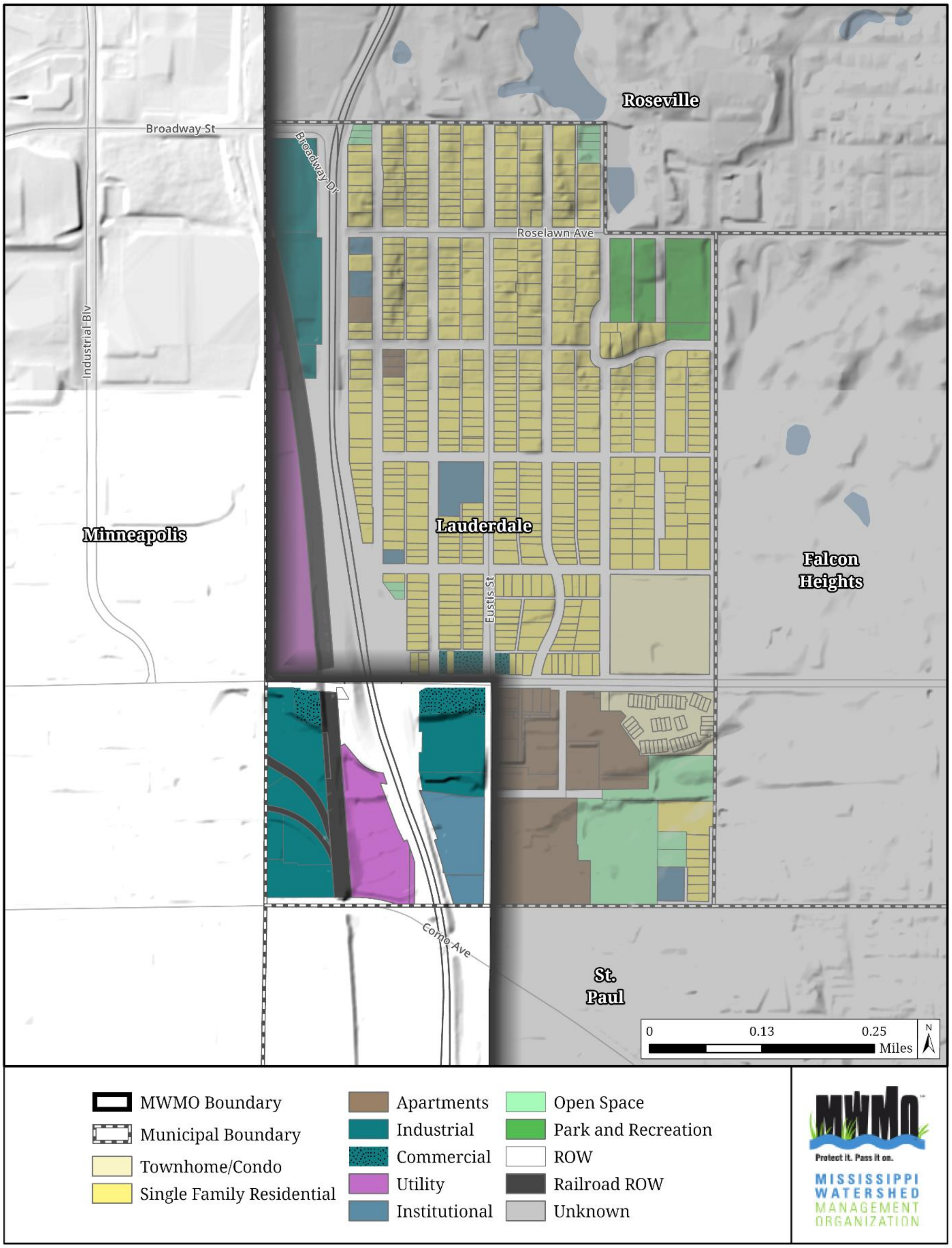


Figure 31: City of Lauderdale Existing Land Use Map from the City of Lauderdale Draft Comprehensive Plan (City of Lauderdale, 2016)

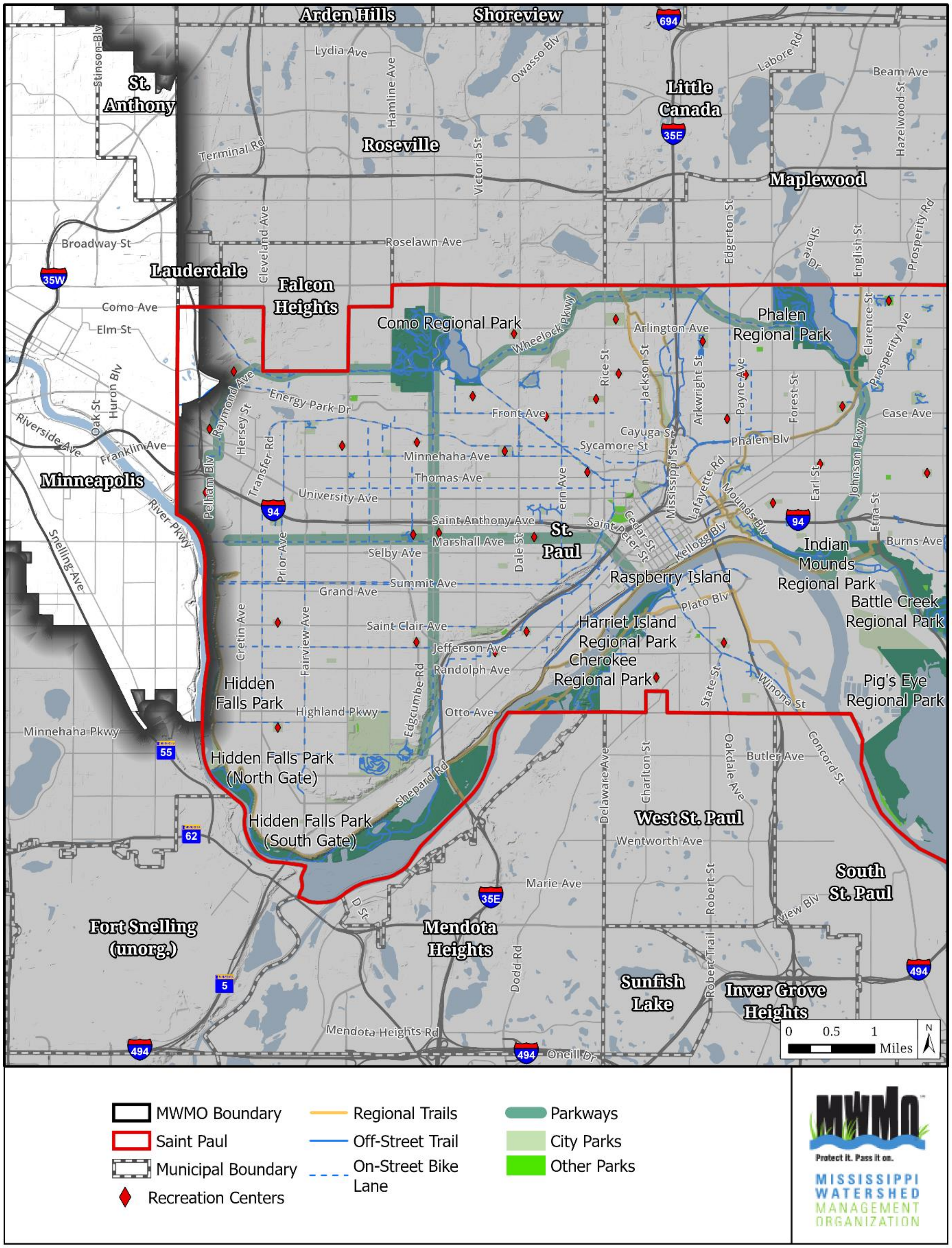


Figure 32: City of St. Paul Park System Map (Met Council, 2020)

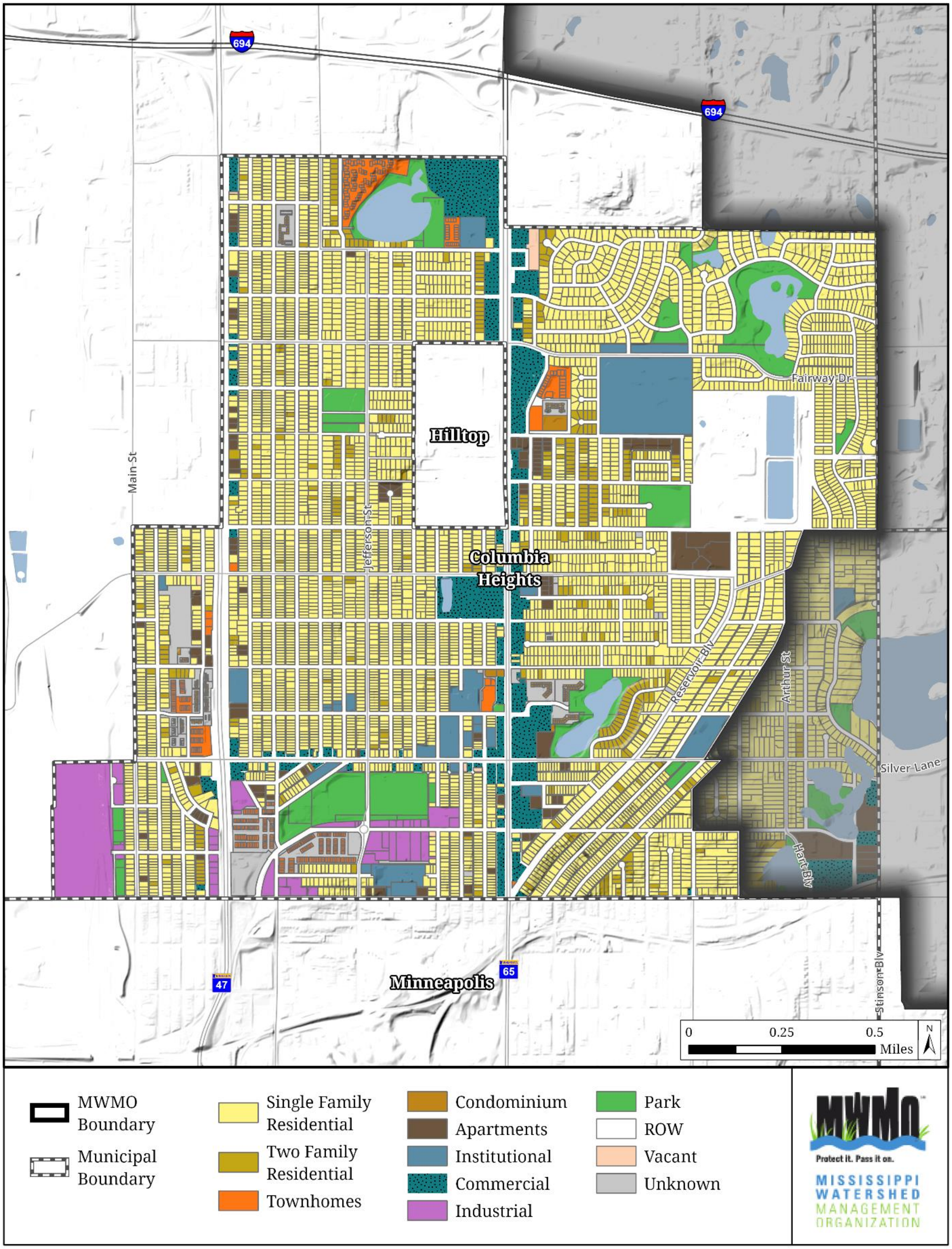


Figure 33: Columbia Heights 2020 Existing Land Use from City's Parcel Dataset (City of Columbia Heights, 2020)

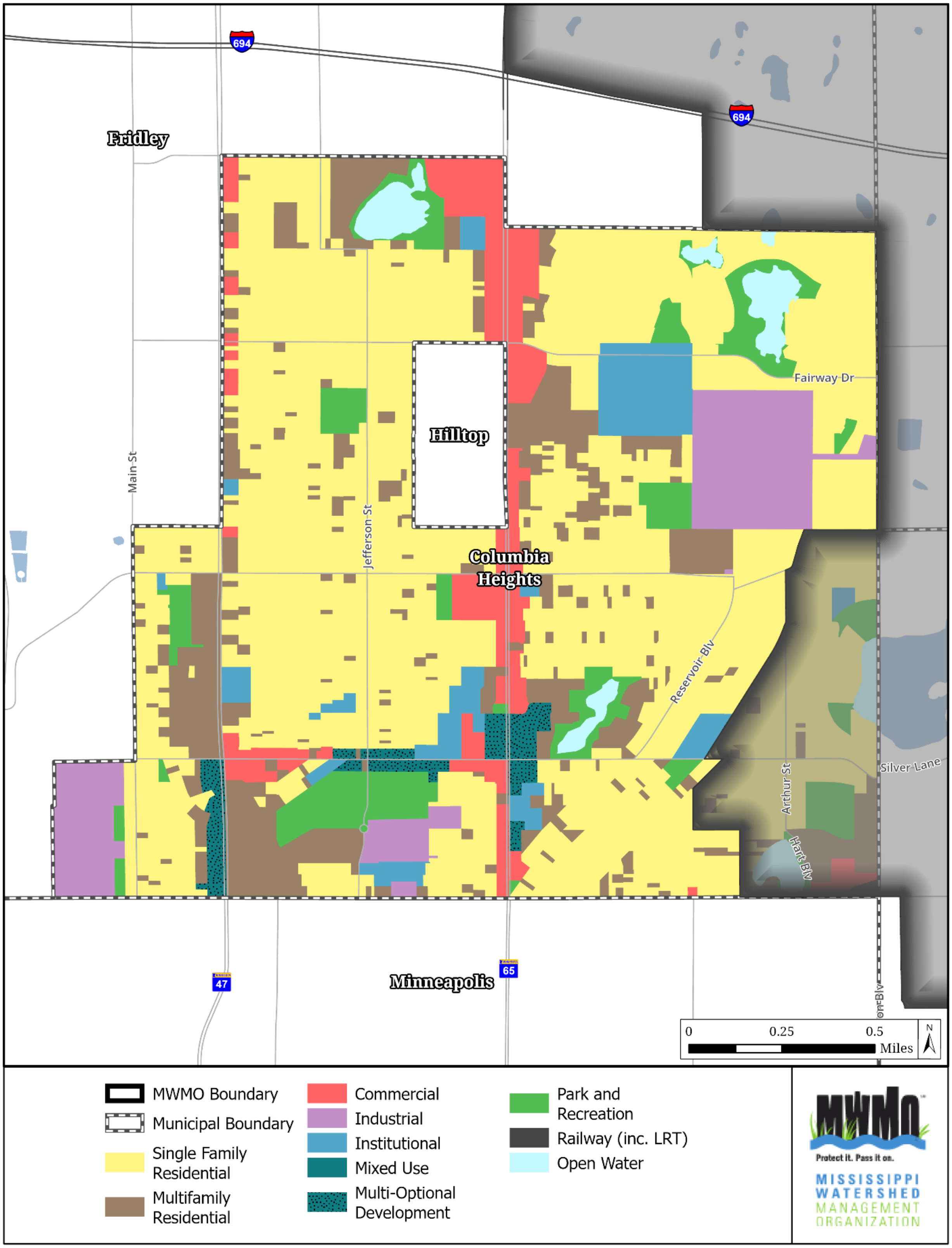


Figure 34: Columbia Heights Future Land Use from 2040 Comprehensive Plan

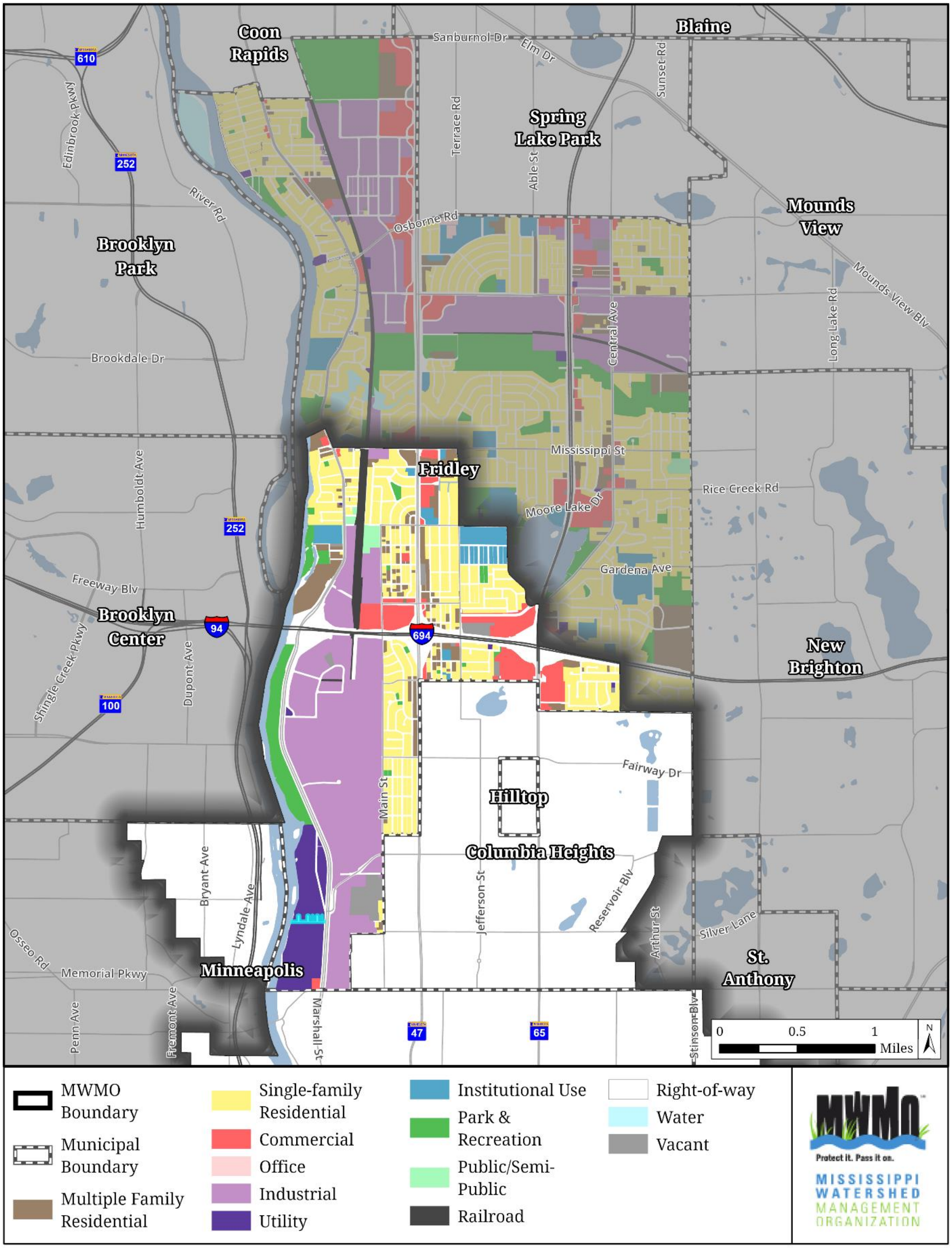


Figure 35: City of Fridley 2020 Existing Land Use from City's Parcel Dataset (City of Fridley, 2020)

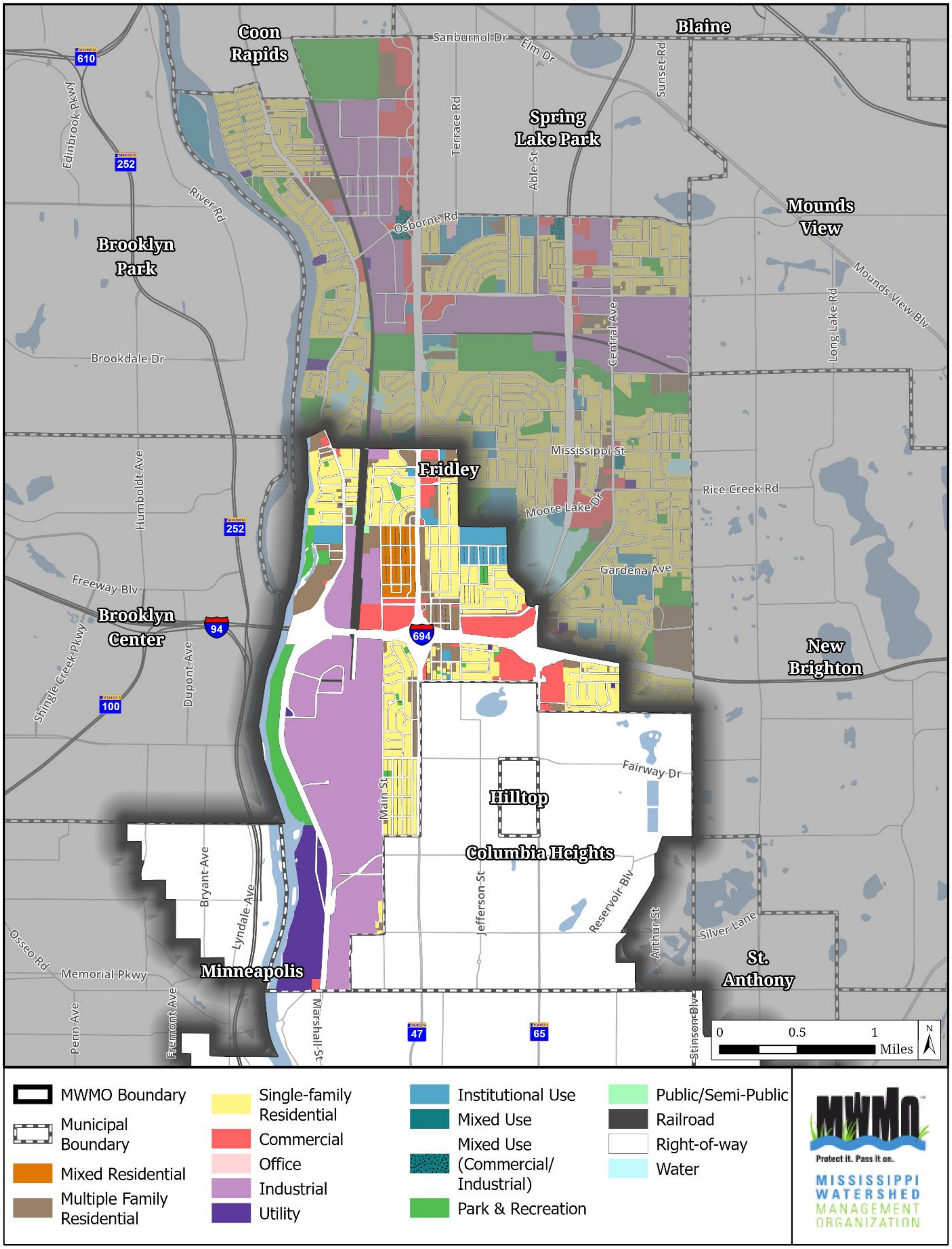


Figure 36: City of Fridley 2040 Future Land Use from 2040 Comprehensive Plan (City of Fridley, 2020)

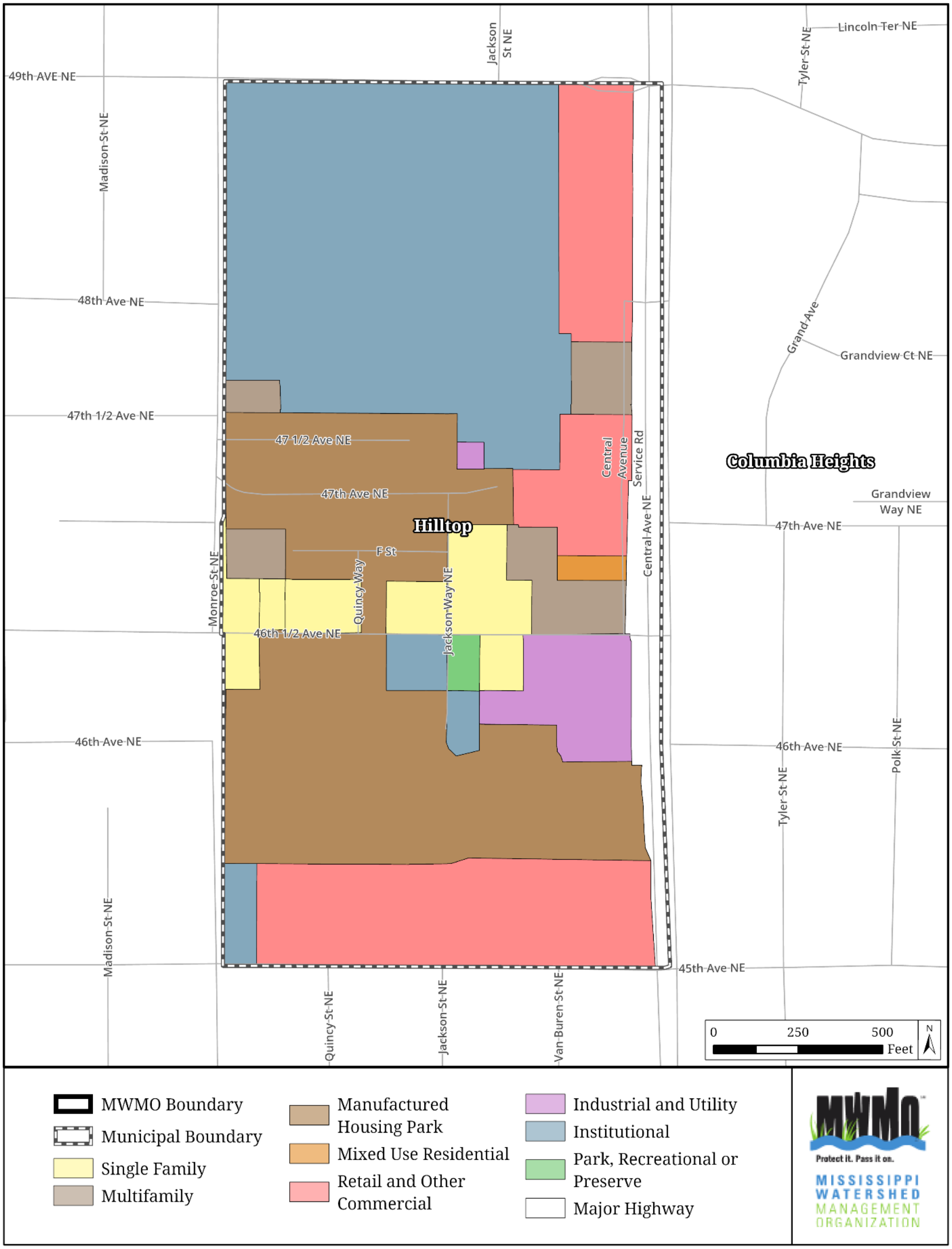


Figure 37: City of Hilltop Existing Land Use from The 2016 Generalized Land Use Inventory (Metropolitan Council, 2017)

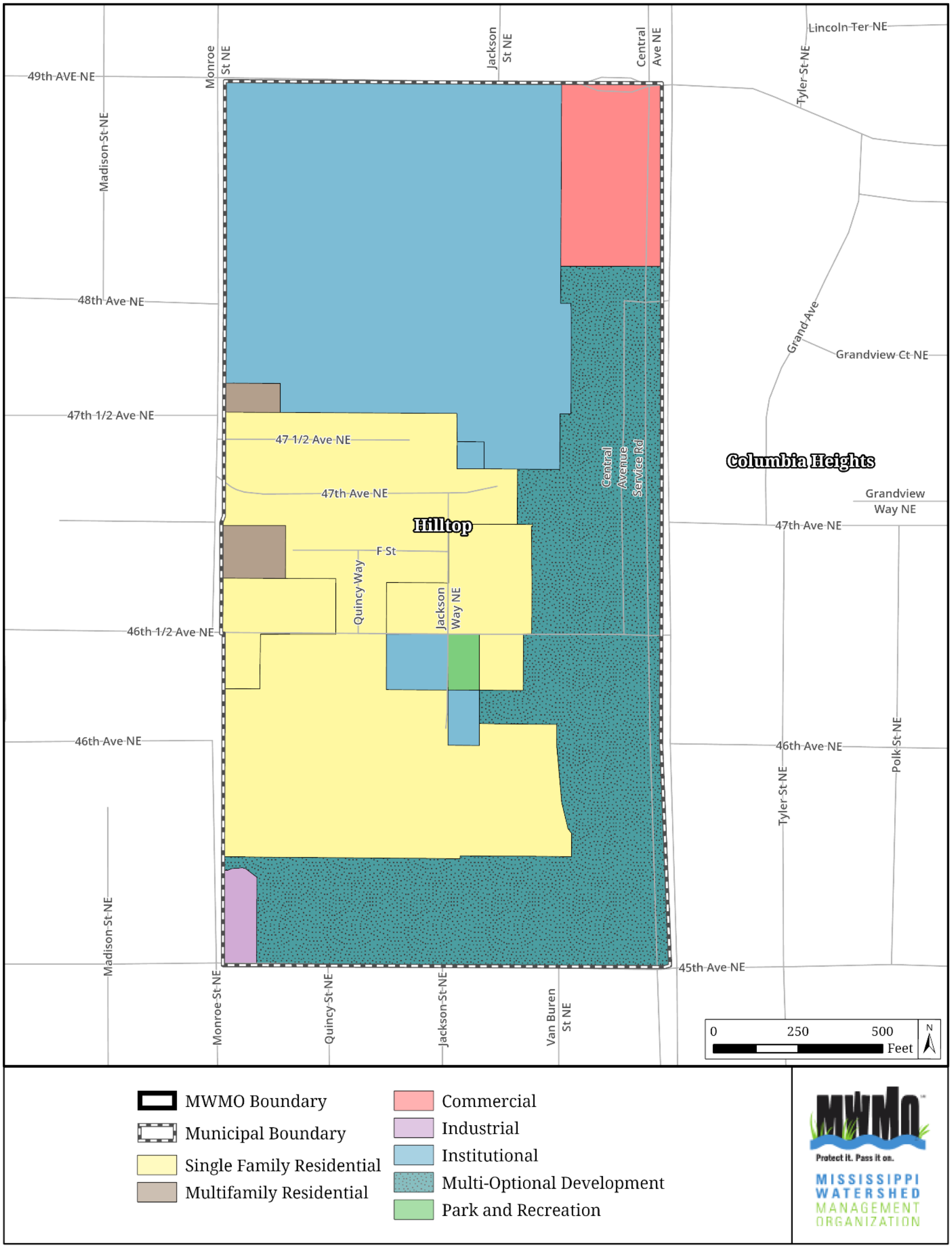


Figure 38: City of Hilltop 2030 Future Land Use from 2030 Comprehensive Plan

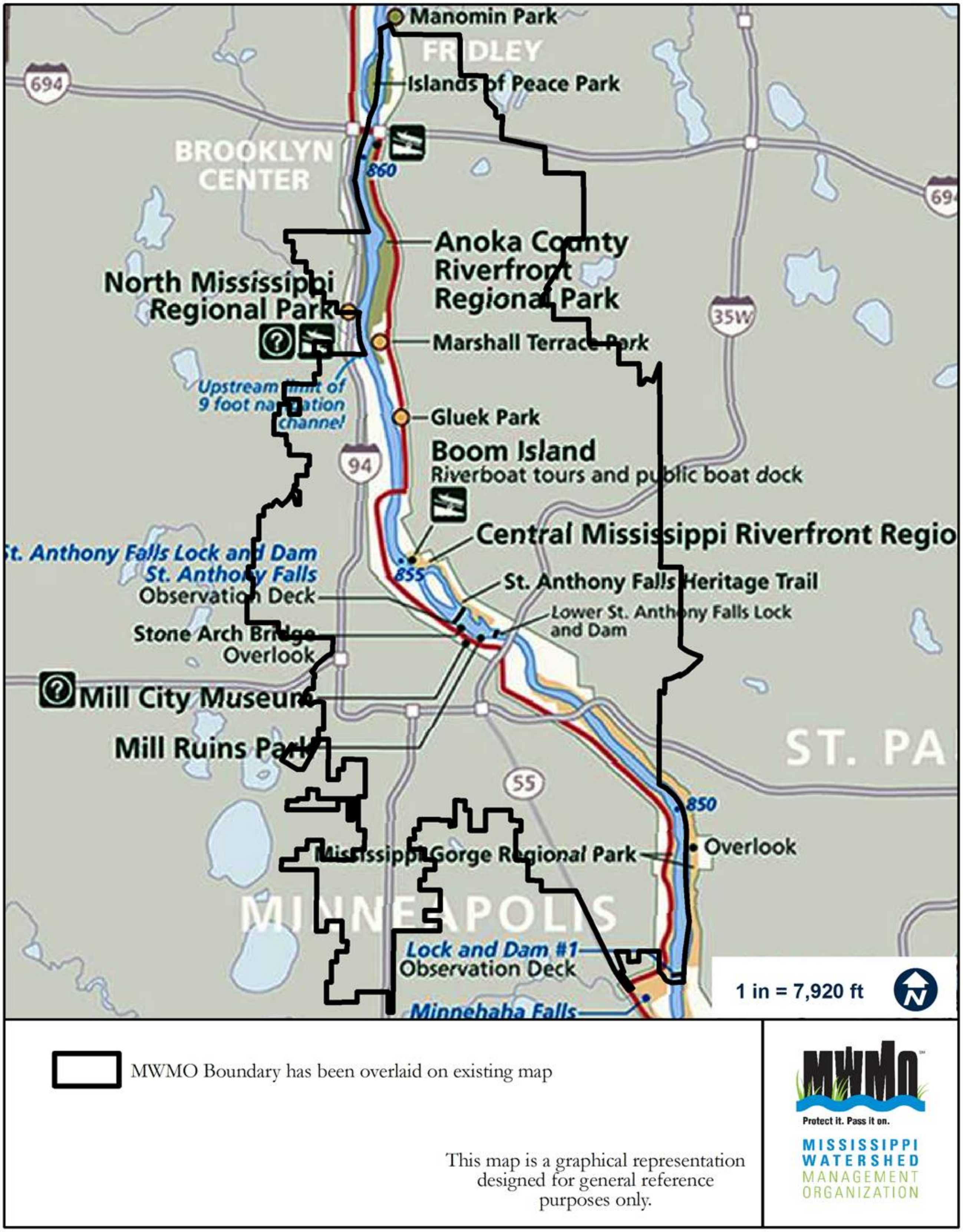


Figure 39: Mississippi National River and Recreation Map

4.4.8 Potential Environmental Hazards

Permitted Pollutant Sources

Municipal Separate Storm Sewer System (MS4) Stormwater

MS4s are defined by the Minnesota Pollution Control Agency (MPCA) as conveyance systems owned or operated by an entity such as a state, city, town, county, district, or other public body having jurisdiction over disposal of stormwater or other authorized non-stormwater discharges. A conveyance system includes ditches, roads, storm sewers, stormwater ponds, and so on. The goal of the MS4 Stormwater Program is to “reduce the amount of sediment and pollution that enters surface and groundwater from storm sewer systems to the maximum extent practicable.” The MS4 stormwater discharges are regulated by National Pollutant Discharge Elimination System/State Disposal System permits administered by the Minnesota Pollution Control Agency.

Phase I of the MS4 Stormwater Program identified Minneapolis and Saint Paul as large MS4s, and each city has an individual National Pollutant Discharge Elimination System/State Disposal System permit. Under Phase II of the program, MS4s outside of urbanized areas with populations greater than 10,000 (or greater than 5,000 if they are located within 0.5 mile of an outstanding value resource or impaired water) were classified as small designated MS4s. MS4s within urbanized areas and with a population of at least 50,000 and a density of 1,000 people per square mile are classified as small mandatory MS4s. As a requirement of the permit, MS4s must develop a Stormwater Pollution Prevention Plan which outlines a plan to reduce pollutant discharge, protect water quality, and satisfy water quality requirements in the Clean Water Act. A report is submitted each year by the municipality documenting the implementation of the Stormwater Pollution Prevention Plan.

Within the MWMO, there are a number of member organizations and road authorities that are mandatory and designated MS4s, as well as Saint Paul and Minneapolis, Phase 1 Large MS4s (**Table 19**).

Table 19: Municipal Separate Stormwater Sewer Systems within MWMO

Permit Holder	Type of MS4	Permit ID
Anoka County	Mandatory Phase II	MW400066
Columbia Heights	Mandatory Phase II	MS400010
Fridley	Mandatory Phase II	MS400019
Hennepin County	Mandatory Phase II	MS400138
Hilltop	Mandatory Phase II	MS400023
Lauderdale	Mandatory Phase II	MS400026
Minneapolis	Phase I Large MS4	MN0061018

Permit Holder	Type of MS4	Permit ID
Minneapolis Community and Technical College	Mandatory Phase II	MS400207
Minnesota Department of Transportation	Mandatory Phase II	MS400170
Ramsey County Public Works	Mandatory Phase II	MS400191
Saint Anthony Village	Mandatory Phase II	MS400051
Saint Paul	Phase I Large MS4	MN0061263
University of Minnesota – Twin Cities	Mandatory Phase II	MS400212

Source: MN Geospatial Commons: MS4 Boundaries in Minnesota

Construction Stormwater

Construction sites can contribute substantial amounts of sediment to stormwater runoff. The National Pollutant Discharge Elimination System/State Disposal System Construction Stormwater Permit administered by the Minnesota Pollution Control Agency requires that all construction activity disturbing areas equal to or greater than one acre of land must obtain a permit and create a Stormwater Pollution Prevention Plan that outlines how runoff pollution from the construction site will be minimized during and after construction. Construction stormwater permits cover construction sites throughout the duration of the construction activities through final stabilization of the site. The Minnesota Pollution Control Agency Data Desk can be contacted to obtain an updated list with location information on all permitted construction sites in the MWMO.

Industrial Stormwater

The National Pollutant Discharge Elimination System/State Disposal System Industrial Stormwater Multi-Sector General Permit applies to 29 sectors of industrial activity each having the risk of exposing significant materials to stormwater. Significant materials include any material handled, used, processed, or generated that contains pollutants to surface or groundwater resources. Facilities that can demonstrate that no significant materials are exposed to stormwater can apply for the No Exposure exclusion instead of the permit. Permit requirements entail development and implementation of a Stormwater Pollution Prevention Plan (SWPPP), quarterly monitoring of site stormwater runoff, and updates or revisions to the SWPPP if monitored constituent concentrations do not meet sector-specific benchmarks established in the permit. The SWPPP entails a description of both structural and non-structural stormwater management practices implemented to prevent contact of stormwater with significant materials. The Minnesota Pollution Control Agency re-issued an Industrial Stormwater Multi-Sector General Permit in April

2010, as an update to the former, expired permit. **Figure 40** shows the approximate locations of the permitted industrial stormwater sites within the MWMO. The industrial stormwater discharge sites are often associated with a zip code rather than an exact location.

Feedlots

There are no feedlot operations within the boundary of the MWMO.

Municipal and Industrial Wastewater

Several facilities within the MWMO are permitted by the Minnesota Pollution Control Agency to discharge water, such as wastewater treatment plants, commercial sites with noncontact cooling water discharge, and manufacturing facilities. For any discharge to a surface water, ground surface or subsurface, a National Pollutant Discharge Elimination System and/or a State Disposal System permit is required and administered by the Minnesota Pollution Control Agency. **Figure 40** shows the approximate locations of permitted discharge sites within the MWMO as of 2014.

Chloride Prevention

The MWMO will continue to support our member cities through our outreach and training initiatives related to reducing the use of chlorides in the watershed.

Household water softeners are an important point source of chloride. Minnesota generally has groundwater with high levels of calcium and magnesium that must be removed through softening to improve taste and prevent lime scale buildup in appliances, pipes and water fixtures. The majority of home water softeners use sodium chloride (NaCl) in a softening process that replaces calcium and magnesium ions with sodium, while the chloride ions are discharged in the wastewater and eventually end up in the environment.

Use of salt on sidewalks, roads, and parking lots are a significant source of chlorides that discharge to surface waters in the watershed.

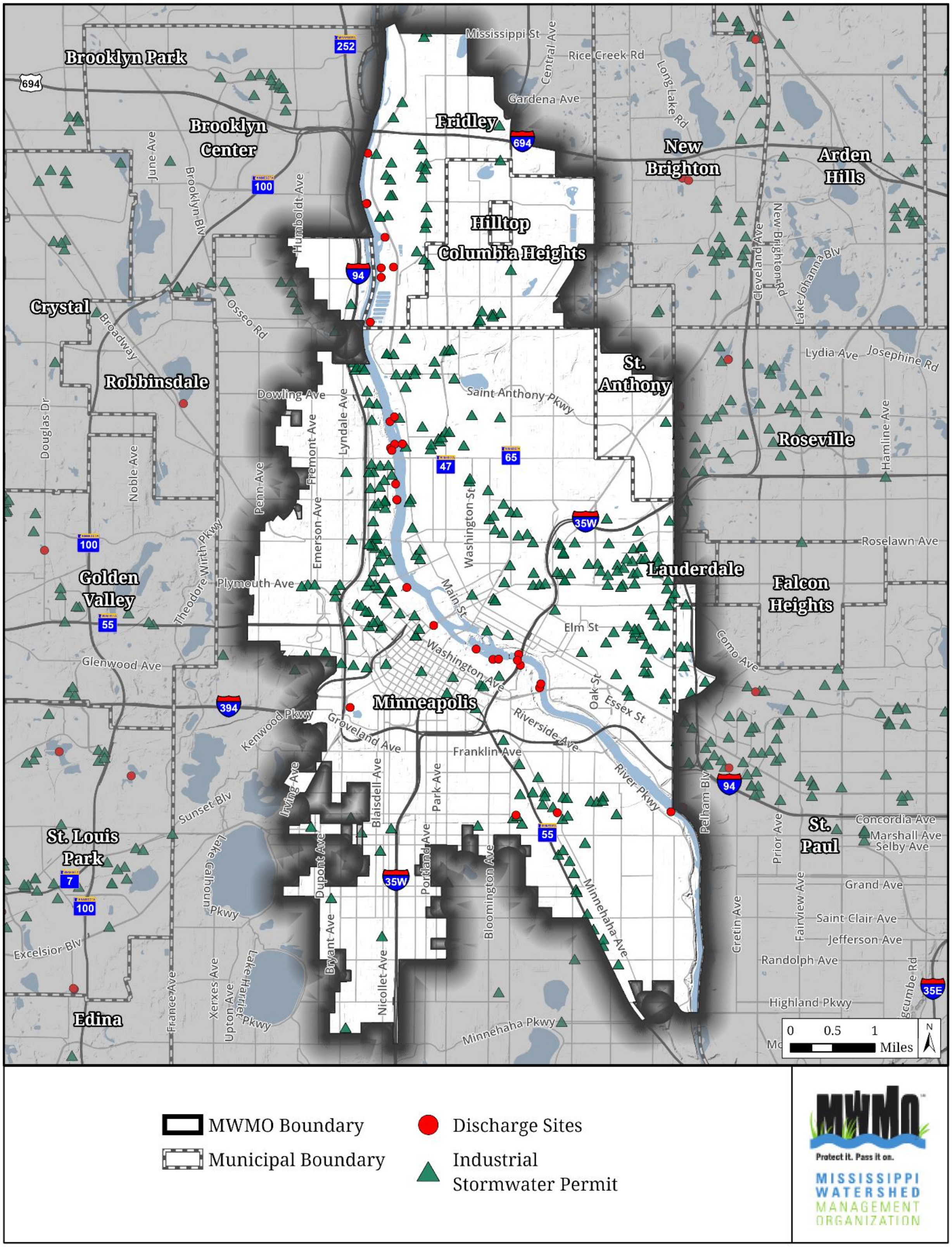


Figure 40: Permitted Discharge and Industrial Stormwater Sites within MWMO

Potentially Contaminated Sites

Sites identified by the Minnesota Pollution Control Agency as potentially contaminated within the watershed are shown on **Figure 41**. The Minnesota Pollution Control Agency has maintained a database of potentially contaminated properties since the early 1980s. The database includes properties that have already been investigated and cleaned up, properties currently enrolled in Minnesota Pollution Control Agency cleanup programs, and properties that were suspected to be contaminated but after investigation turned out to be clean. The types of potentially contaminated sites included in the database are operating and abandoned landfills, dumps, and solid waste sites, among others. Discharges at these sites may contain harmful substances that have the potential to contaminate both groundwater and surface water.

Leaking Above- and Below-Ground Storage Tanks

The Minnesota Pollution Control Agency investigates and cleans up releases from petroleum tanks. Approximately 660 releases from leaking above- and below-ground storage tanks have been reported in the watershed; their locations are shown in **Figure 42**.

Wells

Wells from the County Well Index are shown in **Figure 42**. The County Well Index includes information on the location and characteristics of water wells installed in the State of Minnesota since 1974. Wells can serve as a connection between different aquifers and can serve as a pathway for groundwater contamination. Some of the wells included in the index may have been properly sealed when abandoned, but those still in use and those abandoned but not properly sealed may provide a pathway for contamination to spread between aquifers.

4.4.9 Discussion of Challenges, Gaps, and Next Steps

While the MWMO provides similar services to the public as other watersheds in Minnesota, the complex human and built environment it operates within presents unique resource management challenges. A fully built-out and urbanized area like the MWMO has a long history of population growth, redevelopment of land, changing land use patterns, and water use patterns.

Population growth resulted in a large mix of cultures and languages spoken in the MWMO. Education and knowledge transfer are most effective when it occurs within the framework of individuals' language and culture. The extensive spectrum of ethnic groups present in the watershed means the MWMO will need to continue to develop communication networks, tools, and messaging that go beyond an English-speaking audience. With a forecasted increase in population, the MWMO will need to focus its limited education resources on key messengers and groups that have broader networks and the ability to affect change. As such, the MWMO will continue to educate and connect water resource issues to the daily activities of students, professionals, policy-makers, and community leaders in the MWMO.

With more people, more land uses need to be layered on what once was a single use parcel of land. For example, a historically forested parcel may now serve multiple functions as a corridor for water treatment, buried and overhead utilities, street or rail transportation, and pedestrian pathways. In order to inform multifunctional corridor planning and management efforts, the MWMO will continue to compile and assess shared land use opportunities in all open space, park, and recreational areas maps.

Over time, as growth and redevelopment occur, patterns of land use and water use also shift around on the landscape and waters of the MWMO. Redevelopment of individual building sites as well as transportation corridors (streets, highways, railways, and waterways) are opportunities to incorporate new water management systems into the current built-out landscape. The need to align projects with the pace of infrastructure redevelopment places some of the MWMO's goals on a twenty-five, fifty- or hundred-year timeline depending on the infrastructure being replaced. The MWMO will continue to plan for incorporating new water management systems to the watershed as a part of ongoing redevelopment activities.

As stated prior, Minnesota Department of Natural Resources Division of Ecological and Water Resources (EWR) regulates surface and groundwater appropriations based on daily and yearly withdrawal volumes. This management affects water supply for domestic, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes. A permit through the Water Appropriation Permit Program is required for all users withdrawing more than 10,000 gallons per day or 1 million gallons per year for consumptive or nonconsumptive use. Under Minnesota Statute 103B.211, subdivision 4. appropriations from small watercourses, states that: appropriations that draw less than 10,000 gallons per day or 1 million gallons per year are prohibited unless a permitted by the MWMO. In addition, member cites are required to enforce subdivision 4 when an appropriation occurs within their jurisdiction. To date the MWMO has not established a permitting program nor are they aware of any member city permitting or enforcement programs related to MS 103B.211, subdivision 4. To maximize efficiencies in government the MWMO will request that member cities add the development and enforcement of this permitting requirement to their current regulatory duties. In addition, the MWMO will work with the member cities to determine and approve an appropriate permit fee to be paid to the cities.

As built today, cities and industries in the watershed rely on the surface and groundwater resources to provide a water supply for many different functions such as drinking water, irrigation, and industrial cooling water. A primary function of surface water is the assimilation of waste streams such as stormwater runoff from streets, effluent from wastewater treatment plants, and industrial discharges. Use of the river as a final stage of treatment is straining its ecosystem, i.e. endocrine disruptors and their effect on fish populations downstream of wastewater treatment plants. The river has a finite capacity to serve in this function until its ecosystem is damaged and our society loses the basic benefits that a clean river ecosystem has to offer: swimming, fishing, waterfowl, migratory riparian birds, prime adjacent real estate, and parks. This strain on the river can be eased if there is development of new technologies and systems that utilize today's pollutant waste streams as inputs into tomorrow's new products and services.

Wellhead and source water protection zones assure surface and groundwater quality and available volume is maintained for cities and industries in the watershed. Permitted industrial and wastewater treatment plant discharges attempt to manage the downstream impacts on ground and surface water resources. This system works well with a first generation of development. However, in long standing urban areas natural hydrologic conditions have been altered, land use has changed, and redevelopment has occurred many times over. As a result, the likelihood of a site having water-soluble contaminated soils or groundwater contamination from one of these historic changes is high. Thus, it is critical that the MWMO evaluates historic and present-day groundwater hydrology and contamination whenever it installs stormwater management practices or systems. In addition, the MWMO will stay abreast of emerging water quality, rate, and volume issues affecting the Mississippi River and in turn source water protection and waste stream discharge activities.

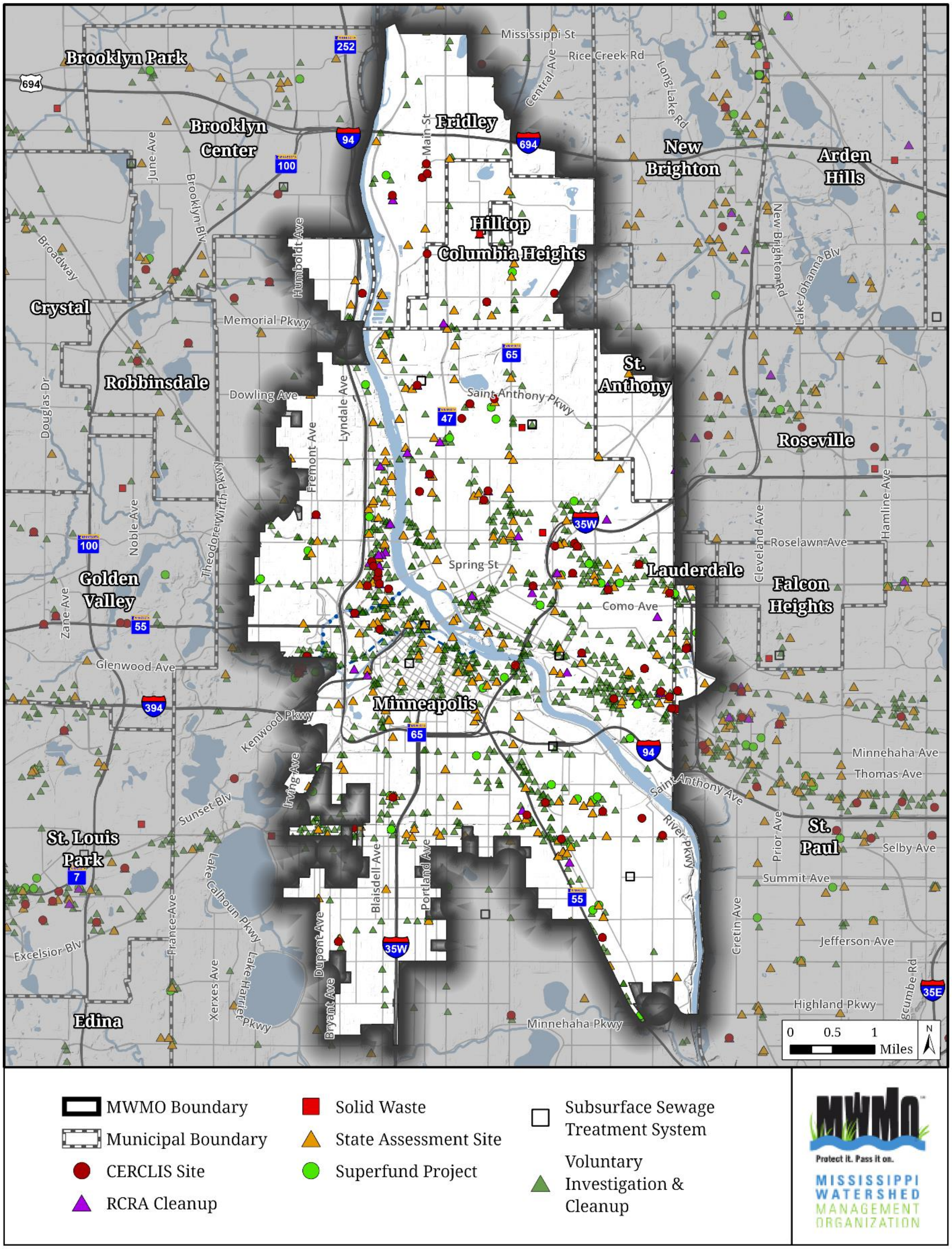


Figure 41: Known and Potential Sources of Soil and Groundwater Contamination

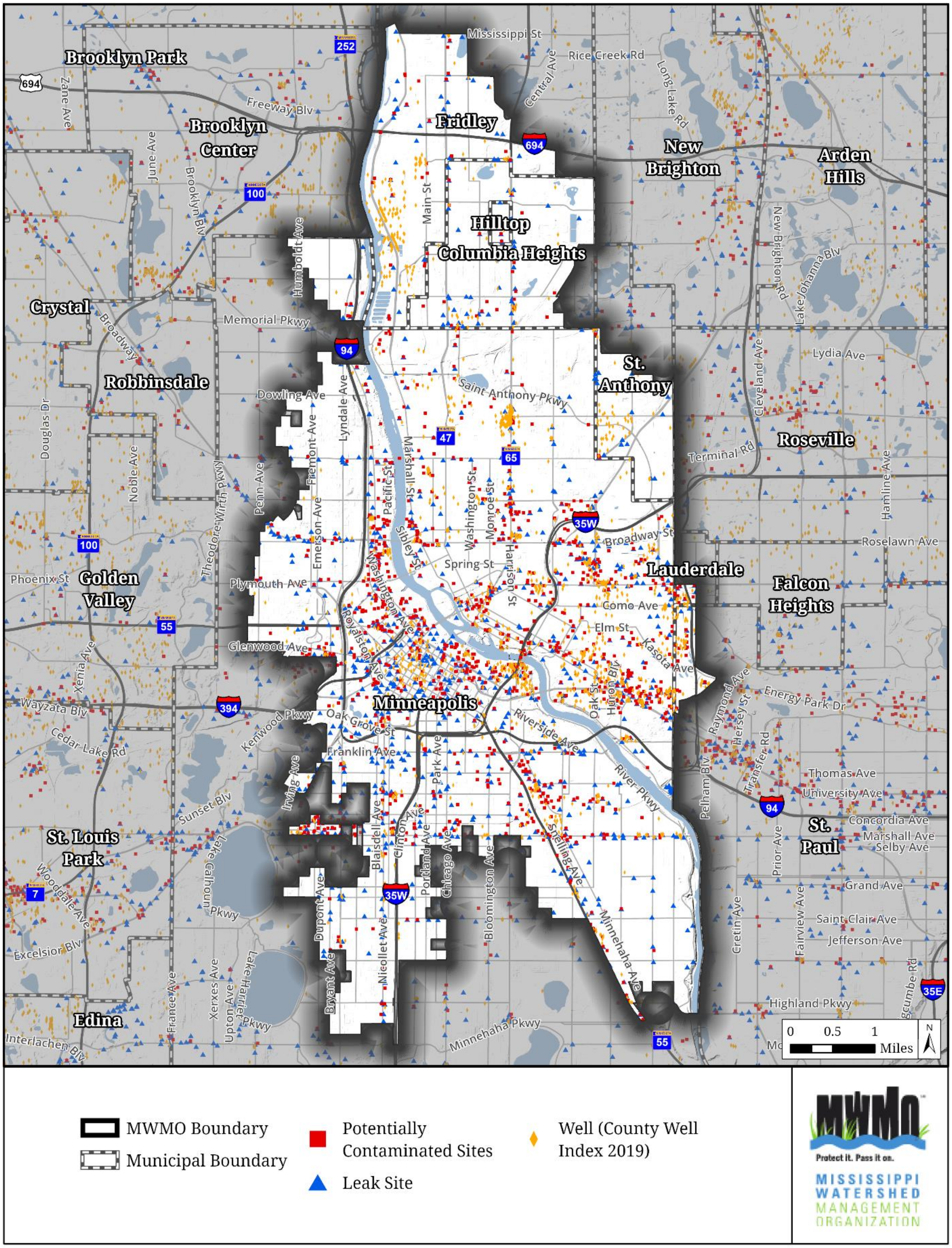


Figure 42: Environmental Hazards in the MWMO

4.5 Hydrologic System

4.5.1 Climate and Precipitation

Rainfall duration, intensity, and distribution are all factors that affect the MWMO's water quality with respect to erosion sedimentation loads, pollutant runoff, and groundwater recharge. Knowledge of their effects on the watershed help watershed managers determine hydrologic designs to mitigate water quality and quantity problems.

The climate within the MWMO is similar to the overall seven-county metropolitan area. The seven-county metropolitan area exhibits the typical characteristics of continental climates. Areas with continental climates have winters with at least one month below 32° F and at least three months of temperatures above 50° F. Regions with continental climates are characterized by winter temperatures cold enough to support snow cover from late fall to early spring, and relatively moderate precipitation that occurs mostly in the summer months.

Monthly averages for precipitation, snowfall, and temperature for the period 1981-2010 are presented in **Table 20**. Data was collected by the National Weather Service Cooperative at the Minneapolis-St. Paul International Airport (Station 215435). The average annual temperature is 46.2 degrees F. Average annual precipitation is 30.61 inches, including approximately 54.4 inches of snowfall.

Table 20: Monthly Climate Averages for the Period 1981-2010

Mean Monthly Precipitation, 1981 - 2010	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Precipitation (inches)	0.90	0.77	1.89	2.66	3.36	4.25	4.04	4.30	3.08	2.43	1.77	1.16	30.61
Mean Monthly Snowfall, 1981 - 2010	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Snowfall (inches)	12.2	7.7	10.3	2.4	-	-	-	-	-	0.6	9.3	11.9	54.4
Mean Temperature, 1981 - 2010	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Max °F	23.7	28.9	41.3	57.8	69.4	78.8	83.4	80.5	71.7	58.0	41.2	27.1	55.2
Min °F	7.5	12.8	24.3	37.2	48.9	58.8	64.1	61.8	52.4	39.7	26.2	12.3	37.2
Mean °F	15.6	20.8	32.8	47.5	59.1	68.8	73.8	71.2	62.0	48.9	33.7	19.7	46.2

Design Storms

Table 21 illustrates the probability of a rainfall event occurring in any given year at the centroid of the MWMO. The probability of exceedance and the return period are measures of the probability of occurrence of the storm event. For example, a 24-hour rainfall event of 7.44 inches has a 1% probability of occurring in any given year which is expressed as once in every 100 years. A 3.56 inch, 24-hour rainfall event has a 20% probability of occurring in any given year which is expressed as once in every 5 years.

The standard accepted practice is to use National Oceanographic and Atmospheric Administration's (NOAA) Atlas 14, Volume 8, Version 2 (Atlas 14), released in 2013, on which **Table 21** is based. Atlas 14 supersedes NOAA's Technical Paper No. 40 (written in 1961), which was previously the standard accepted source of precipitation depths for selected return periods. Atlas 14 data for Minnesota is available on NOAA's website at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mn.

Table 21: Storm Event Precipitation (inches) for the centroid of the MWMO, Atlas 14.

Probability of Exceedance	**Return Period**	**Duration of Storm Event**							
		24-hour	12-hour	6-hour	3-hour	2-hour	1-hour	30-min.	15-min.
100%	1-year	2.47	2.14	1.89	1.61	1.44	1.17	0.89	0.63
50%	2-year	2.85	2.51	2.20	1.88	1.70	1.38	1.06	0.75
20%	5-year	3.56	3.23	2.82	2.42	2.18	1.76	1.35	0.94
10%	10-year	4.26	3.92	3.44	2.93	2.62	2.11	1.60	1.11
4%	25-year	5.38	5.01	4.44	3.76	3.32	2.64	1.96	1.36
2%	50-year	6.36	5.97	5.34	4.48	3.91	3.08	2.24	1.56
1%	100-year	7.44	7.02	6.34	5.29	4.56	3.55	2.53	1.76

Source: National Oceanographic and Atmospheric Administration's (NOAA) Atlas 14, Volume 8, Version 2 (Atlas 14), released in 2013

Climate Change

Over the next 50 years, the approach to watershed management could shift because of climate change. Watershed managers are likely to go from monitoring and evaluating the effects of climate change to mitigating and finally adapting to climate change.

What impacts could climate change have on precipitation in the State of Minnesota? As the earth warms, the intensity of precipitation increases in two ways: (1) increasing the temperature of the land and oceans causes water to evaporate faster; and (2) increasing air temperature enables the atmosphere to hold more water vapor. These factors combine to make clouds richer with moisture, making heavy downpours or snowstorms more likely. The State of Minnesota is predicted to see a total increase in annual precipitation.

Seasonal precipitation could change as follows: precipitation may increase in winter by 15-50 percent and decrease in summer by up to 15 percent. While the frequency of heavy rainstorms (both the 24-hour and the multi-day) may increase, droughts are likely to be more common as the rainfall cannot compensate for the drying effects of a warmer climate. These predictions or trends have already been established: a review of approximately 3,500 National Oceanic and Atmospheric Administration weather stations indicates that Minnesota has already seen a 24 percent increase in the frequency of extreme precipitation events from 1948 to 2006 (Madsen and Figdor, 2007). In the Twin Cities Metropolitan Area, this increase was as large as 47 percent. Other changes expected in the State of Minnesota include a shorter winter season with less snow, more ice, winter rains, earlier ice-out dates, and more rapid spring snowmelt events. **Table 22** summarizes the impacts possible in the State of Minnesota because of climate change.

Table 22: Expected Impacts of Climate Change in Minnesota

Impact to Water Resource	Description	Indicators
Increases in Water Pollution Problems	Warmer air temperatures results in warmer waters	• Warmer waters hold less dissolved oxygen (DO) making instances of low DO and hypoxia more likely • Increased frequency of algal blooms
	Increased flooding increases water-borne diseases and sediment transport	• Increased stormwater runoff washes sediments (erosion) and other contaminants into waterbodies • Overloading of stormwater and stormsewer systems transports contaminants into waterbodies
	Changes in snowfall patterns	• More ice during the winter requires application of more chemicals • Less ice coverage results in greater evaporation of surface waters during winter and lower surface water levels, concentrating pollutant loads
More Extreme Water-Related Events	Heavier precipitation during rainfall events	• Increased risk of flooding • Increased variability of streamflows • Increased velocity of water during high flow periods • Taxes existing infrastructure systems (e.g. levees, sewer pipes, wastewater treatment plans, and so on)

Impact to Water Resource	Description	Indicators
Changes to Availability of Drinking Water Supplies	Changing patterns of precipitation and snowmelt	• Increased drought conditions place higher demands on drinking water supplies • Increased water loss due to higher evaporation (as a result of warmer air temperatures)
	Air temperature	• Places higher demands on community water supplies • Increased water needs for agriculture and industry • Increased need for energy production (e.g. air conditioning)
Water Boundary Movement and Displacement	Size of wetlands and lakes will change	• Changing water flow to lakes/streams • Increased evaporation • Changes in precipitation impacts wetland hydrology (bounce and duration)
	Increased stream channel instability	• Increase in channel-forming flows (bank-full flows) leads to increased sediment transport potential and channel instability
	Decreased Groundwater Recharge	• Rain from extreme events falls too quickly to be absorbed into the ground • Reduced summer water levels diminish recharge of groundwater • Earlier snow melt reduces ability of snow to recharge aquifers
	Increased Erosion	• Due to altered buffer/shoreline

Impact to Water Resource	Description	Indicators
		areas
Changing Aquatic Biology	Warmer water temperatures	• Loss of fisheries habitats as aquatic life replaced by other species better adapted to warmer waters • Interruption of breeding cycles • Increase in invasive species

4.5.2 Surface Water/Water Resources

Surface waters of the MWMO are sources of drinking water, recreation, wildlife habitat, and navigation. Each serves a different function based on size, hydrologic characteristics, and location. Surface waters can also be a source of (or a control for) flooding, depending on surface water management practices. Surface waters can physically divide communities or facilitate intercommunity activity and purpose. The surface waters of the MWMO are described below and shown in **Figure 43**.

Mississippi River

The Mississippi River at the MWMO receives drainage from approximately 19,680 square miles (USACE, 2004). Much of this drainage area is rural woodland and agriculture with large urban communities of St. Cloud, Minneapolis, and surrounding communities. From upstream areas down to the MWMO border, the percentage of agricultural lands, forest, and wetlands decreases, while the percentage of residential, commercial, industrial, and turf lands increases (MDH, 2001). The Mississippi River is part of the MWMO water monitoring program (see **Section 4.5.8**).

The headwaters of the Mississippi River above Anoka, Minnesota are designated as an Outstanding Resource Value Water and a Wild, Scenic, and Recreational River by the State of Minnesota. In addition, the MWMO reach of the river is part of the National Park Service Mississippi National River and Recreational Area. Minnesota Rules 7050.0470 lists the water use classifications for all waters of Minnesota, and the Mississippi River within the MWMO has multiple designations.

As a source of public potable water, the Mississippi River has been studied through the Source Water Assessment Program, administered by the Minnesota Department of Health, as an area for protection from contamination sources. The Minnesota Department of Health develops source water assessments for all public water supplies within the state under the federal Safe Drinking Water Act. A source water assessment area is typically mapped to show the land area over which protection measures should be taken to protect the water supply from contamination. A source water protection plan has been developed by St. Cloud, Minneapolis, and the St. Paul Regional Water Services, along with other local units of government through the Upper Mississippi River

Source Water Protection Project. The Source Water Protection Plans include a delineated source water protection area, an inventory of potential point and non-point contaminant sources within the area, and a description of management strategies and objectives for implementation. The plans and other information about the project can be found at the Upper Mississippi River Source Water Protection Project website: www.umrswpp.com.

The Mississippi River is considered one of the few federally navigable waters in Minnesota. This means that the State of Minnesota actually owns the bed of the Mississippi River, below the low water mark. The beds of most other public waters in Minnesota are either privately owned or are held in trust for the riparian owners by the State.

The Mississippi River Corridor Critical Area (MRCCA) includes the Mississippi corridor within the MWMO. The MRCCA consists of 72 miles of river and 54,000 acres of surrounding land from Anoka to the confluence of the Saint Croix River. The land was designated in 1976 under the Critical Areas Act passed by the State Legislature three years prior. The MRCCA Minnesota Critical Areas Program is housed under the Environmental Quality Board, and the Minnesota Department of Natural Resources administers the MRCCA. The purpose is to protect and preserve the unique natural, recreational, transportation, and cultural features of the section of the Mississippi River flowing through the Minneapolis-Saint Paul Metropolitan Area. The corridor's designation gives the state oversight in local land use decisions and a tool for managing development within the corridor. Partners in the protection and preservation of this area include the Environmental Quality Board, the Metropolitan Council, and the National Park Service. For communities that have adopted new MRCCA zoning regulations consistent with the 2017 rules, MRCCA districts determine structure setbacks from the Mississippi River and bluffs as well as height limits. As of February 1, 2020, the old MRCCA districts and standards still apply to Fridley, Minneapolis, and St. Paul.

According to the Upper Mississippi River Water Quality Assessment Report (EPA, 2002), water quality of the Upper Mississippi River is most influenced by nonpoint source inputs from tributary streams, major point source discharges, and river flows. The Twin Cities Metropolitan Area has a noticeable negative effect on the river's quality. Implementation of point source pollutant controls in the 1980s have reduced ammonia nitrogen concentrations and increased dissolved oxygen concentrations below the metropolitan area. Nitrification as a wastewater treatment technology and increased nonpoint source runoff from agricultural watersheds in the 1990s is a potential cause of increasing nitrite and nitrate-nitrogen concentrations.

Overall water quality trends were assessed for the 2006-2007 water year based on data from as early as 1953 to the present in the Minnesota Pollution Control Agency's 2008 Report to Congress (MPCA, 2008b). Just above Saint Anthony Falls, data indicate an increasing trend for nitrite/nitrate and decreasing trends for biochemical oxygen demand (BOD), total phosphorus (TP), unionized ammonia and fecal coliform. Downstream of the MWMO, in Pool 2 (upstream of Lock and Dam No. 2), data indicate the same findings except for no trend found for TP and an additional increasing trend for total suspended solids (TSS).

Combined Sewer Overflow

To address degrading Mississippi River water quality because of combined sewer overflows, the cities of Minneapolis, Saint Paul, and South Saint Paul together with the Metropolitan Council were involved in a ten-year sewer separation project, the Minneapolis Combined Sewer Overflow Program - Phase I (1986-1995). The Metropolitan Council monitored results from the project and data indicated a reduction by half in fecal coliform bacteria levels. In 1986, an estimated 4,651.3 acres of runoff from street inflow connections were served by combined sewers (City of Minneapolis, 2006). By 2000, 98.5% of street drainage was separated, leaving approximately 69 acres that are still served by combined sewers. Each year the City identifies additional connected acreage. For example, in 2010 additional acres have been identified through continuous flow monitoring, smoke testing, and investigation.

The City's former National Pollutant Discharge Elimination System (NPDES) permit (Permit No. MN0046744, held jointly with the Metropolitan Council) required elimination of combined sewer overflows by its expiration in 2001. Since this goal was not fully achieved, a documented approach for the elimination of combined sewer overflows was required for permit renewal. The Metropolitan Council Environmental Services and the City of Minneapolis jointly conducted a combined sewer overflow study, completed in April 2002. Based on study results, the Minneapolis Tier II Comprehensive Sewer Plan was approved by Metropolitan Council Environmental Services in January 2003 and constitutes the Minneapolis Combined Sewer Overflow Program - Phase II for the five-year period 2003-2007.

Based on the study, the Combined Sewer Overflow (CSO) Program requires the removal of both public and private stormwater inflows to the sanitary sewer system. Minneapolis has worked to eliminate major sources of clear water discharges to the sanitary sewers in an effort to minimize the occurrence of CSO events. To-date, this program has been successful with no measured CSO events since 2010. CSO controls remain in the system to prevent sewage backups into or onto streets and/or into basements during a major precipitation event, and to protect sanitary sewer infrastructure from failures caused by excessive pressure. The EPA continues to regulate CSO systems through the NPDES permit program, which is administered in Minnesota by the MPCA.

Efforts to eliminate stormwater runoff connections to the sanitary sewers will persist as the City continues to identify catch basin and other sources of clear water to the sanitary sewers.

In March 2018, the City and the Metropolitan Council executed another MOU to direct their future efforts to coordinate the study of and investment in their connected sanitary sewer infrastructure. Consistent with the MOU, the City and the Metropolitan Council are initiating a comprehensive study of the City and the Metropolitan Council sanitary systems. The goals of that study, which will be completed during multiple phases, include identifying areas in the City with high inflow and infiltration (I/I) that contribute to increased risk of CSO events and highlighting how these areas related to areas where the Metropolitan Council's system is capacity limited. Areas identified as having I/I that contributes to risk of CSO and limited capacity will be prioritized for future investment by the City and the Metropolitan Council. Additionally, the study will evaluate the cost/benefit of alternatives to reduce the risk of CSOs, reduce I/I, and increase capacity. Alternatives to be studies include making potential changes to the remaining regulators in the City.

Metropolitan Council Surcharge Program

In 2016, the Metropolitan Council appointed the third Task Force of local community representatives to discuss and identify areas of improvement for the existing Metropolitan Council Environmental Services (MCES) Ongoing Inflow and Infiltration Program (Ongoing I/I Program) and the potential for future inflow and infiltration mitigation strategies for both public and private infrastructure. The Ongoing I/I Program aims to provide resources to communities to address excessive I/I by monitoring and informing communities about excessive flows, developing work plans to address those flows, and administering grants through State Bond funds. In 2014/2015, for every $1 in grant funding, the communities completed over $8 in construction projects. The grant program and the I/I program have incentivized over $180 million in community investment in local infrastructure since 2004. Recent studies show that communities that invest in reducing I/I have reduced peak flows by 20% or more. This reduction saves the communities from investing in larger infrastructure and keeps wastewater fees low.

In 2002, Minneapolis initiated the rain leader inspection program seeking to eliminate direct connection of roof drains to sanitary sewer. The Combined Sewer Overflow Program incorporates the rain leader inspection program. A new ordinance was approved effective August 1, 2003: Chapter 56, Prohibited Discharges to Sanitary Sewer System. It prohibits property owners from discharging rooftop rain leaders and private surface drainage to sanitary sewer and requires redirection to either the public stormdrain system or to side yards.

Dams

The Mississippi River has been molded (straightened) and maintained for navigation since 1930 such that today the River consists of a series of locks and dams and an uninterrupted navigation channel. The Upper Mississippi River has a maintained navigation channel depth of at least 9 feet. The Saint Paul District of the United States Army Corps of Engineers (USACE) operates and maintains 13 locks and dams, beginning at Upper Saint Anthony Falls in downtown Minneapolis and ending at Lock and Dam 10 in Guttenberg, Iowa. The USACE was required by law to close the Upper Saint Anthony Falls Lock to all navigation traffic on June 10, 2015. The lock is now only operated for upstream flood mitigation.

There are three dams with navigation locks within the watershed. Upper Saint Anthony Falls Lock and Dam and Lower Saint Anthony Falls Lock and Dam, completed in 1963 and 1956, respectively, are owned by Xcel Energy Center, which operates a hydroelectric plant. Construction was completed in 1963 and 1956, respectively. Upper Saint Anthony Falls Lock and Dam is the uppermost lock and dam along the River. Lock and Dam No. 1, also referred to as the Ford Dam, was formerly owned by Ford Motor Company, Inc., which operated an automobile assembly plant nearby. Due to plans to close, Ford Motor Company's hydroelectric power project was acquired and operated by Brookfield Renewable Power Inc. in 2008. Lock and Dam No. 2 superseded the role of Lock and Dam No. 2, known today as the Meeker Island Lock and Dam, built by the USACE north of the Lake Street-Marshall Bridge and in operation only from 1907 to 1912 before being closed and demolished. Caught in debates about river navigation and hydroelectric power as well as Minneapolis and St. Paul Rivalry, the ruins of the Meeker Island facility are now only visible on the east side of the River during periods of low water. The Meeker Dam was seen as having insignificant potential for hydroelectric power and no longer necessary for getting steamboats to St. Anthony and Minneapolis. Construction of Lock and Dam No. 1 was completed in 1917 but it underwent reconstruction in 1929. The main lock was not completed until 1932, and the last major rehabilitation took place from was as recent as 1978 to 1983. The locks of all three dams are 56 feet wide by 400 feet long. Lock and Dam No. 1 has two locks of this size, making it the only dam with twin locks in the Saint Paul District of the USACE.

The USACE is conducting Minneapolis locks disposition studies to examine the costs and benefits of continuing to operate federal projects which are no longer serving their authorized purpose (i.e. river navigation). If the dams were to be removed, the hydroelectric facilities would close because they depend on dams to keep the flow of water steady in wet or dry weather. The lower gorge area (generally between Lake Street and the Ford Dam) of the Mississippi Gorge Regional Park, is anticipated to change greatly with dam removal, leading to opportunities for new floodplain islands and floodplain habitat restoration as well as challenges to existing recreation such as rowing. If the Lower St. Anthony Falls Lock and Dam and Lock and Dam No. 1 are not removed, the gorge will remain in its current state as an impounded river and the impoundments will continue to fill with sediment (MPRB, 2019).

Loring Park Pond

Loring Park Pond (sometimes referred to as Loring Lake) is within Loring Park, originally named Central Park, on the southwest edge of downtown Minneapolis, east of the 90-degree bend of Interstate 94. Designated a Type 5 (open water) wetland (Cowardin et al., 1979), it is an eight-acre eutrophic lake that receives strictly urban surface runoff and ultimately discharges to the Mississippi River (see **Figure 43**). Loring Pond was created by connecting Jewett Lake and Johnson's Pond, two small bodies of water. The Minneapolis Park and Recreation Board acquired the lake in 1883, excavated Johnson's Pond to remove a floating bog, and filled the surrounding marsh. The pond was dredged again in 1976.

In 1997-1998 the Minneapolis Park and Recreation Board enhanced the aesthetic value of Loring Park Pond by improving both water level stability and water quality. A liner consisting of a layer of clay and several sequential soil layers was installed to minimize seepage and reduce or eliminate groundwater pumping to maintain pond levels. The pond was buffered with a vegetative strip to prevent Canadian Geese from accessing the pond and to protect the shoreline from erosion, filter pollutants, and create wildlife habitat. In addition, an aeration system was installed to help prevent oxygen depletion during the summer months. The lake has been stocked annually by the Department of Natural Resources with bluegill and black crappie since 2003 and channel catfish since 2005. Native wetland and upland plantings have helped protect water quality for the stocked fish.

In March 2007, accumulated sediments in the north basin of Loring Park Pond were dredged to restore deeper water levels and improve habitat. Dredging made the island in the north basin a distinguishable feature by deepening water levels under the bridge. Dewatering the northern basin and lowering the water level of the southern basin to dredge sediments had the unintended consequence of stimulating hybrid and narrow-leaf cattail growth, which the MPRB began removing in 2013 and replanting with native aquatic emergent vegetation. A significant amount of native emergent plants (notably sweet flag) installed as part of a 1999 planting were found to be doing well after the cattails were removed. An additional 5,000 plugs of a variety of native aquatic emergent plants were planted into Loring Pond in July 2016 (MPRB, 2016).

According to the 305(b) lake assessment, the south basin of Loring Park Pond has insufficient information to determine whether it supports aquatic recreation. Since 1992 the Environmental Operations Section of the Minneapolis Park and Recreation Board has monitored the Pond as part of a diagnostic study for the Chain of Lakes Clean Water Partnership. The 2017 trophic status index (TSI) score for Loring Pond was 63, which falls between the 50th and 25th percentile for lakes in the Northern Central Hardwood Forest ecoregion. There was no significant trend in TSI from 1992-2017 in Loring Pond ($p > 0.05$). Dredging projects from 1997-1998 and the summer of 2007 had large influence in water quality. Water levels were also manipulated from 2013-2016, with a large quantity of groundwater pumped into the lake in 2016, which may have improved the score (MPRB, 2017). From 1992 to 1996, the TSI was on an increasing trend. After stabilization of pond improvements, the TSI shifted to a decreasing trend, indicating steady improvement in water quality (MPRB, 2006). For 2019, The Lake Aesthetic and User Recreation Index gives Loring Park Pond an *excellent* for aesthetics (color and odor of water, garbage and debris), a *good* for water clarity, and a *poor* for habitat quality (aquatic plant and fish diversity) and recreational access. Loring Pond does not have a swimming beach and was therefore not scored for public health.

The Kasota Ponds, Including Mallard Marsh

The Kasota Ponds, including Mallard Marsh (referred to as Kasota Pond East), are located in St. Paul along either side of Kasota Avenue and to the west side of its intersection with Hwy 280. Mallard Marsh is approximately 1 mile south of Larpenteur Avenue on the south side of Kasota Avenue and to the west of Highway 280 among the Kasota Ponds (Cowardin et al., 1979). This deep freshwater marsh is 2.5 acres in size and is not meandered. The ponds treat stormwater runoff from the Bridal Veil Creek subwatershed during storm events and then slowly release that stormwater into the storm sewer system. Groundwater recharge and discharge occurs in the Kasota area, including Skonard Spring, and discharges into one of the ponds. Mallard Marsh and the Kasota Ponds are a remnant of a much larger 100-acre wetland and pond complex.

Saint Anthony Park Community Council (SAPCC) sponsors annual cleanups around Mallard Marsh to remove discarded trash in shoreline areas. Volunteer turnout usually reaches 50-60. Historical volunteer efforts have included tree planting, nesting box installation, buckthorn clearing, turtle habitat creation, and pollutant removal. Saint Anthony Park Community Council volunteers have monitored Mallard Marsh, including three surrounding ponds, for at least 15 years. They have recorded water quality indicators such as observations, temperature, pH, and conductivity. Besides water quality monitoring, a basic wetland inventory was done by SAPCC and University of Minnesota faculty and students in 1999-2000. The inventory included three turtle species, vegetation, fish and other wildlife including reptiles, amphibians, birds, and mammals. Fathead Minnows, Brook Stickleback, crayfish, and salamanders have also been found in Mallard Marsh and surrounding ponds (MWMO, 2006).

MWMO staff have been monitoring the area since 2008. Biological sampling was conducted in 2011 and 2016 to develop an IBI. The results indicated all three monitored wetlands are in poor health based on aquatic plant communities. Receiving runoff from various impervious surfaces including Highway 280, the wetlands were listed on the Federal Clean Water Act's Section 303(d) list of impaired waters in 2014 for chloride and were part of the Minnesota Pollution Control Agency's TCMA Chloride Total Maximum Daily Load Study and TCMA Chloride Management Plan (MWMO, 2019). A basic wetland inventory was done by Saint Anthony Park Community Council and University of Minnesota faculty and students in 1999-2000. In 2015 Saint Anthony Park Community Council received a grant with the Minnesota Conservation Corps to remove buckthorn and to restore and stabilize shoreline areas around Mallard Marsh and three surrounding ponds. In 2018 MWMO monitoring staff prepared a report to summarize 10 years of water quality and Biological Sampling. Again in 2019, Saint Anthony Park Community Council received a MWMO stewardship funds mini grant to remove buckthorn and to restore and stabilize shoreline areas around Mallard Marsh and three surrounding ponds.

Bridal Veil Creek

Bridal Veil Creek was originally a small creek or gully flowing southwesterly and draining a large, wooded swampy area covering about 1,177 acres before plunging into the Mississippi River gorge. Beginning in the mid-1800s with the growth of railroad yards, commercial areas, and residential areas, the creek was enclosed in a piecemeal fashion within culverts. The current pipeshed drains about 740 acres and lies entirely west of Highway 280. The creek is visible at its confluence with the Mississippi River just north of the Franklin Avenue Bridge and west of East River Parkway in Minneapolis. Once dramatically spilling over the bluffs into the Mississippi River, Bridal Veil Falls now have very little water and flows over a manmade tiered wall into a stony creek bed before emptying into the Mississippi River. The creek is visible via a path and viewing platform accessible by stairs north of Franklin Avenue.

During subsequent residential development, some of the stormwater runoff was diverted into sanitary sewers and discharged directly into the river. During the mid-1930s, the interceptor system was built to collect the sanitary flows, but not the stormwater runoff, which was allowed to mix with the sanitary sewage and permitted to overflow into the river in large rain events. The construction of commercial buildings, paved streets, driveways, sidewalks, and homes increased the amount of stormwater conveyed by Bridal Veil Creek. The size of the stormdrain pipes increased with time, from a 27-inch to a 72-inch pipe following construction of I-94.

After the construction of Highway 280 (built between 1954 and 1957), the City of Saint Paul Public Works noted that projected developments in the Bridal Veil Creek subwatershed would eventually exceed the design capacity of the storm sewer system. In 1995, the City of Saint Paul completed the Eustis Tunnel, separating Saint Paul runoff from the Minneapolis storm sewer system to correct capacity problems and shared management issues. The Cities of Lauderdale and Falcon Heights, formerly connected to the Bridal Veil sewer system, began draining to the Eustis Tunnel (MWMO, 2006).

The Bridal Veil Open Space, a 6.6-acre site bordered by Kasota Avenue to the south, a Burlington Northern Railroad line to the north, and industrial properties, is downstream from a Superfund site (the only one in the MWMO) to the northeast where a wood treatment facility operated from 1908 until 1962. This facility treated wooden telephone poles with creosote and pentachlorophenol (PCP) preservative. Waste product was discharged from the treatment area of the Valentine Clark site into a channel connecting to Bridal Veil Creek and southward beneath the railroad tracks to the Bridal Veil Open Space. The Open Space included Bridal Veil Pond, which was created in 1970 by the city of Minneapolis to serve as a storm water detention pond. Much of the ground adjacent to the Superfund site, including Bridal Veil Pond and the surrounding Bridal Veil Open Space, was polluted by chemical runoff from the site as well as runoff from Hwy 280, which is located directly over the lowest portions of the Bridal Veil stream valley. The pond was stocked with fish by the Minnesota Department of Natural Resources from 1976 to 1991, but ducks and fish were killed when upstream dredging of Bridal Veil Creek released contaminants in December 1990. Contaminants of concern include polyaromatic hydrocarbons (PAH), PCP, and dioxins.

Local community groups, such as Southeast Como Improvement Association and the SAPCC, have made the Bridal Veil Creek Watershed a high priority. In the winter of 2007-2008, Minneapolis Public Works and the Minnesota Pollution Control Agency remediated Bridal Veil Open Space and Bridal Veil Pond within it. Remediation activities included removal of four feet of contaminated soil over the entire Bridal Veil Open Space and replacement with clean soil, filling of the previous Bridal Veil Pond and conversion to a wetland area reseeded with native vegetation, and creation of a shallow, rocky meandering stream within the wetland to promote natural bioremediation of contaminants. In addition, the project involved extension of the storm sewer from the railroad tracks to a new outfall by the pond, limited removal of contaminated sediment from the creek, and installation of sedimentation basins to decrease the potential for contaminated sediments to migrate into the new wetland area.

Bassett Creek

Bassett Creek flows through the MWMO by way of a tunnel which was built in phases and completed in 1992. The new Bassett Creek Tunnel is in an entirely different alignment than Old Bassett Creek Tunnel (OBCT). The new tunnel was routed through downtown Minneapolis and its outfall is just downstream from Upper St. Anthony Falls dam; the outfall carries the majority of the flow of Bassett Creek (MPRB, 2016a). Although OBCT no longer carries Bassett Creek flow from portions of Minneapolis and eight upstream cities, it remains in-place to convey local flows from its remaining drainage area of 870 acres within the Central and Near North Communities of North Minneapolis. A study was completed by Barr Engineering for the MWMO and City of Minneapolis to understand the structural condition of OBCT and develop a plan to remove accumulated sediment and debris (Barr Engineering Co., 2017). A boundary change between the BCWMC and the MWMO transferred the area encompassing both tunnels to the MWMO. In 2000, the BCWMC, MWMO, and the City of Minneapolis entered into a joint and cooperative agreement, which resulted in a boundary change that transferred 1,002 acres from the BCWMC to the MWMO. The agreement defines the responsibilities of the MWMO and the BCWMC with respect to the new and old tunnel. For example, the agreement requires accommodation of a 50 cfs overflow from Bassett Creek to OBCT during a 100-year storm event. The agreement also requires written approval of the BCWMC for changes in the area tributary to the new tunnel, or increases in the rate of runoff to the new tunnel by either the City of Minneapolis or the MWMO. A copy of the agreement is attached as Appendix F.

Sullivan Lake

Sullivan Lake is located in Columbia Heights along 51st Avenue, east of Central Avenue. According to the City of Columbia Heights' Comprehensive Plan (2010), Sullivan Lake serves as a detention area for stormwater. Its drainage basin is 0.73 square miles and the surface area is 15.3 acres at the normal water level of 880.3. A gated outlet structure controls outflow from the lake. The lake is surrounded by the largest park in Columbia Heights, with trails around the lake. The MWMO contracted Anoka Conservation District to complete a stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects to address TP and TSS throughout the drainage areas to of Sullivan as well as Highland Lake described below (Anoka Conservation District, 2019). MWMO monitoring staff have been partnering with Anoka Conservation District. Water quality monitoring is conducted on 3 year rotation while lake levels are monitored on an annual basis. MWMO water quality monitoring team has also collected bathymetric data on Sullivan Lake.

Highland Lake

Highland Lake is located in Kordiak County Park in the northeast portion of Columbia Heights. The City of Columbia Heights' Comprehensive Plan (2010) states that Highland Lake has six stormwater drains discharging to it and serves as a stormwater detention area. The drainage basin is 0.32 square miles and the surface area is 15.7 acres at a water elevation level of 996.1 feet above sea level. MWMO monitoring staff have been monitoring the water quality of Sullivan Lake by partnering with Anoka Conservation District. Water quality monitoring is conducted on 3 year rotation while lake levels are monitored on an annual basis. MWMO water quality monitoring team has also collected bathymetric data on Highland Lake.

Public Waters and Wetlands

The Minnesota Department of Natural Resources identifies the entire stretch of the Mississippi River, Loring Pond, Mallard Marsh, Sullivan (Sandy) Lake, and Highland (Unnamed) Lake as the only public waters within the watershed (see **Figure 43**). Public waters include, but are not limited to, those where there is publicly owned and controlled access, waters of the state determined to be public waters by court jurisdiction, watercourses with a drainage area greater than two square miles, and water basins surrounded by publicly owned lands. Public waters wetlands are types 3, 4, or 5 wetlands (Cowardin et al., 1979) that are at least two and one-half acres in surface area. Minnesota's public waters and wetlands have been inventoried by the Minnesota Department of Natural Resources. Minnesota Department of Natural Resources public waters and wetlands maps for Hennepin and Ramsey Counties are adopted by reference and are available from Minnesota Department of Natural Resources.

The Minnesota Department of Natural Resources provides waterbody size, ordinary high water levels, and normal water levels for most public waters and wetlands. Current records of water levels are available from the MWMO office, the regional hydrologist of the Minnesota Department of Natural Resources, and the Hennepin and Ramsey Counties Public Works Departments.

National Wetlands Inventory

The United States Fish and Wildlife Service has inventoried wetlands using the Cowardin system of wetland designation (see Cowardin et al., 1979). These maps are known as the National Wetland Inventory Maps. National Wetlands Inventory wetlands are inventoried for the United States Geological Survey (USGS) quadrangle maps: Minneapolis North, Minneapolis South, New Brighton, and Saint Paul West. The jurisdictional limit of any wetland, however, must be determined by trained wetland delineators based on field review.

Figure 43 also identifies the National Wetlands Inventory wetlands within the MWMO including three systems: riverine, lacustrine, and palustrine. Riverine systems are those wetlands or deepwater habitats contained within a channel that is not dammed nor dominated by trees or emergent vegetation. Lacustrine systems are those wetlands or deepwater habitats in a depression or in a dammed river channel that have less than 30% coverage of vegetation (e.g. trees and persistent emergent varieties) and total at least 20 acres in surface area. Palustrine systems are all nontidal wetlands that are dominated by vegetation (e.g. trees and emergent vegetation). In systems lacking such vegetation, palustrine includes areas less than 20 acres and with active bedrock shoreline features less than 6.6 feet (2m) deep. These systems can characterize some tidal areas, though they are not applicable here.

Most wetland area in the MWMO is the part of the Mississippi River affected by dams. Those wetlands not along the Mississippi River are found in pockets throughout the urban watershed. The Mississippi River, Loring Park Pond, Bridal Veil Creek, Mallard Marsh, and the Kasota Ponds are associated with National Wetlands Inventory wetlands.

The MWMO conducted a function and value assessment of any wetlands. The project used Version 3.3 of the Minnesota Routine Assessment Method for Evaluating Wetland Functions. In addition to traditional federal and state data sources, the MWMO identified potential wetland sites using soils data from its *Historic Waters of the MWMO* study (MWMO, 2011) and data gathered from its

recent Land Cover Classification and Natural Resources Inventory (MWMO, 2008). To view Minnesota Routine Assessment Method visit the Minnesota Department of Natural Resources website or go directly to the web address:
http://www.bwsr.state.mn.us/wetlands/mnram/MNRAM_fulltext_9_2010.pdf.

Results of this study will be integrated in the MWMO's planning and resource management efforts.

Metropolitan Mosquito Control District Wetland Map

The Metropolitan Mosquito Control District maintains its own maps of all wet areas that provide habitat for larval mosquitoes in the seven-county metropolitan area. Areas as small as 400 square feet that occasionally hold water for seven days are mapped in **Figure 44**. In addition to lakes and ponds, the maps include cattail marshes, grassy ditches or vegetative swales, and a wide array of natural or constructed water holding areas. Each wetland is classified into wetland types using the US Fish and Wildlife Service Circular 39 system. This wetland inventory is updated every five years by field inspection. The wetland inventory maps are available for review at the offices of MWMO and Metropolitan Mosquito Control District.

Impaired Waters

Previous development and redevelopment in the watershed have placed a significant burden on the health and sustainability of the MWMO's water resources due to increasing impervious surfaces generating polluted stormwater runoff. Section 303(d) of the Federal Clean Water Act requires that states establish total maximum daily loads (TMDLs) of pollutants to waterbodies that do not meet water quality standards. The loading limits are to be calculated such that, if achieved, the waterbody would meet the applicable water quality standard. To comply with the Clean Water Act, the Minnesota Pollution Control Agency assesses the state's waters, lists those waterbodies that are impaired (i.e. do not meet water quality standards), and conducts studies to determine the pollutant loading limits for the impaired waterbodies. These studies are known as Total Maximum Daily Load studies.

The Minnesota Pollution Control Agency sets target start and completion dates for individual Total Maximum Daily Load studies. Studies are usually funded by either the Minnesota Pollution Control Agency or by local units of government. Each Total Maximum Daily Load study describes the impairment, identifies the relevant pollutant(s), inventories the pollutant sources, calculates the assimilative capacity of the waterbody, allocates the allowable loads to the different sources, and prescribes an implementation strategy to restore the waterbody to meet water quality standards. Within a year of completing the Total Maximum Daily Load study, the Minnesota Pollution Control Agency requires the completion of an implementation plan, which provides more specific management details than are provided in the initial Total Maximum Daily Load study.

In 2016 the Minnesota Pollution Control Agency (MPCA) approved the Twin Cities Metropolitan Area (TCMA) Chloride Management Plan. The MPCA worked with stakeholders in the Seven County Twin Cities Metropolitan Area (TCMA) to assess the level of chloride in water resources, including lakes, streams, wetlands, and groundwater. There are two primary sources of chloride to the TCMA water resources: 1) salt applied to roads, parking lots and sidewalks for deicing; and 2) water softener brine discharges to municipal wastewater treatment plants (WWTPs). The MPCA and stakeholders also worked together to develop a plan to restore and protect waters impacted by chloride. This Chloride Management Plan (CMP) incorporates water quality assessment, source identification, implementation strategies, monitoring recommendations, and measurement and tracking of results into a performance-based adaptive approach for the TCMA. The goal of this plan is to develop the framework to assist local partners in minimizing salt (chloride) use and provide safe and desirable conditions for the public. The TMDLs were developed for each of the lakes, wetlands, and streams in the TCMA impaired for chloride. Chloride impaired waters in the MWMO along with those having other impairments show up in **Table 23**.

MPCA has identified 11 non-mercury/non-toxic impaired water bodies that are completely or partially within the boundary of the MWMO sub-watershed boundary as of the 2018 EPA approved 303(d) impaired waters list. Five of these impaired waterbodies have an approved TMDL plan with the remaining six having targeted TMDL completion dates within the timeframe of this updated water plan. Nutrient/eutrophication biologic indicators, chloride, fecal coliform (E.coli), Total Suspended Solids (TSS) (South Metro Mississippi Turbidity TMDL) remain issues within some of the surface waters within the MWMO's boundaries. MWMO's listed waters and their impairments are shown in **Figure 45**, and **Table 23**. The information was taken from the 2018 MPCA Impaired Waters List and is provided only for water bodies within the MWMO.

In 2010, the MPCA began work in the Mississippi River – Twin Cities HUC-8 level watershed as part of the watershed approach to restoring and protecting water quality. The resulting monitoring and assessment report can be found at the following webpage. https://www.pca.state.mn.us/water/watersheds/mississippi-river-twin-cities . In 2020, the MPCA will revisit the Mississippi River - Twin Cities Watershed to monitor and reassess lakes and streams.

Table 23: Impaired Waters of the MWMO

Waterbody	Year Listed	Impairment	Target Completion Year or Status
Streams			
Bassett Creek - Medicine Lake to Mississippi River[1]	2010	Chloride	TMDL Approved in 2016
	2008	Fecal Coliform	TMDL Approved in 2014
	2004	Fish Bioassessment	2025
Mississippi River - Crow River to Upper St. Anthony Falls	2006	Fecal Coliform	2024
	1998	Mercury in Fish Tissue	TMDL Approved in 2007
	2016	Nutrients	2018
	2002	PCB in Fish Tissue	2020
Mississippi River - Upper St. Anthony Falls to St. Croix River	1994	Fecal Coliform	2022
	1998	Mercury in Fish Tissue	TMDL Approved in 2007
	1998	Mercury in Water Column	TMDL Approved in 2007
	2016	Nutrients	2018
	1998	PCB in Fish Tissue	2020
	2008	PFOS in Fish Tissue	2025
	2014	PFOS in Water Column	2025
	2014	TSS	TMDL Approved in 2016
Lakes			
Loring (South Bay)	2014	Chloride	TMDL Approved in 2016
Kasota Pond North	2014	Chloride	TMDL Approved in 2016
Kasota Pond West	2014	Chloride	TMDL Approved in 2016
Mallard Marsh	2014	Chloride	TMDL Approved in 2016
Sandy	2002	Nutrients	2025
Unnamed (Highland Lake)	2004	Nutrients	2025

[1] Bassett Creek is wholly contained underground within the MWMO.

PCB = Polychlorinated biphenyl

PFOS = Perfluorooctane Sulfonate

TSS = Total Suspended Solids

MPCA 2018 Impaired Waters List

Ditches

There are no public ditches within the watershed as established by Minnesota Statutes chapter 103E.

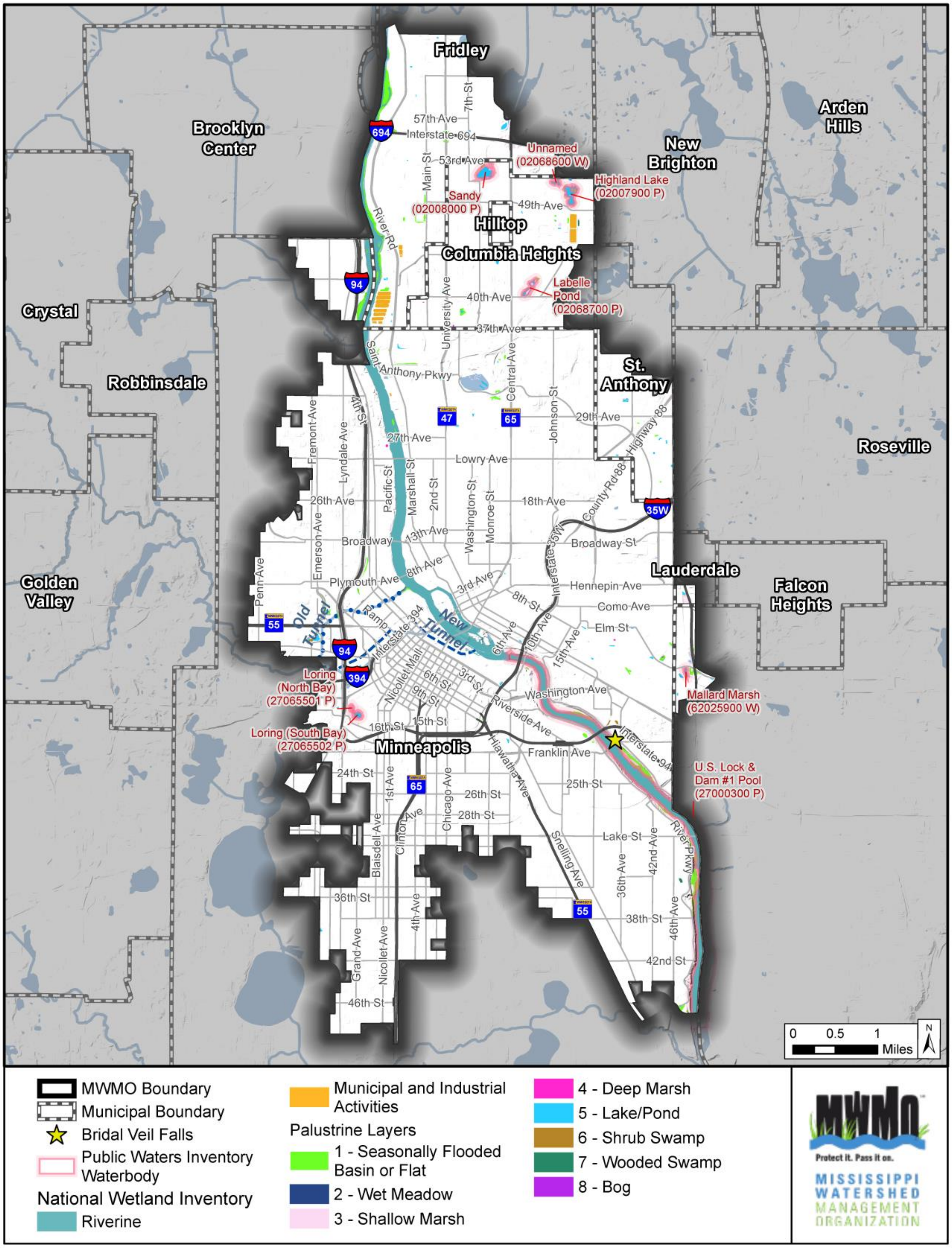


Figure 43: Surface Water Resources of the MWMO

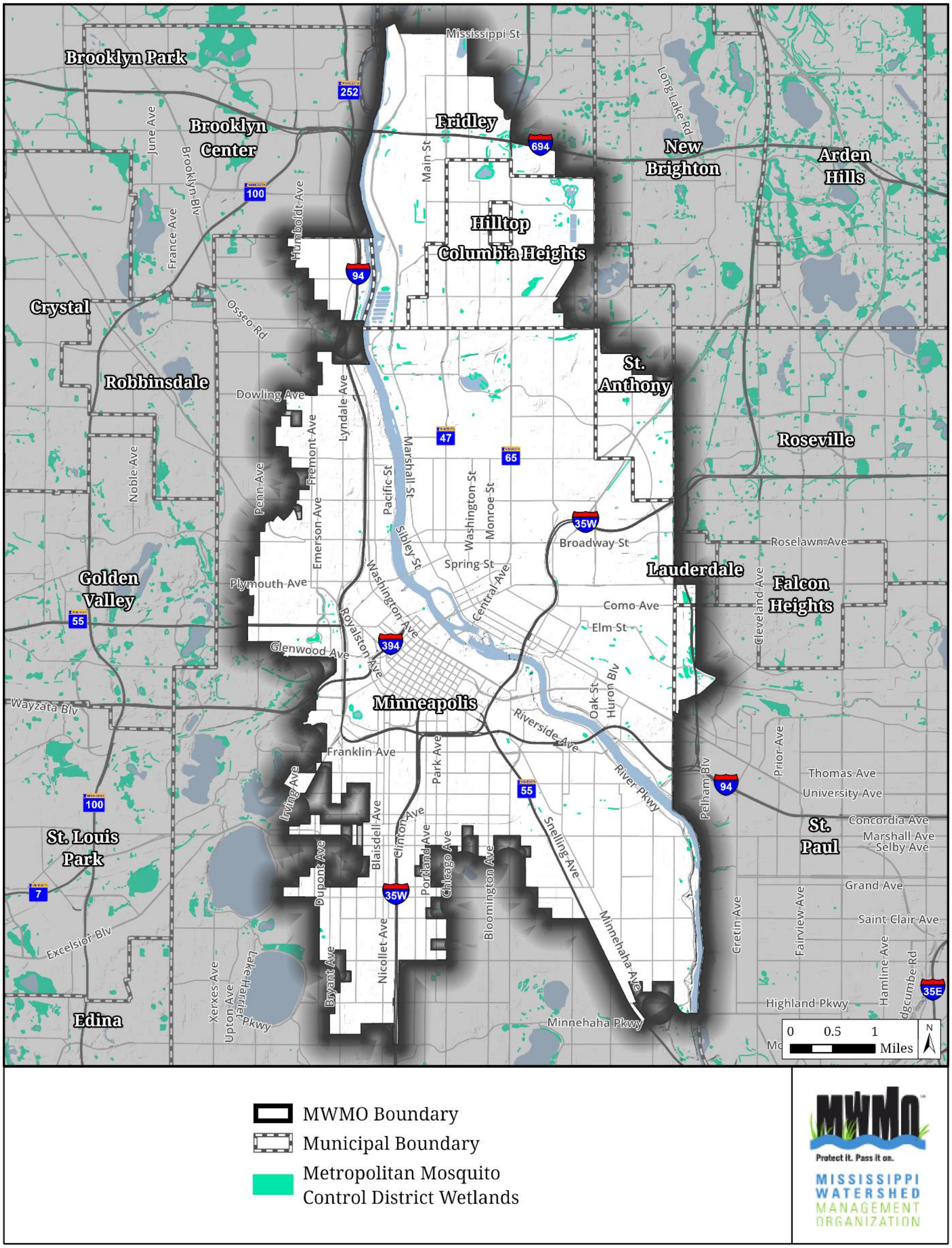


Figure 44: Metropolitan Mosquito Control District Wetland Areas in the MWMO

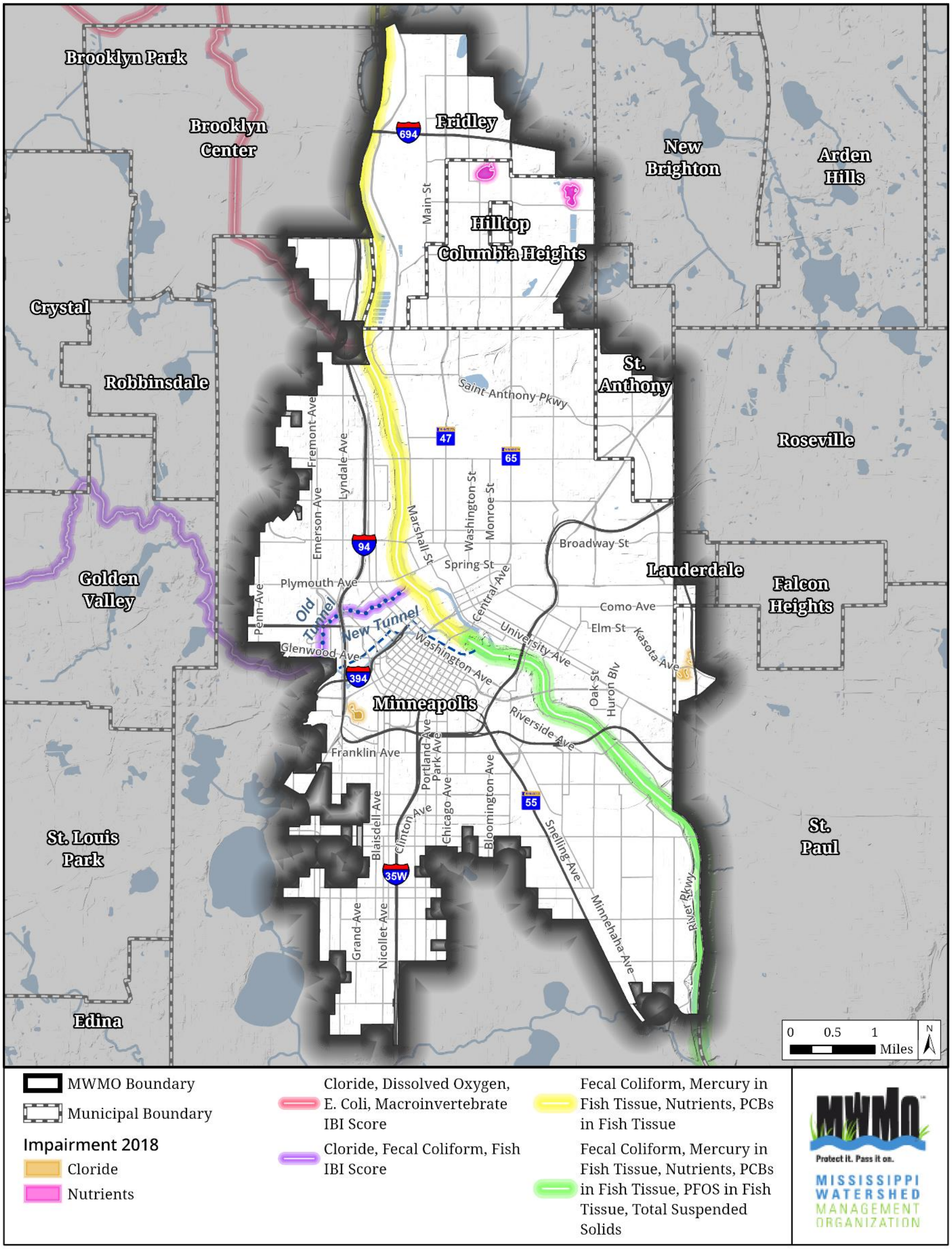


Figure 45: Impaired Waters of the MWMO

4.5.3 Stormwater System

The MWMO is highly urbanized. Many of the streams, lakes, and wetlands once found in the watershed have been buried, filled, drained, or otherwise altered as the watershed developed. As historic surface water drainageways were altered to make way for development, an extensive series of pipes and tunnels were put in place to collect and convey stormwater downstream. This conveyance system is mostly manmade—stormwater pipes and tunnels have replaced the creeks and streams that once conveyed water within the area to the Mississippi River. Understanding this extensive stormwater pipe and tunnel system is key to watershed management in the MWMO. Pipesheds throughout the MWMO can be found in **Figure 46** and the Drainage area of the Minneapolis Storm Tunnel System can be found in **Figure 49**.

The MWMO has aggregated pipesheds shown in **Figure 46** into five subwatershed management units. These subwatershed areas shown in **Figure 47** will be the management units the MWMO uses when identifying projects and assessing changes (improvements/degradation) occurring in the watershed's resources. The MWMO reserves the right to define additional areas in the future if needed. Four main criteria were used to establish the subwatershed management units: existing pipeshed boundaries, potential greenway corridors based on existing land cover, existing MWMO boundaries, and existing pervious areas.

The City of Minneapolis stormwater system receives runoff from approximately 50 square miles. The system includes main line storm pipes, deep storm tunnels (23 miles in total), catch basins, outfall control structures, pump stations, and numerous stormwater management practices including ponds, wetlands, and grit chambers (City of Minneapolis, 2008a). Cross connections between storm sewer and sanitary sewer systems still exist.

Over the past several years the City has been updating its stormdrains spatial database. Almost all of the stormdrain system has been digitized with attribute information attached. Minneapolis Park and Recreation Board stormdrain networks were incorporated into the database recently.

The major Saint Paul storm system within the MWMO is the Eustis Branch, of the Saint Anthony Park Storm Tunnel, in the Bridal Veil Creek region. The Saint Paul storm sewer network is available from the City in GIS format. The City of Lauderdale has mapped the storm sewer system throughout the city. The maps are available in Geographic Information System (GIS) format. The City of Saint Anthony Village storm sewer system is not available electronically.

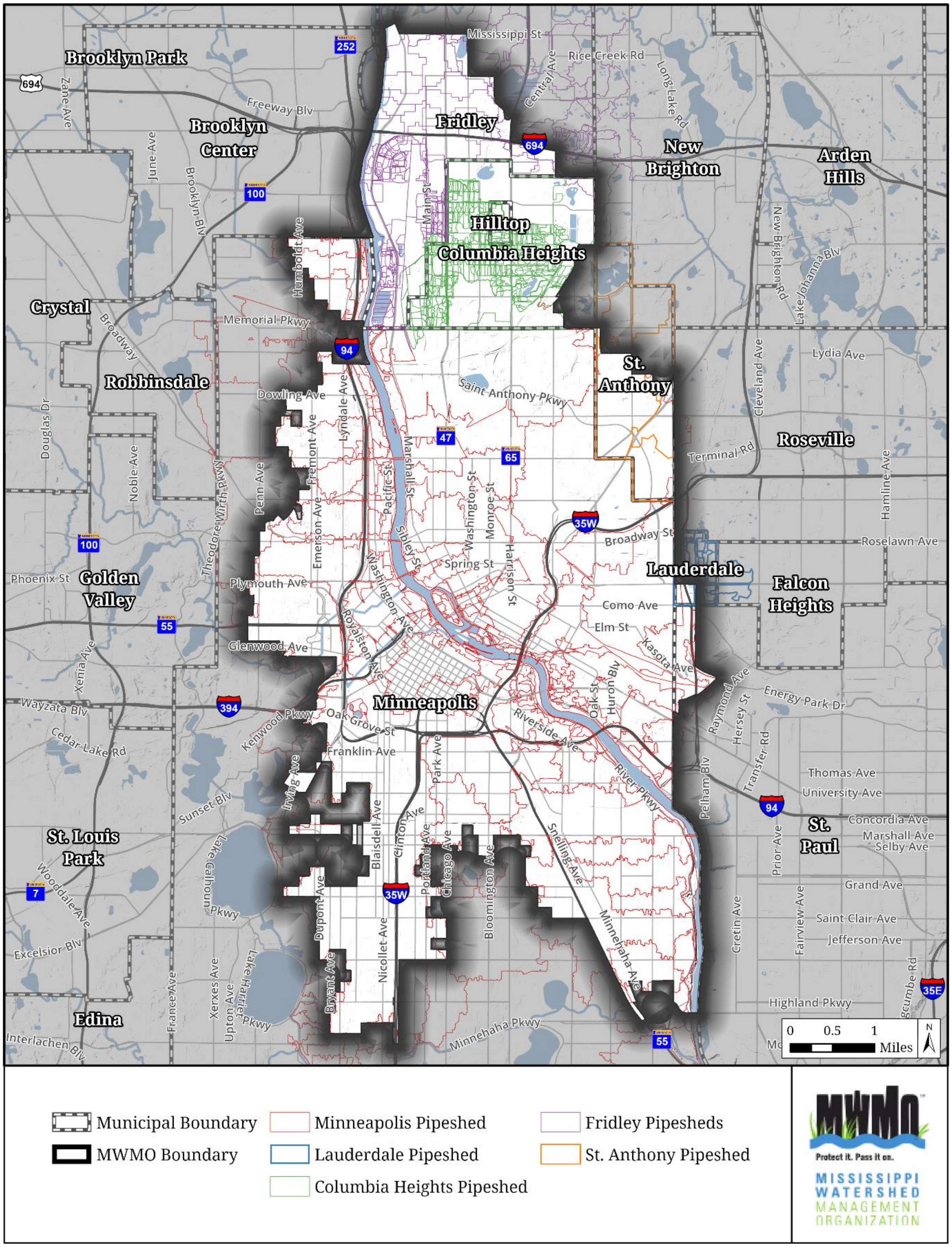


Figure 46: Pipesheds of the MWMO

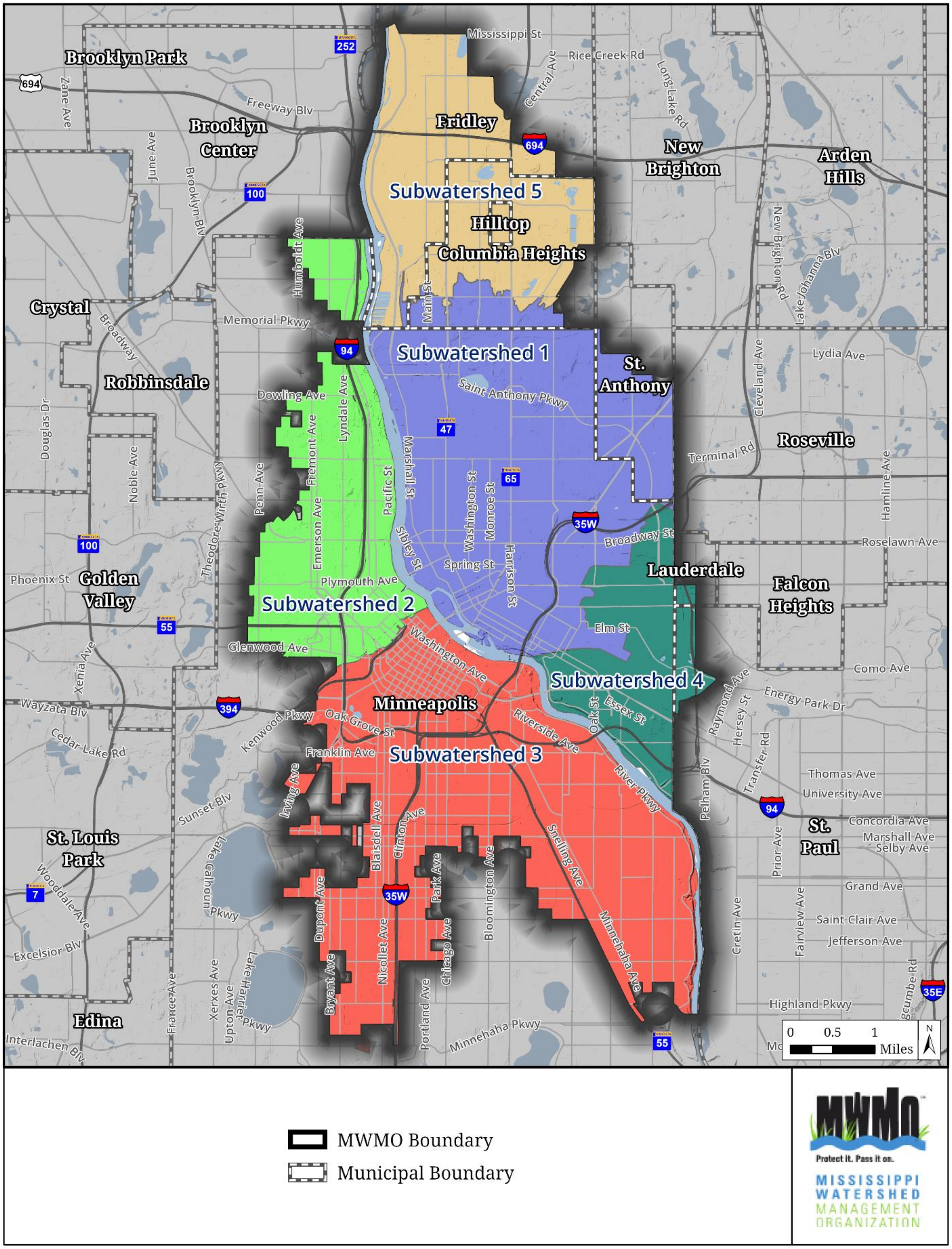


Figure 47: 2010 Subwatershed Management Areas of the MWMO

4.5.4 Flood-Prone Areas

The urbanized condition of the MWMO, coupled with a natural history that indicates this area once featured a network of streams and wetlands, now defines a landscape that is (among other things) prone to flooding. July 1997 rainfall totaled twelve inches and included five events that produced flooding complaints throughout the watershed. These five events prompted simultaneous flood control awareness and action on the part of the cities within the MWMO.

From 1998 to 2006, the City of Saint Anthony Village completed approximately $16 million in flood improvements based on recommendations from their 1997 analysis of problem areas (City of Saint Anthony Village, 1997); 7 of the 13 problem areas were located within the MWMO. The City has since identified an additional flooding problem area at Anthony Lane South in the Saint Anthony Village Industrial Park. The City is planning to undergo a feasibility study to investigate the causes and solutions for this problem. The site is within the New Brighton Boulevard Stormdrain (NBBS) subwatershed. The area of the watershed that includes the Village of Saint Anthony defines the NBBS.

In 2018, the City published an inventory in their Water Resource Management Plan of all their flood mitigation projects including designation of study areas and prioritized flood mitigation projects for implementation. This is part of the City's flood mitigation program. The program addresses localized flooding and drainage problems. The programs look at volume, load, and rate controls and aim to protect homes and businesses and improve water quality. Hydraulic and hydrologic modeling is being done citywide to determine the extent of the localized problems. When modeling is completed in 2018, flood areas will be evaluated. Areas found to be a highest risk for flooding will be subject to feasibility studies. The results of the feasibility studies will inform selection and prioritization of solutions considering constructability and costs, as well as the need to leverage other opportunities and funding. Solutions for larger-scale drainage problems may include underground storage, pipes, and ponds in combination with green infrastructure such as rain gardens, bioswales, constructed wetlands, and pervious pavements. Future projects for this funding category will be informed by the Hydrologic and Hydraulic Modeling efforts currently underway.

The City of Saint Paul made substantial flood mitigation efforts within the MWMO back in 1995, the year of completion of the Eustis Tunnel, and throughout the past few decades leading up to completion of combined sewer overflow work. The Tunnel resulted in major alleviation of potential flooding in the Bridal Veil Creek (BVC) subwatershed. The BVC subwatershed, as discussed earlier, is that area of the watershed that includes the cities of Lauderdale, Saint Paul, and east Minneapolis.

In 2003 the City of Lauderdale rebuilt city streets, the utilities under those streets (natural gas, water, sanitary sewer), and used stormwater management practices to create stormwater drainage capabilities throughout the residential portion of the city which integrated with surrounding established systems.

Since 2014, the MWMO has been working with member cities Minneapolis, Columbia Heights, Hilltop and Fridley on the development of comprehensive water quantity models (Hydrology and Hydraulic: H & H). These models are used to identify areas at risk of flooding, predict the frequency and severity of flooding, and help in the targeting and performance assessment of flood mitigation projects. The MWMO delineation and naming of these subwatersheds can be found in **Figure 48**.

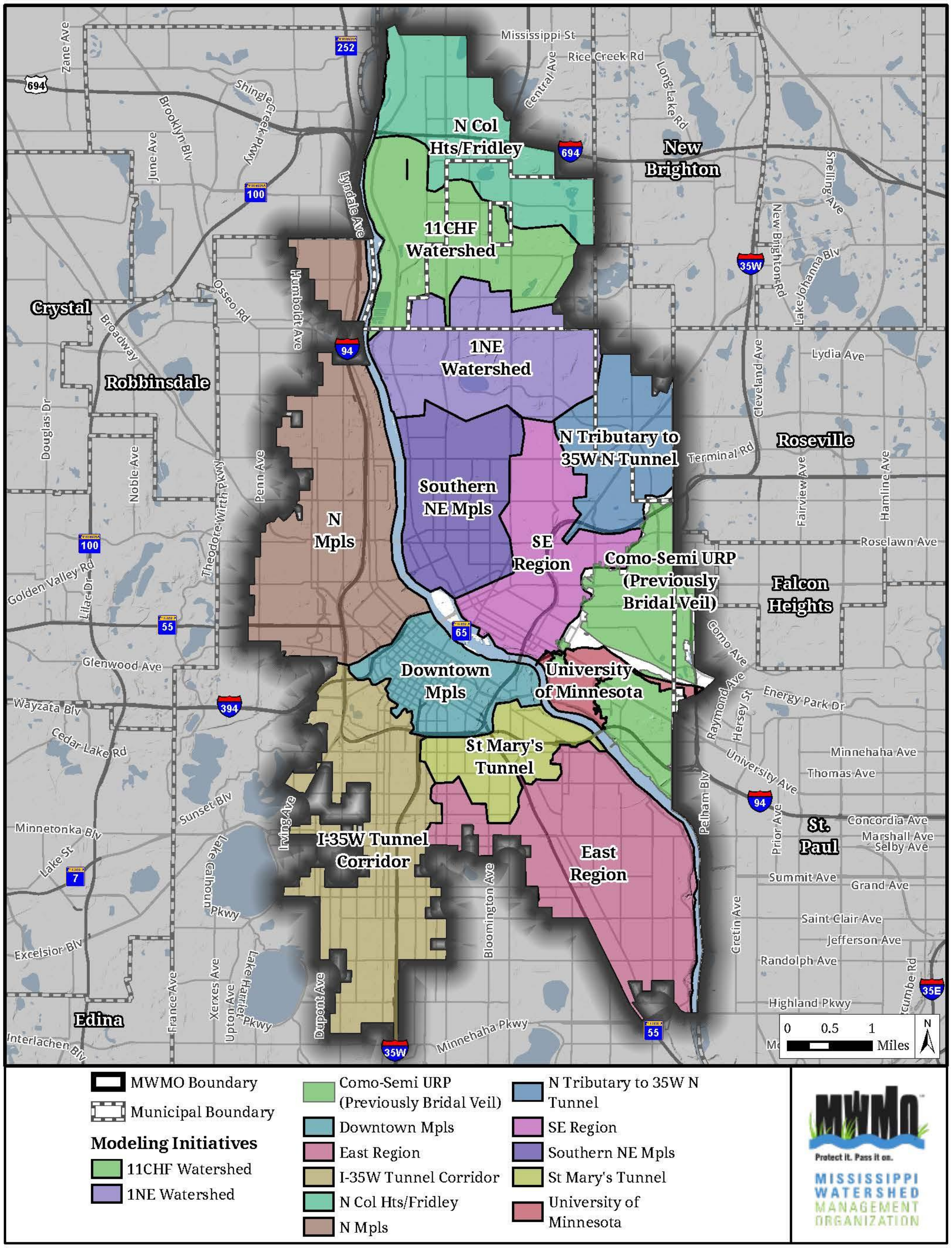


Figure 48: Map of MWMO new H&H and P8 Modeling Subwatersheds

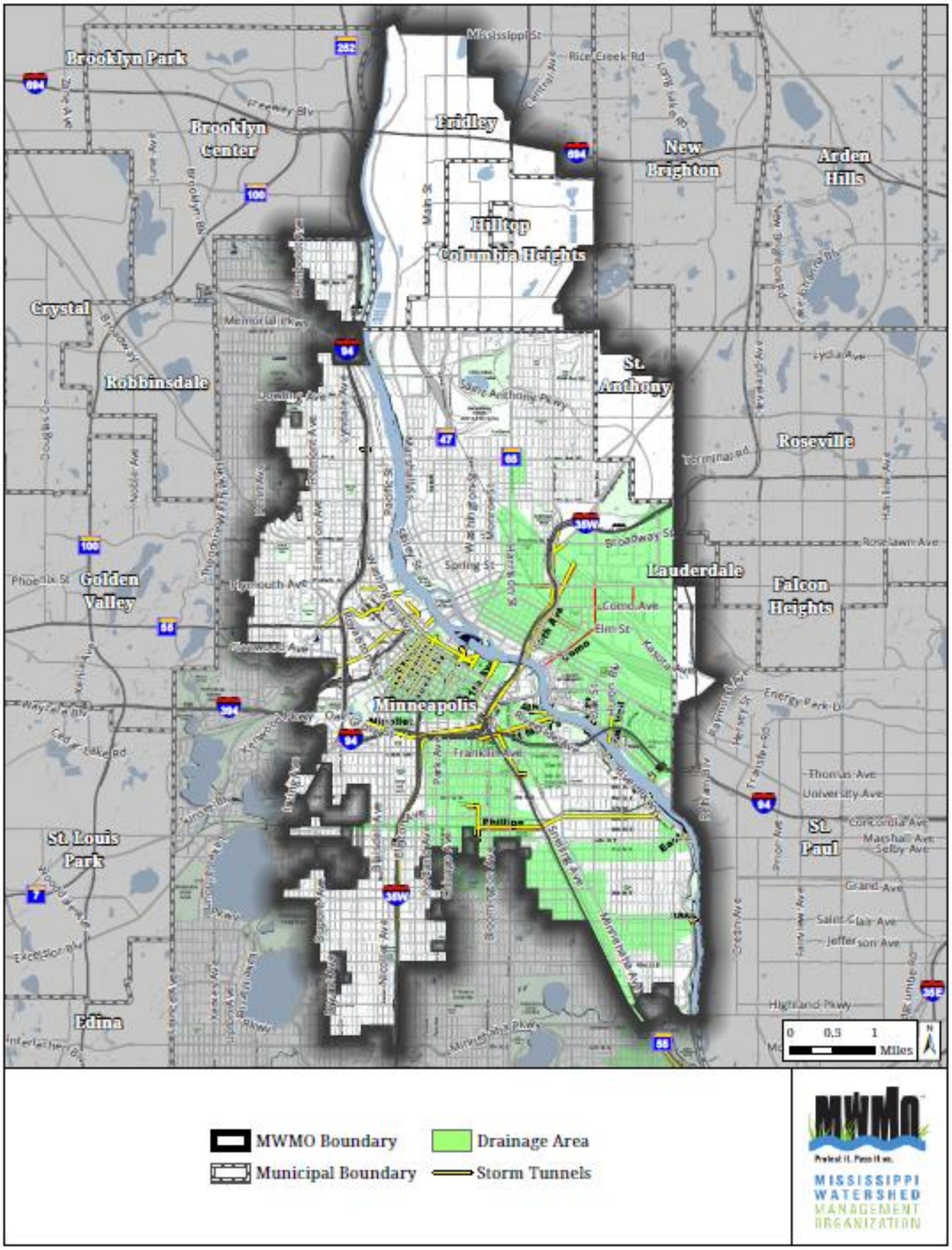


Figure 49: Minneapolis Storm Tunnel System

4.5.5 Floodplain and Shoreland

Floodplain

Most floodplains in the watershed are adjacent to the Mississippi River except for a small zone affiliated with Bassett Creek on the west side and some small areas in the City of Columbia Heights. All floodplains are within the Cities of Fridley and Minneapolis. Current 100- and 500-year floodplains are illustrated in **Figure 50**. Flood insurance studies are completed by the Federal Emergency Management Agency in compliance with the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial National Flood Insurance Program Maps for the City of Minneapolis were completed in 1974. Initial Flood Insurance Rate Maps (FIRM) were completed in 1981. The most recent FIRM update in the Twin Cities metropolitan area was 2016.

By law, Minnesota's flood-prone communities are required to adopt floodplain management regulations when adequate technical information is available to identify floodplain areas and to participate in the National Flood Insurance Program. Participation in the National Flood Insurance Program is a commitment to administering and enforcing ordinances that are intended to keep people and structures reasonably safe from flooding and enables the people of Minnesota to insure themselves from future losses through the purchase of flood insurance.

When the FEMA maps are updated, as they were in 2004, the cities participating in the National Flood Insurance Program must adopt those new maps by the effective dates or FEMA suspends them. The maps are adopted by either adopting a new floodplain management ordinance or amending an existing ordinance. State law requires that Department of Natural Resources approve the draft ordinance before they adopt it. All MWMO member cities participate in the National Flood Insurance Program and Columbia Heights, Fridley, Lauderdale, Minneapolis, Saint Paul, and Saint Anthony Village have approved floodplain ordinances.

Shoreland Ordinances

The Minnesota Department of Natural Resources (DNR) administers the Shoreland Management Program. This program requires that local governments implement, administer, and enforce shoreland management standards through their planning and zoning controls. A model shoreland ordinance was updated October 3, 2019. The model serves as a tool for local governments to develop new or amend existing shoreland ordinances. These requirements must be met within the MWMO's jurisdiction by the cities of Columbia Heights, Fridley, and Minneapolis.

The DNR completed the Rule Making process for the Mississippi River Critical Corridor Area (MRCCA) in 2017 Minn. R 6106.0010 - 6106.0180 and revised the MRCCA boundary legal description in 2018 (Minn. Rule 6106.005 Subp. 64). As a result, the cities of Fridley, Minneapolis, and St. Paul were all required to develop plans and zoning regulations that comply with state rules which were submitted to the Metropolitan Council and DNR as a part of their 2040 Comprehensive Plan approval process.

Minnesota's buffer law passed in 2015 establishes new perennial vegetation buffers of up to 50 feet along rivers, streams and ditches that will help filter out phosphorus, nitrogen, and sediment. The law provides flexibility and financial support for landowners to install and maintain buffers.

The DNR's role in Minnesota's buffer law is to produce and maintain a map of public waters and public ditch systems that require permanent vegetation buffers. The DNR released the buffer protection map in July 2016. The map is helping to guide the implementation of Minnesota's buffer law by landowners, with the help of the Board of Water and Soil Resources (BWSR), Soil and Water Conservation Districts (SWCDs), Drainage Authorities and other local governments. These requirements must be met within MWMO's jurisdiction by the cities of Columbia Heights, Fridley, and Minneapolis.

4.5.6 Surface Water and Water Quality & Quantity Modeling

Surface water and water quality and quantity modeling provides communities and organizations with the ability to identify flood-prone areas and test solutions, identify key areas for stormwater management practices implementation, and coordinate policy with those practices that have the most positive effect on the watershed. In addition, models create a central database of hydrologic, hydraulic, and water quality information at many possible scales, from small subwatersheds to national drainage systems like the Mississippi River.

As described in **Section 4.5.4** (Flood-Prone Areas), the MWMO is working with member cities Minneapolis, Columbia Heights, Hilltop and Fridley on comprehensive water quantity (Hydrology and Hydraulic: H & H) and associated water quality model studies for areas covering Northeast Minneapolis, and portions of Columbia Heights, Hilltop and Fridley. In the years following, the MWMO will continue partnering with its member cities to complete H&H and water quality models across the remainder of the MWMO.

In 2019-2020 Saint Paul worked with a consultant to generate a detailed Hydrologic & Hydraulic model of the Saint Anthony Park subwatershed, including areas within Saint Paul, Lauderdale, Falcon Heights, State Fair property, and University of Minnesota property. Also created was a P8 model for water quality assessments and prioritization of capital projects.

Modeling enables the MWMO and its member cities to understand and analyze stormwater as it flows through the existing infrastructure system. The completed models also assist cities with local system management and programmatic reporting. The MWMO and member cities can use the models to target locations for stormwater control measures, ecological restoration, and best practices to manage or improve water quantity and quality infrastructure, and the models also inform cost/benefit analyses used to determine which of these practices are the most effective and efficient for a given location. The models also function as the basis for probabilistic studies to understand the relative impact of changes in land use, climate, and infrastructure.

The MWMO continues to partner with the city to develop models that can be used for a variety of purposes including flood mitigation and water quality assessments and solutions. In 2004, the City of Minneapolis initiated a Storm Water Management Model calibration and standards study for the purpose of establishing standards for future modeling efforts in the City such that all models can ultimately be integrated. The result has been higher model accuracy and greater confidence in model results. SRF Consulting developed for the City a *Development Manual for SWMM Users* (City of Minneapolis Public Works Department, 2005). The Manual includes basic modeling standards, data sources, and processing requirements to be used by a variety of professionals for all Storm Water Management Models developed for the City. To date, the City of Minneapolis has modeled each of its deep storm tunnel systems under the 100-year, 24-hour event as an effort for the 2004 Storm Tunnel System Management Plan. The main findings were that most of the tunnels operate under surcharge conditions during this extreme event.

In addition to models that simulate stormwater as it flows through the existing infrastructure system and to the Mississippi River, the MWMO has developed a hydraulic model of the Mississippi River from River Mile 860.4 (Interstate 694) down to River Mile 847.7 (the Ford Dam), as a part of the MWMO's *A Guide to Bank Restoration Options for Large River Systems* (MWMO, 2010). The study modeled shear stress and flood levels along the reach from 2-year to 500-year flood events to inform the potential for bioengineering restoration techniques along the Mississippi's riverbanks. Eventually this same modeling will be tied into stormwater discharge modeling of tunnels and pipes leading to the river.

Intercommunity Flows Analysis

79% of the MWMO's area is within Minneapolis. Roughly six square miles of drainage from Columbia Heights, Hilltop, St Anthony Village, St Paul, and Lauderdale cross over into Minneapolis and contribute to intercommunity flows. A central role for the MWMO is to understand and assist its member cities in managing the quality, rate, and volume of these intercommunity flows.

4.5.7 Groundwater Resources

Most of the residents within the MWMO obtain their drinking water from the City of Minneapolis, which uses the Mississippi River as its primary water source. However, groundwater is also used to privately supply drinking water to organizations and businesses. It is also likely that there are private wells located within the MWMO supplying groundwater for drinking water or small irrigation uses that are not identified within existing databases. There are three aquifers of significance in the MWMO including the Quaternary water table, Saint Peter, and Prairie du Chien-Jordan. The proximity of the Quaternary water table aquifer to the land surface makes the Quaternary water table aquifer susceptible to pollution, therefore it is not typically used for residential wells. However, many monitoring wells in the MWMO are set in the Quaternary water table aquifer.

Regional groundwater flow modeling (Metropolitan Council's Metro Model 3) is a tool that allows water supply planners to consider a range of potential future aquifer levels under a set of planned and alternative water demands and sources. Metro Model 3 is a planning tool, not a regulatory tool, and it provides information to support regional planning and cooperation to ensure sustainability. Regional groundwater modeling, which simultaneously evaluates the combined impacts of all wells in the region, suggests that our current (2015) plans for water supply are likely to cause further declines in aquifer levels. Information and maps developed in conjunction with the Metro Model 3 model scenarios illustrating predicted aquifer declines under projected 2040 groundwater pumping conditions, which are expected to fall within a range 20% above or below the 2040 projection. Analysis and planning should be done to ensure that groundwater pumping does not exceed safe yield conditions, as defined in Minnesota Rules (part 6115.0630). These model results include some uncertainty. The regional groundwater flow model, along with water demand projections, provides useful information to consider as part of regional growth planning. It is the best tool available to illustrate “the big picture” pattern of aquifer decline that may occur if 2040 demand is supplied solely by currently (2015) planned sources. The MWMO will utilize the Met Council’s model 3, as well as the Master Water Supply Plan to continue to inform decisions on projects that could impact groundwater within the MWMO.

Groundwater flow within the MWMO is locally toward lakes, springs, and wetlands and regionally toward the Mississippi River. Unconsolidated sediments in the MWMO can be generalized as a two-tiered system. The top tier is the unsaturated zone, sometimes referred to as the vadose zone. This zone is not continuously inundated with water. The vadose zone may become saturated after large precipitation or melting events, however the water within the zone either infiltrates to lower aquifers, moves laterally down gradient, is evaporated into the atmosphere, or is used through transpiration by plants.

The lower tier, which is fully saturated with water, is known as the saturated zone. The top of the saturated zone is the water table. Elevation of the water table fluctuates through time due to changes in climatic conditions and groundwater withdrawal. Understanding regions where the vadose zone is seasonally greater than five feet deep aids in identifying regions where infiltration is a viable stormwater management practice.

Bedrock aquifers underlying unconsolidated deposits in the MWMO are typically used as groundwater sources. These deeper units typically offer better protection from contaminates and typically offer better water yield. The Saint Peter aquifer is the first bedrock aquifer that is sometimes used in the MWMO. It is confined in some areas by the Platteville-Glenwood Formations and unconfined in areas where these confining layers have eroded away. Flow in this unit is toward the Mississippi River. This aquifer does not provide for a significant source of water in the MWMO. It is used locally for domestic supply and other low-capacity uses.

The Prairie du Chien-Jordan aquifer system, or a combination of aquifers including the Prairie du Chien-Jordan, provides for most of the groundwater uses in the MWMO. This aquifer is somewhat confined on the top by the shaley base of the Saint Peter Sandstone and on the bottom by the Saint Lawrence confining unit. This aquifer has a total thickness between 120 and 130 feet. Flow in this unit is toward the Mississippi River. The Prairie du Chien-Jordan aquifer has been subject to large withdraws by industrial, municipal, and commercial uses which have lowered the water level by almost 50 feet since the initial use of the aquifer in the 1880s.

Groundwater Sensitivity and Protection

Groundwater analysis is important for both the quality and quantity of municipally utilized water. Groundwater uses throughout the MWMO make it necessary to monitor this resource for quality and quantity.

Figure 51 shows the sensitivity of the shallow groundwater aquifers to pollution. The groundwater's susceptibility was determined by a methodology developed by the Minnesota Geological Survey. The ratings are based on the ability of the geological material to absorb contaminants, attenuate contaminants, change the contaminant to a benign substance, and the rate at which the aquifer transmits contaminated water.

Both Ramsey and Hennepin Counties have published draft county groundwater protection plans. The 2009 Draft *Ramsey County Groundwater Plan* presents a comprehensive overview of the surficial and geologic features, and it provides the county's assessment of the groundwater resources. This plan uses maps and tables to show locations of contaminated sites, wellhead protection areas, and sensitive geologic areas. Similarly, the *Draft Hennepin County Groundwater Plan* contains information on geologic features, areas of special groundwater protection needs, and strategies to protect groundwater resources that can be implemented by local government units. Anoka County has prepared a groundwater protection assessment.

Source Water Assessment and Wellhead Protection

The Source Water Assessment Program administered by the Minnesota Department of Health develops source water assessments for all public water supplies within the state. A source water assessment provides basic information regarding a public water supply, including the water supply's susceptibility to contamination, and is a requirement of the 1986 amendments to the federal Safe Drinking Water Act. A source water assessment area is typically mapped to show the land area over which wellhead protection measures should be taken to protect the water supply from contamination. There are currently no mapped source water assessment areas within the MWMO (**Figure 52**).

Some public water suppliers are required to develop a detailed wellhead protection plan; others are required to implement wellhead protection measures within a specific area surrounding their well(s). There are currently four delineated wellhead protection areas that overlap the political jurisdiction of the MWMO. These mapped areas are regions where the Cities of Fridley, New Brighton, Richfield and Saint Anthony Village's Well Head Protection Areas overlap the MWMO political jurisdiction.

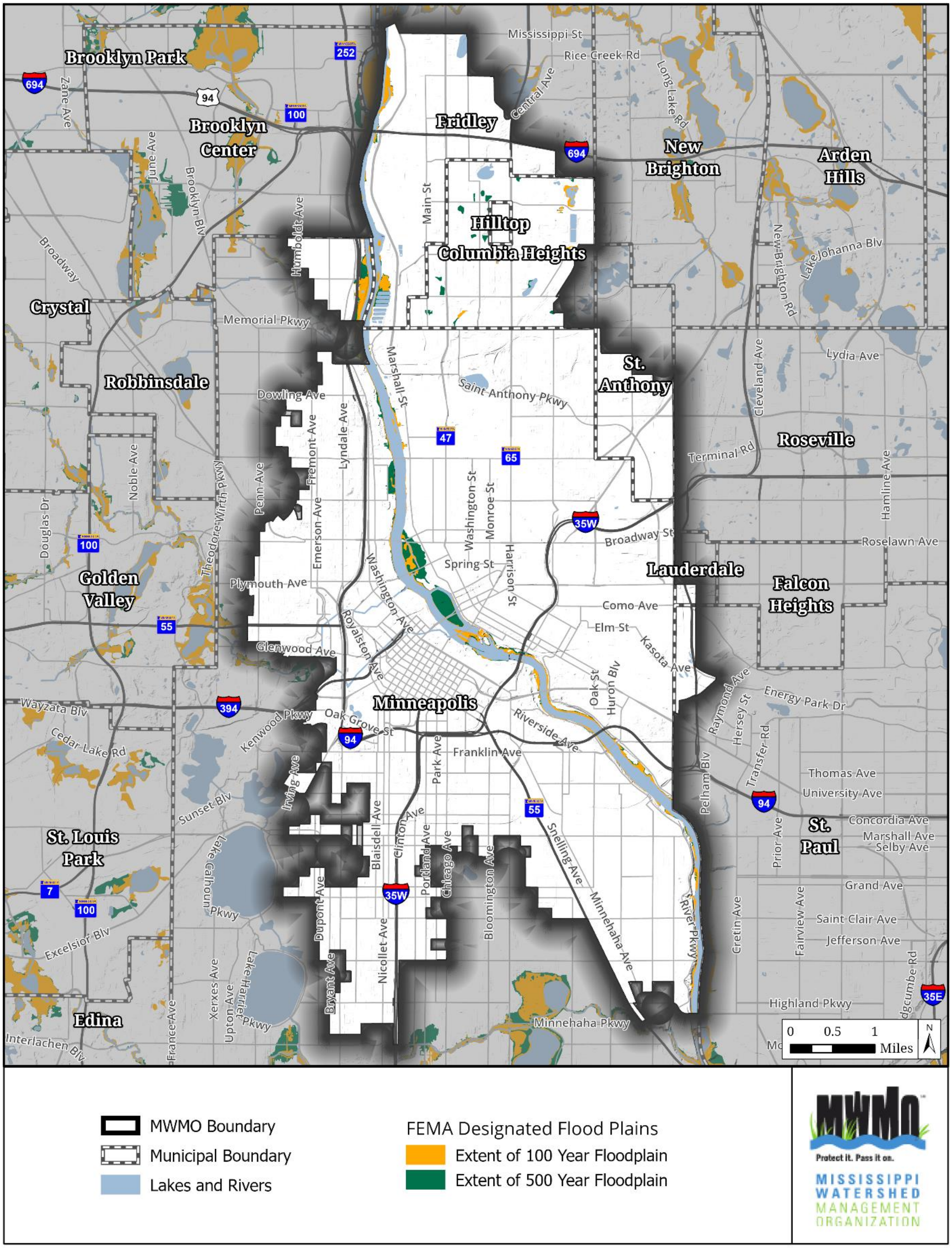


Figure 50: FEMA Designated Flood Plains in the MWMO

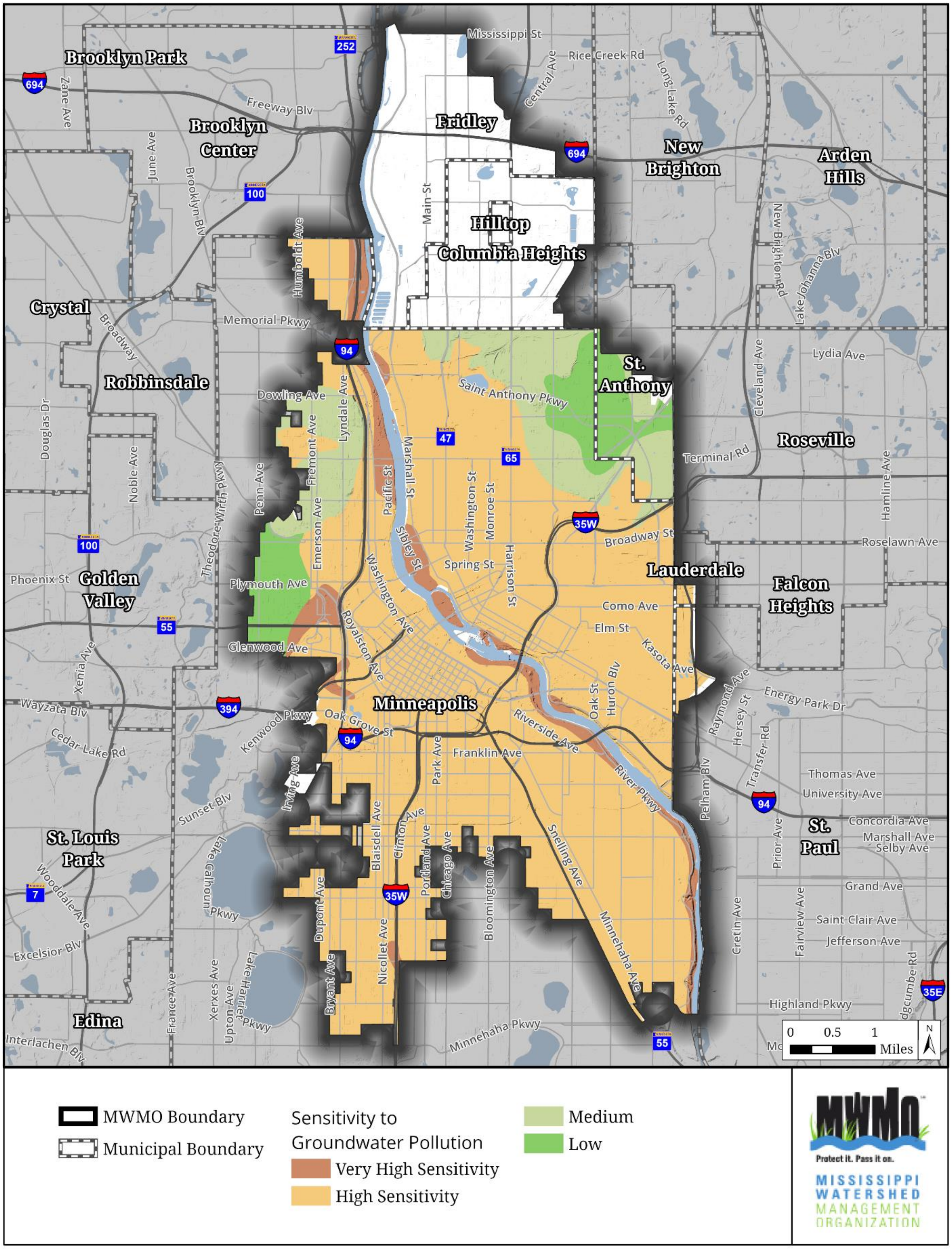


Figure 51: Groundwater Sensitivity of the MWMO

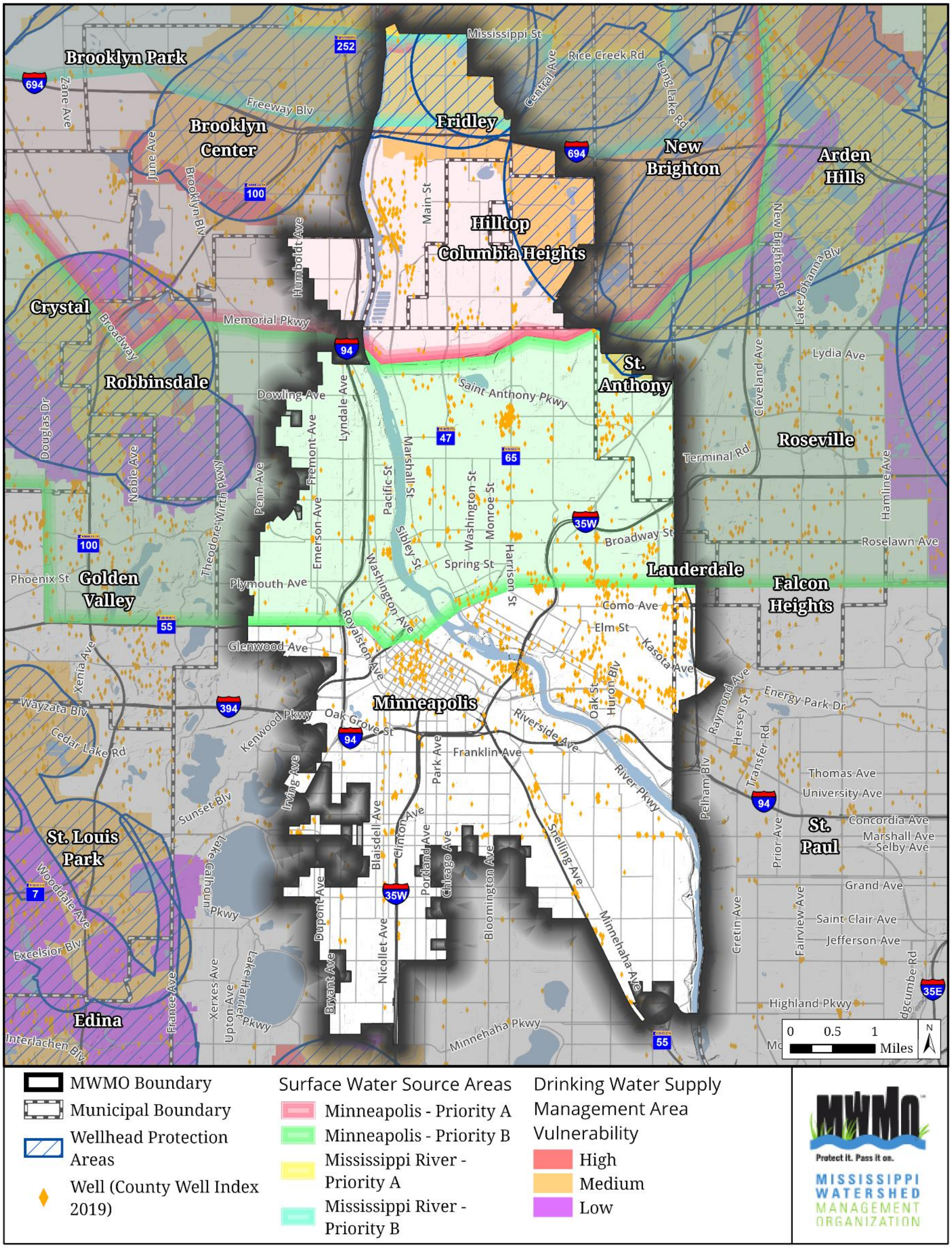


Figure 52: Groundwater Management Areas of the MWMO

4.5.8 Monitoring

One of the most important functions at the MWMO is to monitor and track changes in the water quality of the Mississippi River and in the local stormwater drainage systems. MWMO monitoring staff conduct regular, year-round sampling of both river water itself as well as the stormsewers that discharge into the river. The data collected provide a scientific basis for identifying and tracking water quality issues over time. This information is used to help guide public policies and projects designed to control pollution and improve water quality. These data are also important for hydrologic and water quality modeling in order to improve the accuracy and ultimate value of the model.

The MWMO's Monitoring Program currently includes seven sites along its portion of the Mississippi River, seven stormwater outfall sites as they discharge to the Mississippi River, one jurisdictional boundary site between Saint Anthony Village and Minneapolis, six stormwater best management practices, and the three Kasota Ponds (including Mallard Marsh). See **Figure 53** for monitoring locations.

Precipitation is recorded at two outfall sites, at the jurisdictional boundary site between Saint Anthony Village and Minneapolis, at the MWMO headquarters, and at three other locations in Northeast Minneapolis, Saint Anthony Village, and Columbia Heights. At the Mississippi River and stormwater monitoring sites, water quality data includes *E. coli*, dissolved oxygen, pH, transparency, salinity, and specific conductivity, nutrients, sediment, inorganics, organics, and metals. Continuous flow data are collected at all the stormwater monitoring sites and water flow, temperature, and conductivity are measured at four of the stormwater outfalls. Water elevation is measured at seven locations along the Mississippi River. In 2019, the MWMO published a summary report of ten years of data collected at the Kasota Ponds. Site descriptions and monitoring results can be found in Annual Monitoring Reports at https://www.mwmo.org/monitoring-and-reports/water-quality-monitoring/.

Future monitoring will expand to additional MWMO wetlands and waterbodies, jurisdictional boundaries, best management practices, and representative outfalls of each subwatershed. New Hydrology and Hydraulic models being completed will identify the subwatershed and jurisdictional boundary framework which will be used for locating future monitoring activities.

4.5.9 Discussion of Challenges, Gaps, and Next Steps

To date the MWMO has reviewed all monitoring activities occurring in the watershed and is identifying efficient ways to address gaps in monitoring, while avoiding duplication of any existing monitoring efforts. Specific partnerships and coordinated efforts include working with MPCA on Total Maximum Daily Load studies, member cities on interjurisdictional flows, and the City of Minneapolis on system-wide illicit discharge detection. The MWMO plan to continue to develop local, regional, and international partnerships that coordinate and unify multi-organization monitoring goals.

The MWMO conducted a function and value assessment of wetlands. The MWMO recognizes that member communities may place differing value and priorities on each wetland function depending on their own policies, values, and goals. As such, this assessment will be followed up with a cooperative effort among its members to classify allowable uses for each wetland identified and draft a model buffer zone ordinance.

In the future MWMO capital projects and programmatic efforts are considering subwatershed management units identified in **Figure 47** as one possible scale for managing for flooding, water quality, and habitat. To better inform member organizations' capital projects and programmatic activities the MWMO plans to leverage monitoring data and subwatershed models that can prioritize water resource project areas and contamination hot spots in the watershed.

The MWMO plans to expand its monitoring efforts to characterize loading within each subwatershed identified in **Figure 47** and to gather information on interjurisdictional flows.

MWMO needs to understand pollutant mixing on two levels for the Mississippi River. First, to adequately address public health issues around Total Maximum Daily Loads for bacteria (*E. coli*), a big river sampling methodology that accurately measures existing pollutant loads in the river needs to be developed. The MWMO has collected data from the Mississippi River to determine pollutant mixing in the river and has developed monitoring protocols using this information. However, the extent of pollutant mixing from outfalls is still unknown. The MWMO will conduct additional studies of pollutant mixing from stormwater outfalls to better understand the overall pollutant mixing of the river. The MWMO plans to seek out broader regional partnerships or funding to accomplish both of these studies. These studies exemplify the type of assessments the MWMO will need to complete to more accurately monitor and evaluate the impact specific programmatic efforts and capital improvements are having on the Mississippi River.

From its start in 2004, the MWMO's monitoring program has focused on gathering reliable flow-weighted data that can be used for long-term loading and trend analysis. Difficult site conditions and limited staffing resources have limited the growth of the program and the amount of consistent reliable data gathered. Currently, data collected is reported in the MWMO's Annual Monitoring Reports and loading analysis is underway.

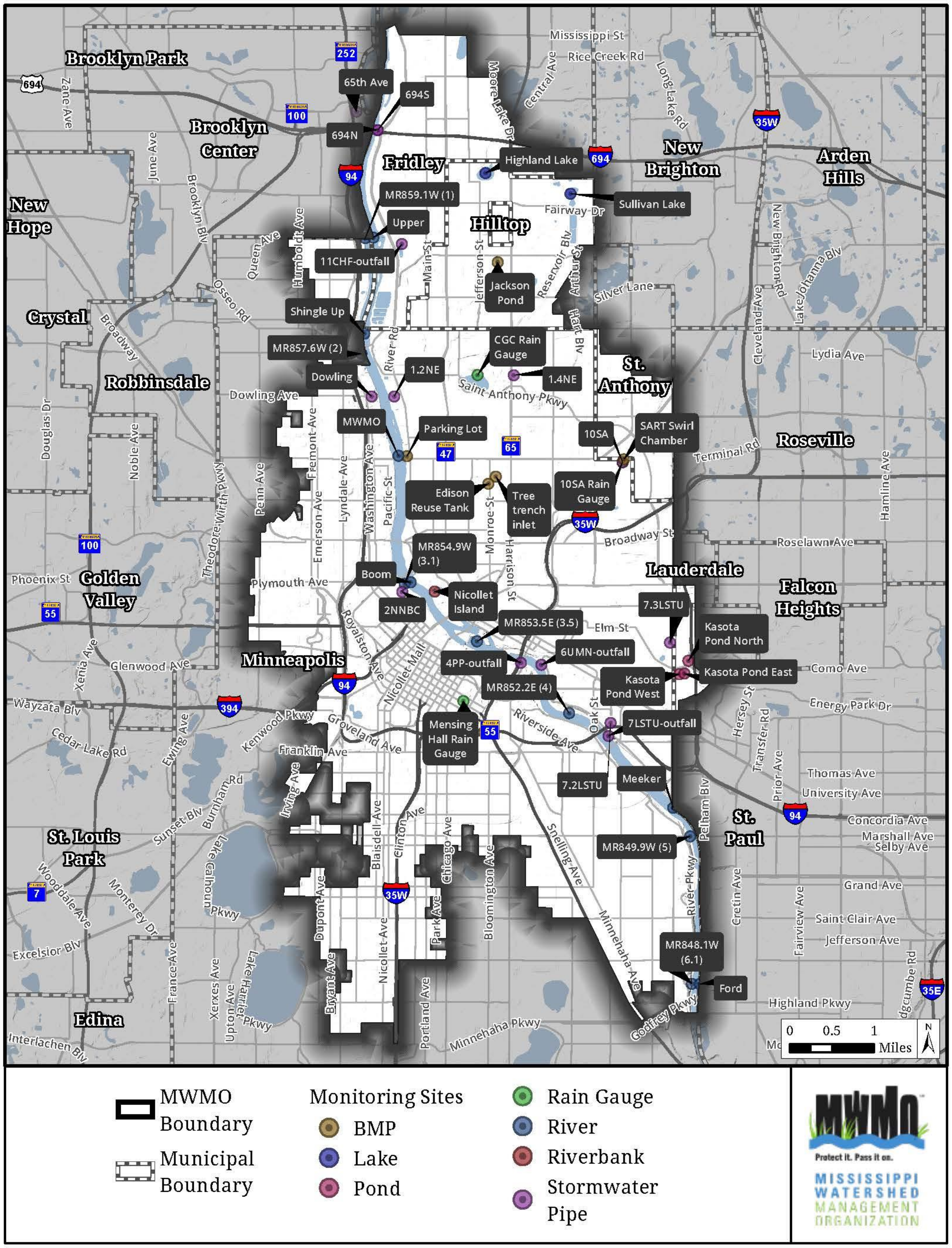


Figure 53: Monitoring Locations of the MWMO