# Lino Lakes Resource Management Plan

June 2008

Prepared for:

Rice Creek Watershed District and
City of Lino Lakes

Prepared by:

Emmons & Olivier Resources, Inc.
651 Hale Avenue North
Oakdale, MN 55128

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# EXECUTIVE SUMMARY

The Lino Lakes Resource Management Plan (LL RMP) came about through a partnership between the Rice Creek Watershed District (RCWD) and the City of Lino Lakes. This collaboration was initiated in 2006 and included extensive coordination between the City, the Watershed and other regulatory agencies.

The LL RMP provides a watershed-based approach to wetland management that is consistent with RCWD goals. The approach uniquely addresses management in the context of wetland functions and the effects of anticipated future land use. The RMP was developed in close coordination with state and federal permitting authorities and has been prepared to be consistent with both state and federal wetland regulations. It is intended that components of the plan be incorporated into Clean Water Act Section 404 permit evaluations. The approach is unique as a means to develop a comprehensive wetland management plan according to the State of Minnesota Wetland Conservation Act because it not only includes the required assessment of existing wetland functions and values, but it also forecasts future functions in light of anticipated land use and watershed-based approaches for no net loss of wetland function.

This iterative collaboration with Lino Lakes is intended to meet the following objectives:

- Provide maximum consistency with Minnesota Wetland Conservation Act (WCA) requirements for a Comprehensive Wetland Management Plan and no net loss in acreage and function of wetland resources;
- Be consistent with the Federal Clean Water Act requirements for Section 404;
- Provide an implementation strategy for multiple Total Maximum Daily Load projects;
- Provide watershed-based context to the public Ditch Repair process proceeding on a parallel track;
- Through an iterative process, provide guidance to the City of Lino Lakes for ecological-based land use decisions during their Comprehensive Plan Update process;
- Provide stormwater management guidance to the City of Lino Lakes for their Comprehensive Plan Update requirements and municipal stormwater permitting.

The LL RMP report has four sections: existing conditions, future conditions, resource management units (RMU), and references materials. Each section is summarized in more detail below. The report also includes an appendix with four reports providing greater detail on the modeling of the existing watershed, the full-build out (FBO) modeling, the LL RMP modeling, and on the recommendations for Centerville Lake's outlet.

Section 1, Existing Conditions, page 3, is a watershed-based natural resource plan used for preliminary planning of the Lino Lakes Comprehensive Plan. Resource assessment is discussed at a watershed scale and includes ditch systems, wetlands and associated upland habitat, watershed runoff characteristics, and lakes. GIS-based modeling allowed for evaluation of flooding (excess volume), excess nutrients and other pollutants, as well as priority resources and impaired resources.

Section 2, Future Conditions, page 24, is an assessment of GIS-based modeling allowed for a discussion of potential effects on resources given either a full-build out land use scenario or an

'RMP-based' land use scenario. The latter scenario is intended to model the land use conditions needed to maintain and protect priority resources in the City of Lino Lakes. A municipal programming framework is laid out for addressing resources at the land use decision level.

Section 3, Resource Management Units, page 54, contains a description of the 15 watershed-based land areas called the resource management units (RMUs). Detailed data were evaluated for the resources in each RMU. Existing and future condition maps are shown for many of them, and recommendations for projects are made. The LL RMP provides stormwater management guidance on a watershed basis in the context of the natural resources.

Section 4, Reference Materials, page 96, includes companion document titles, references, acronyms, definitions, and the draft RMP-3 implementing watershed district rule. Much of the LL RMP is based on previous methodologies and resource planning worked developed by the RCWD in Resource Management Plans that preceded this effort. Previously documented technical information contained in the state approved 53-62 RMP and JD4 RMP are not repeated in the LL RMP document.

The Appendix, with four reports and memos, includes a reporting of the multiple hydrologic models used throughout this planning process. Ditches, wetlands, lakes and streams tightly link to the character of rainfall and runoff throughout their contributing watersheds. This rainfall and runoff is assessed using a hydrologic model. Due to the important role of the hydrologic modeling, the appendix includes a description of the model and results.


**Figure 1. Related Efforts in the LL RMP Process.**

# SECTION 1, EXISTING CONDITIONS ASSESSMENT

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# SECTION SUMMARY

The Lino Lakes Resource Management Plan (LL RMP) Existing Conditions is a watershed-based natural resource plan for preliminary planning of the Lino Lakes Comprehensive Plan (Comp Plan). This section of the LL RMP contains an Existing Conditions, watershed-based analysis of wetlands, lakes, ditches, and the quality and quantity of water they depend on. The assessment of existing resource condition establishes the baseline for which future land use conditions are tested. Future Conditions assessments found in the second section of the LL RMP examines two build out scenarios and compares results to Existing Conditions.

The Existing Conditions section of the LL RMP presents watershed condition and resource assessments today to be used to inform recommendations for protection and restoration tomorrow. The following watershed components and processes have been examined.

- Public Ditch System
- Watershed Runoff
- Nutrient Load
- Wetlands and Associated Habitat
- High Priority Resources

***Public Ditch System***

The RCWD Board is authorized to manage the public ditch system. The majority of the drainage system was constructed during the late 1800's and early 1900's. Over the decades, much of the system was minimally maintained by different ditch authorities. Today, many ditches function as straightened creeks within a partially or marginally drained wetland slough or riparian corridor. The major public ditch systems in Lino Lakes are:

- ACD 10-22-32
- ACD 25
- ACD 55
- ACD 72

ACD 55 and 72 are each separate tile systems. Also found within Lino Lakes is the former public ditch ACD 47 , a small portion of Anoka/Washington Judicial Ditch #3 (Clearwater Creek) and a small portion of Anoka Ramsey Judicial Ditch 8. Existing conditions of the ditch establish the baseline for which various repair alternatives are evaluated.

***Watershed Runoff***

Today, upland runoff from Lino Lakes and upstream communities moves through a series of ponds, ditches, wetlands, and pipes collectively called the conveyance system. Hydrologic modeling has been used to examine how these components are expected to respond under a range of storm events. Modeling and analysis has been performed at the catchment level, which are much smaller drainage areas within each subwatershed. Subwatersheds are in the 640 to 6,400 acre size range. Catchments are in the 32 to 320 acre range. Scale differences are shown in Figure 2. The Appendix to this document describes the hydrologic model assumptions and results in more detail. The City can utilize these models for their existing conditions Local Water Management Plan Update.

Hydrologic boundaries do not stop at the municipal border and orderly coordination between related municipalities is addressed in the LL RMP. Hydrologic boundary based, Resource Management Units identified in the LL RMP are the basis for neighbor community coordination of shared water resources. The hydrologic modeling encompasses true watershed catchments even where the boundaries are outside the municipal boundaries. The modeling covers small portions of land area within North Oaks, Hugo, and Blaine, as well as all of Centerville. The contributing areas of Upper Rice Creek, Hardwood Creek, and Clearwater Creek were also factored in.

***Nutrient Load***

Total maximum daily load (TMDL) studies are being coordinated with the LL RMP to understand the source of excess phosphorus in several of the lakes. The Peltier/Centerville TMDL study is being funded by the MPCA. The second TMDL study, being funded by the Watershed, includes the Chain of Lakes downstream of Peltier. To identify phosphorus sources and loads, subwatershed catchment areas were broken out and modeled. The TMDL studies will discuss the relevance of the loading to lake impairment. In this document, loading is discussed with respect to wetlands and the implications for wetland management

***Wetlands and Associated Habitat***

Habitats are formed from lakes, wetlands, drainage systems, streams, grasslands and woodlands all working together. Except when endangered species come into play, the upland portions of habitat are not afforded direct regulatory protection like wetlands and lakes and streams (aquatic resources). Assessing the health of existing wetlands and associated habitat is important for the purposes of preparing a Comprehensive Wetland Management Plan and studying two biologically impaired streams.

<u>Upland</u>

Upland vegetation mapping is based on current land use and includes all natural and non-natural land cover types as well as a vegetative quality indicator. In Lino Lakes, certain rare plant species are found along the marginal area between wetlands and uplands. Protection of these species is a local priority for the City and this habitat is accounted for in the LL RMP. The Peltier Lake heron rookery has also been a notable habitat component in the area.

<u>Wetlands</u>

Wetland vegetation mapping is based on current land use data and includes the size and types of wetlands. High priority wetlands will establish the critical nodes and linkages for what will become the Wetland Preservation Corridors. Wetland quality was assessed by looking at the functioning of the wetland habitat, characteristic wetland hydrology and water quality, wetland role in downstream flooding, as well as plant species and community diversity.

<u>Streams</u>

Aside from the small segments of Rice Creek that connect the Chain of Lakes, Lino Lakes contains two other creeks, Hardwood and Clearwater. Both creeks are TMDL-listed for biotic impairment, meaning the fish and insect life living in the stream is unhealthy. Biotic stressors can include in-stream habitat structure, stormwater volume, sediment, temperature, nutrients and other pollutants The Hardwood Creek TMDL is nearly complete and the Clearwater Creek TMDL is planned to start in the future.

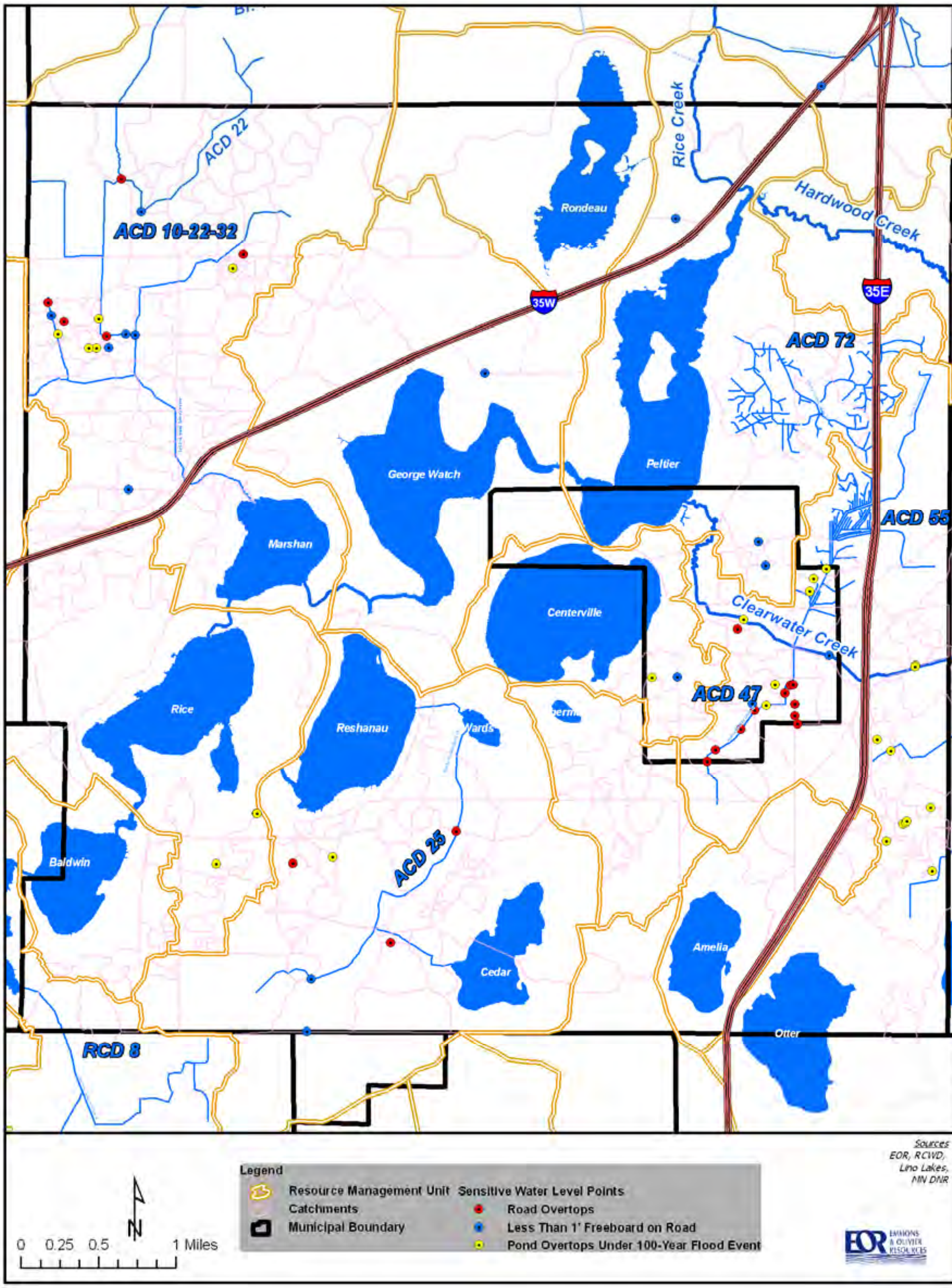


**Figure 2. Geographic Scale of Analysis.**

# EXISTING WATERSHED CONDITIONS

A more detailed look at each of the watershed components and processes discussed in the summary is provided in this section. The watershed components and processes are:

- Public Ditch Systems,
- Watershed Runoff,
- Nutrient Load,
- Wetlands and Associated Habitats and
- High Priority Resources.

## PUBLIC DITCH SYSTEMS

The public ditch systems are an integral part of the RMP, and the RMP serves as the ditch repair alternative for each system. Updated ditch maps and system data were developed based on field surveys and historic records (Figure 3). The 10-22-32 and 25 ditches are traditional open channels in urban or urbanizing areas. An evaluation of repair options will be conducted through a legal process including a ditch repair petition and report. The repair for these two public ditches will be coordinated with the LL RMP and City comprehensive plan. Ditch 47 was constructed as a public ditch and has since been officially abandoned. The ditch still functions as a stormwater conveyance system, but it is not managed by the drainage statutes under 103E. Ditch 55 and 72 are tile systems that are functioning at capacity. Portions of these tile systems are proposed to be converted to open swales and greenways in the context of future urban land use. Profile and repair reports have been completed for all of these ditch systems, and the Resource Management Unit (RMU) recommendations integrate ditch repair implementation projects. The 10-22-32 system is particularly complex and recommendations for each branch is provided in the Future Conditions section of the RMP.

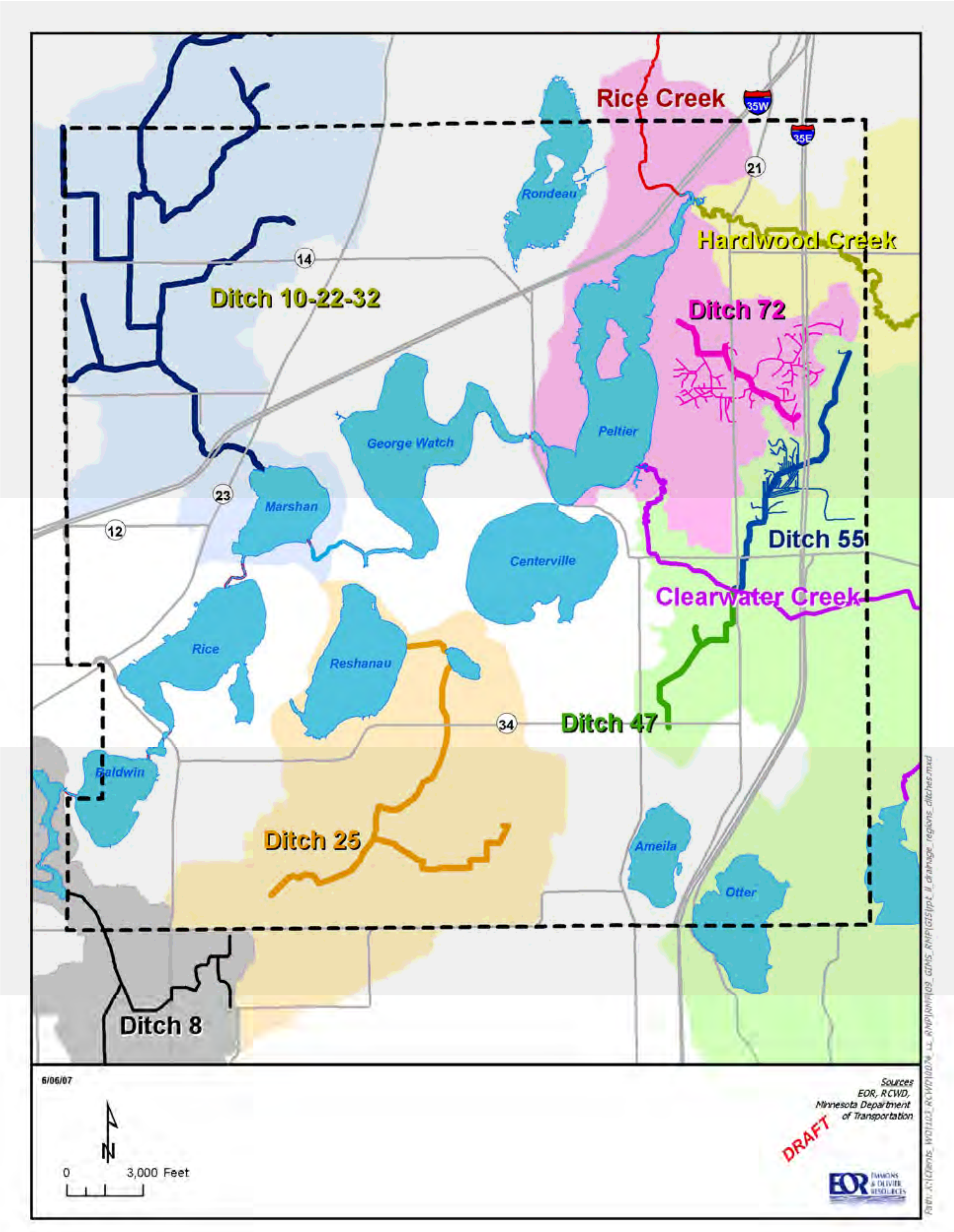


**Figure 3. Major Public Ditch Systems in Lino Lakes.**

## WATERSHED RUNOFF

Lino Lakes is at a midpoint in the Rice Creek watershed. From the Chain of Lakes, Rice Creek flows west to the Mississippi River. Three large subwatersheds contribute to Peltier Lake: Clearwater Creek, Hardwood Creek, and Upper Rice Creek (Figure 4). Through Peltier Lake these subwatersheds contribute to the condition of the entire Chain of Lakes. The majority of the Clearwater Creek, Hardwood Creek, and Upper Rice Creek subwatersheds are located in other communities.

Lake Amelia, located in the southeast corner of Lino Lakes does not have such large contributing surface water flows. The drainage area flows south into North Oaks and the Vadnais Lake Area Watershed Management Organization.

The system of swales, ditches, wetlands, ponds, and pipes that is identified as the Lino Lakes watershed conveyance system has been surveyed and modeled to determine flow response under the 100-year rainfall event (refer to Figure 2). Sensitive water level points in the system have been mapped. These points suggest a need to consider various options for wetland restoration, land use, and road planning in nearby catchments. Planning decisions require examining the catchment-scale and subwatershed-scale resources related to each point. Each of the sensitive water level points is given closer consideration in the Resource Management Unit recommendations.

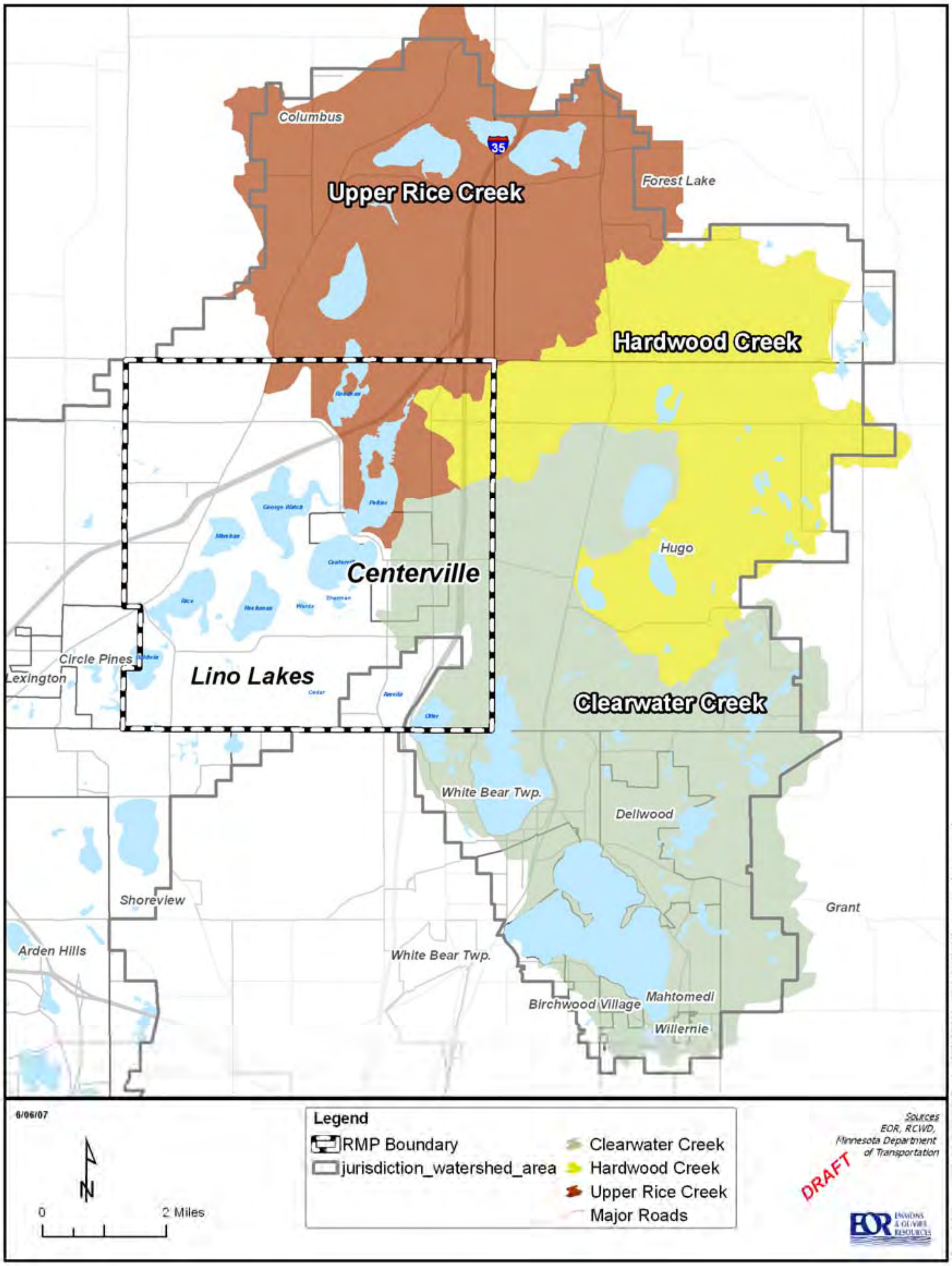


**Figure 4. Creek Systems of Lino Lakes.**

## NUTRIENT LOADS

Several lakes are impaired from excess phosphorus in the water. All of the 'listed waters' in Lino Lakes recently had investigations completed to determine the sources of pollution. Peltier Lake receives inflow from Rice Creek from the north, Hardwood Creek from the northeast, and Clearwater Creek from the southeast.

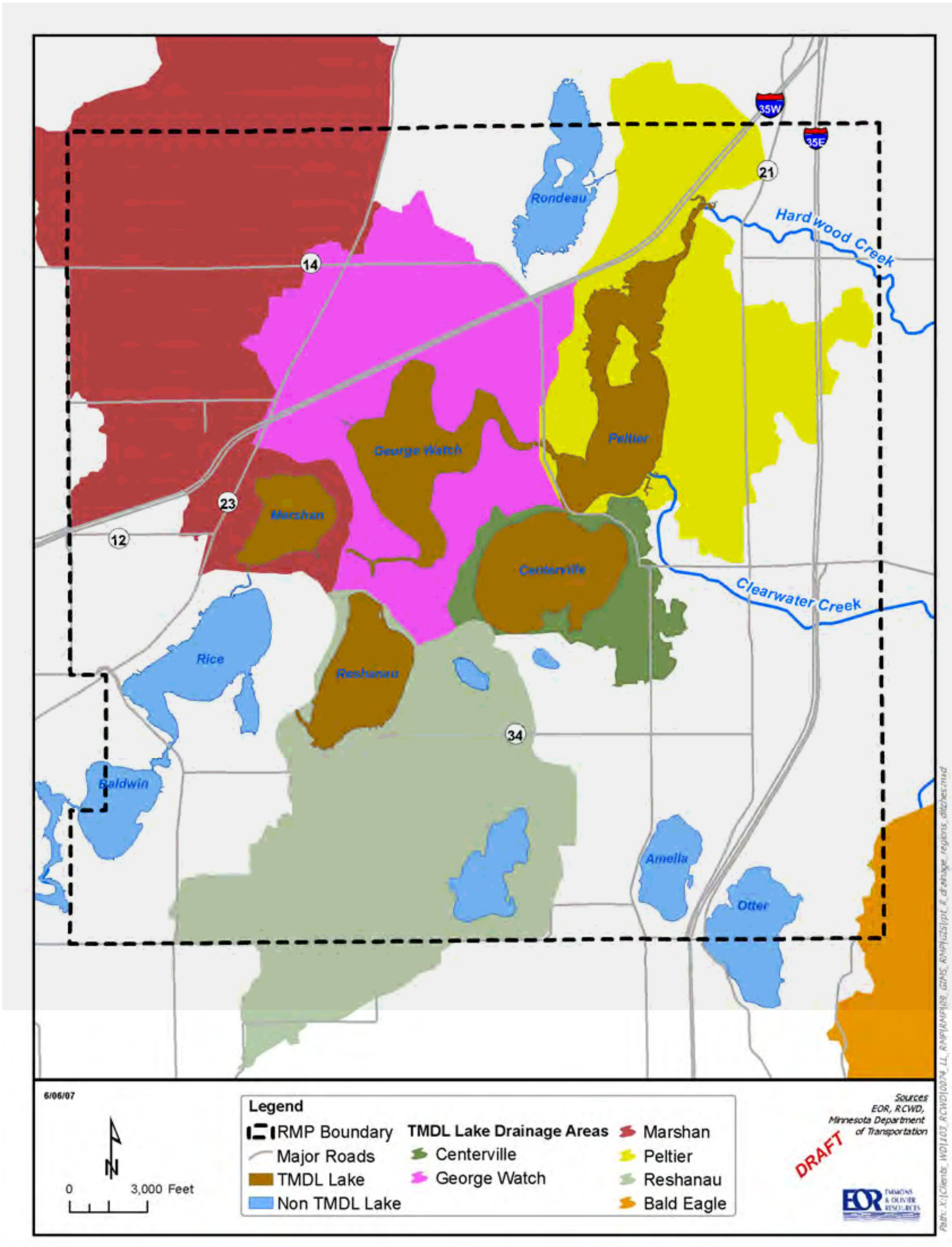


**Figure 5. Area Lakes with TMDL Studies Underway.**

Centerville Lake is connected to Peltier Lake by culverts under County Road 14. Through these culverts, water can flow in either direction depending on the water elevation difference between the two lakes. Other than the occasional inflow from Peltier Lake, Centerville Lake receives surface water from a small direct drainage area only. Phosphorus loading from Peltier has a significant negative impact on the water quality of Centerville Lake.

George Watch and Marshan Lakes are significantly impacted by the high phosphorus loads coming from Peltier Lake. The direct drainage area to George Watch is relatively small and therefore contributes a relatively small load to the lake. Marshan Lake has a much larger drainage area (served by ACD 10-22-32) but still receives the majority of its nutrients from upstream lakes in the Chain.

Unlike lakes, standards for assessing nutrient impairment of wetlands have not yet been fully established by federal or state agencies. The nutrient load modeling developed for the TMDL projects generated qualitative ranking of subcatchment nutrient loading (high, medium, or low). The results of the vegetation quality ranking and nutrient ranking are shown in Figure 6. There is no relationship between vegetation quality and catchment phosphorus loading. The phosphorus loading may be indirectly related to the vegetative quality. Recent studies have shown that nitrogen in the surface water tends to be more associated with vegetation quality than phosphorus. The loading information is useful for setting priorities on protecting wetland condition in Lino Lakes. It is important to know which areas are under the greatest stress from nutrient loading, because even without a direct relationship between vegetative integrity and phosphorus, the wetland stressors may be indirectly related to phosphorus loading. Any wetland restoration plan, regardless of location, examines the contributing catchments for their specific loading (both nitrogen and phosphorus), the loading sources, and the vegetation quality.

The catchments in Lino Lakes have concentrations that are at a minimum value of approximately 0.1 mg/L and range to over 10-fold higher at a maximum. In Figure 6, catchments with an outflow concentration of 0.2 mg/L or lower are given a ranking of “low”, between 0.2-0.3 mg/L are ranked “medium”, and over approximately 0.3 mg/L are ranked “high”. Almost all catchments exceed north central hardwood ecoregion standards for reference watersheds, and this may partly explain the lack of an association between wetland vegetative integrity and catchment nutrient loading.

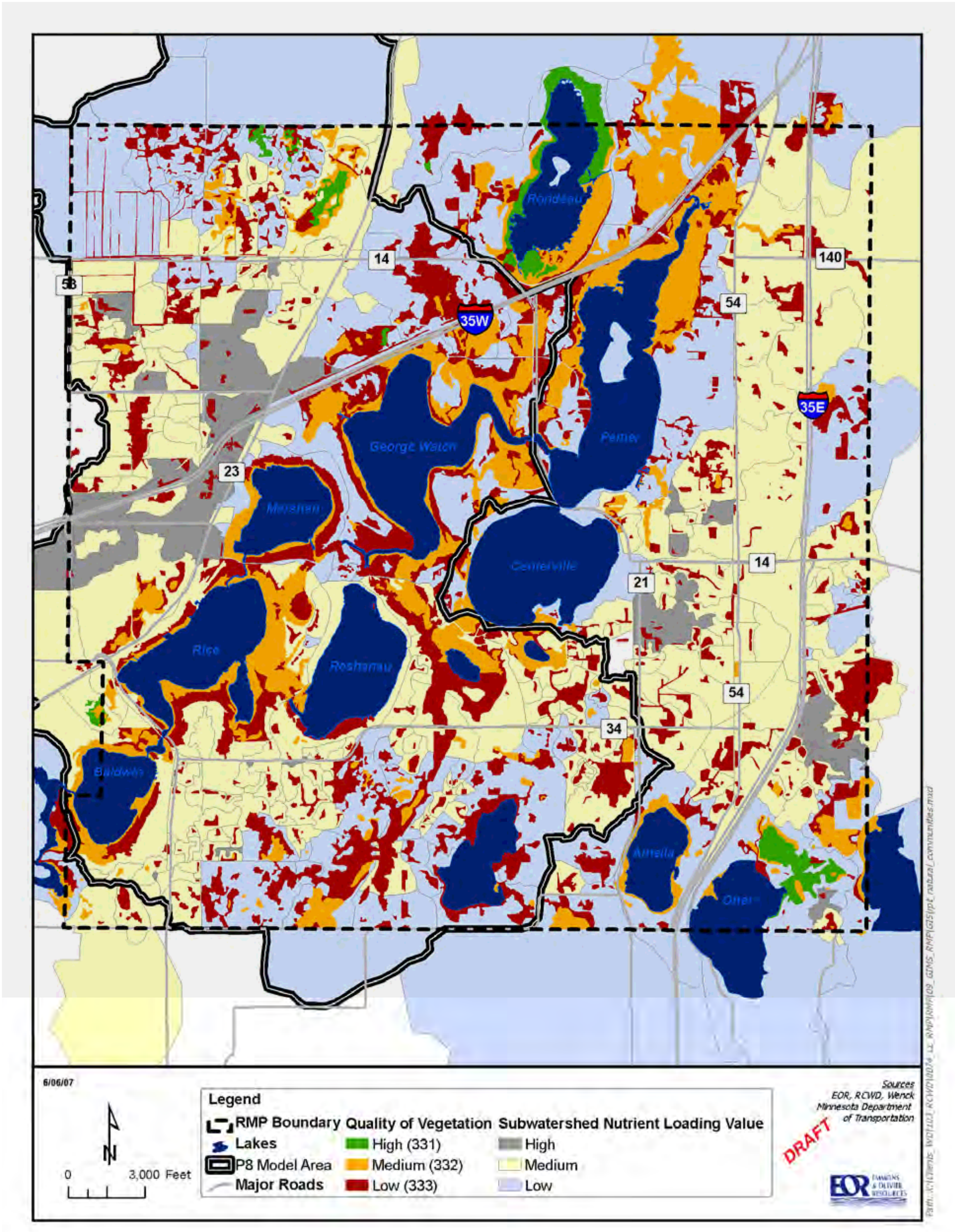


**Figure 6. Nutrient Loading to Wetlands under Current Land Use Conditions.**

## WETLANDS AND ASSOCIATED HABITAT

### Wetland Public Values

The valuation of wetlands was conducted by Lino Lakes at a public open house in March 2007. A total of 31 community members completed a wetland values survey. Respondents ranked nine wetland-related values in order of importance from 1 (most important) to 9 (least important). The results (Table ) show that surface water quality, groundwater quality, and wildlife habitat were the highest wetland values overall.

**Table 1. Lino Lakes Citizen Values about Wetland Resources.**

| **Importance of Wetlands to the Following Public Values*** | **Mean Score All Respondents (31) With 1 Being Most Important** |
|---|---|
| Surface Water Quality | **2.5** |
| Groundwater Quality | **3.0** |
| Wildlife Habitat | **3.3** |
| Recreation/Education Uses (i.e. parks, open space, bird watching) | **4.2** |
| Flooding Prevention | **4.2** |
| Ecological Diversity (unique plants and landscapes) | **4.8** |
| Aesthetics (visual appearance) | **5.6** |
| Conversion to Upland for Development | **7.3** |
| Commercial Use (i.e. sod, peat mining) | **7.6** |

* March 2007 Open House

A Lino Lakes community visioning meeting in January 2007 was also used to gather views on wetland values. There were only four respondents, but the results are consistent with those reported above. Groundwater quality ranked most important, followed by flood prevention, wildlife habitat, and surface water quality. Two respondents said wetlands have inherent value and should be a major focus in the future planning and development of the plan area regardless of their utility for humans. Two respondents said wetlands are valuable due to the beneficial functions they provide and they should be a major focus of the future planning and development of the area.

Information gathered through the value survey and other public input meetings helped shape the RMP and Rule. For example, to address the surface and groundwater quality values, the stormwater management rule emphasizes infiltration and protection of groundwater dependant wetland resources. The Wetland Preservation Corridor will serve to enhance multiple wetland functions including the relatively high-valued wildlife habitat that requires limited habitat fragmentation.

### The Status of Wetlands

A great diversity of wetlands exist in both large, diverse assemblages and scattered throughout the City of Lino Lakes (Figure 7). Marshes and shallow lakes are the most common wetland habitats. Mapping accuracy follows the Minnesota Land Cover Classification System (MLCCS) and is not acceptable for wetland permitting decisions. Several site-specific natural resource mapping and field studies have been performed in Lino Lakes for various development projects. The findings have been incorporated here, and as a result, there is greater mapping detail in some areas than others on Figure 7. Aggregations of different wetlands types indicate regions of higher biodiversity. Additionally Figure 7 shows the connectivity of wetland areas into corridors.

Past alterations to wetlands were primarily agricultural ditching and draining. These activities resulted in areas that have hydric soils but are not mapped as wetland. These are considered fully drained wetlands. The fully drained wetlands can be seen as the heavy concentrations of tan color in Figure 8. These soils are hydric but were not identifiable as wetlands in the remote, landscape scale mapping of wetlands performed in the 1970s by the U.S. Fish and Wildlife Service. This mapping does not discriminate fully drained from partially drained wetlands. A rough estimate of partially drained wetlands can come from NWI map wetland codes; however this is not needed since ditch reports have much more detailed data.

These fully and partially drained wetlands provide the greatest opportunity for wetland restoration activities. Wetland restoration projects function to retain and treat stormwater and at the same time enhance natural resources, all of which were determined to be of highest priority for the citizens of Lino Lakes. As specified by the Minnesota Routine Assessment Methodology (MNRAM), the factors evaluated when considering a wetland for restoration include the number of nearby wetlands, hydrologic restoration potential without flooding structures, number of landowners involved, size, potential for a naturalized buffer, and restoration design complexity (see Reference Section for companion documents and details). As shown in Figure 9, wetlands ranked high and medium are considered high priority for restoration. Local wetland values such as Lino Lakes' interest in Tamarack Swamp restoration was also used in the evaluation.

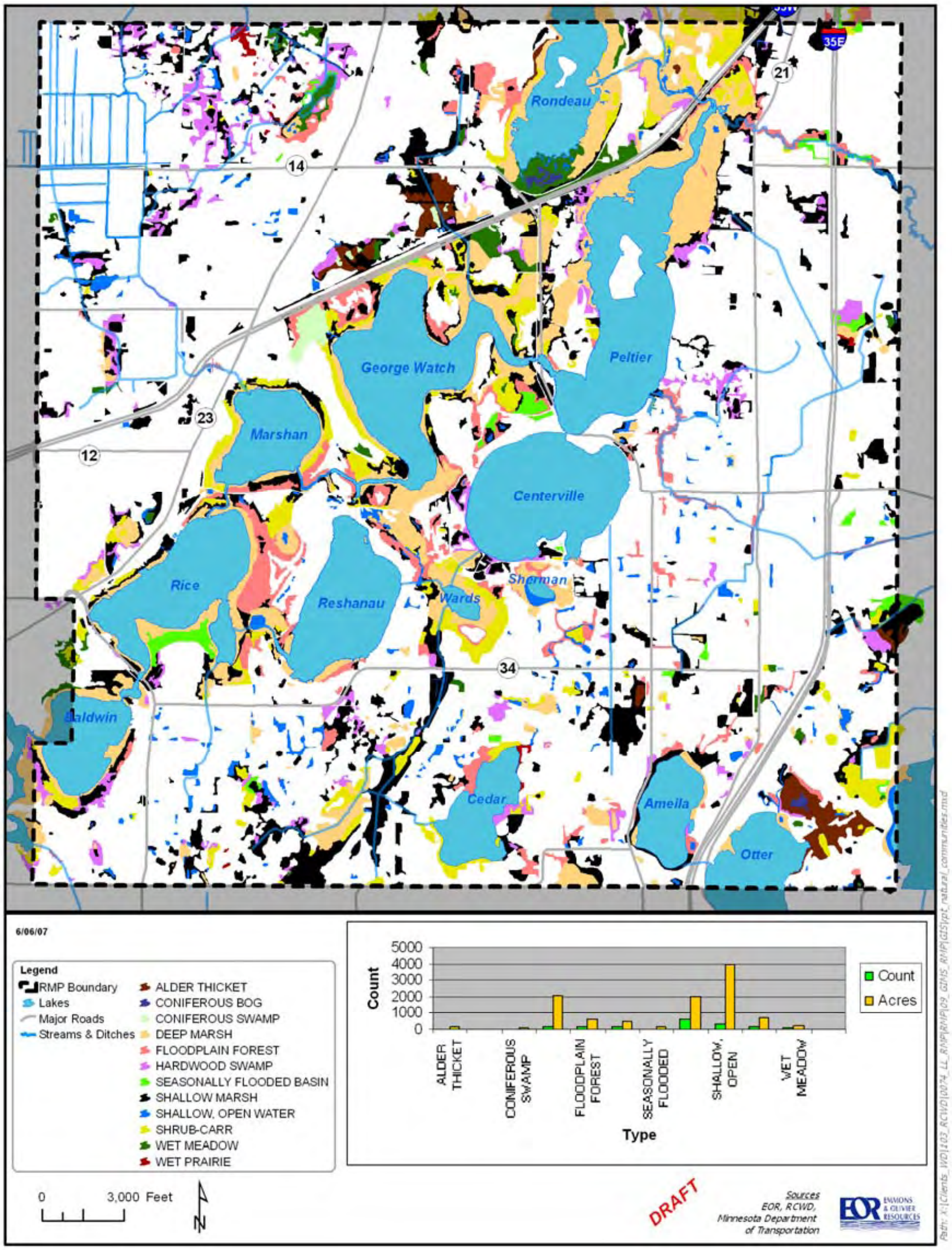


**Figure 7. Wetland Plant Communities in Lino Lakes.**

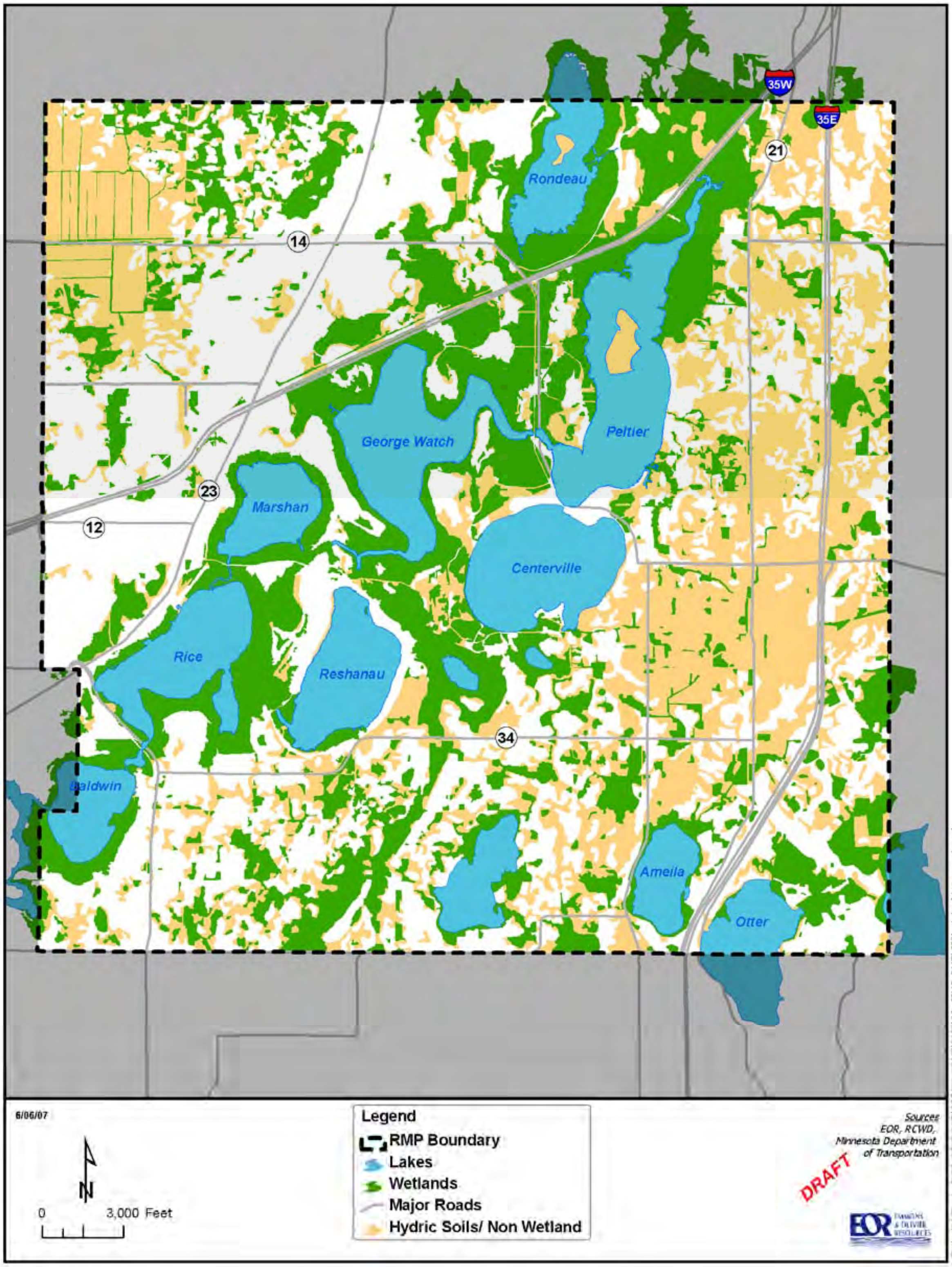


**Figure 8. Fully Drained, Historic Wetlands.**

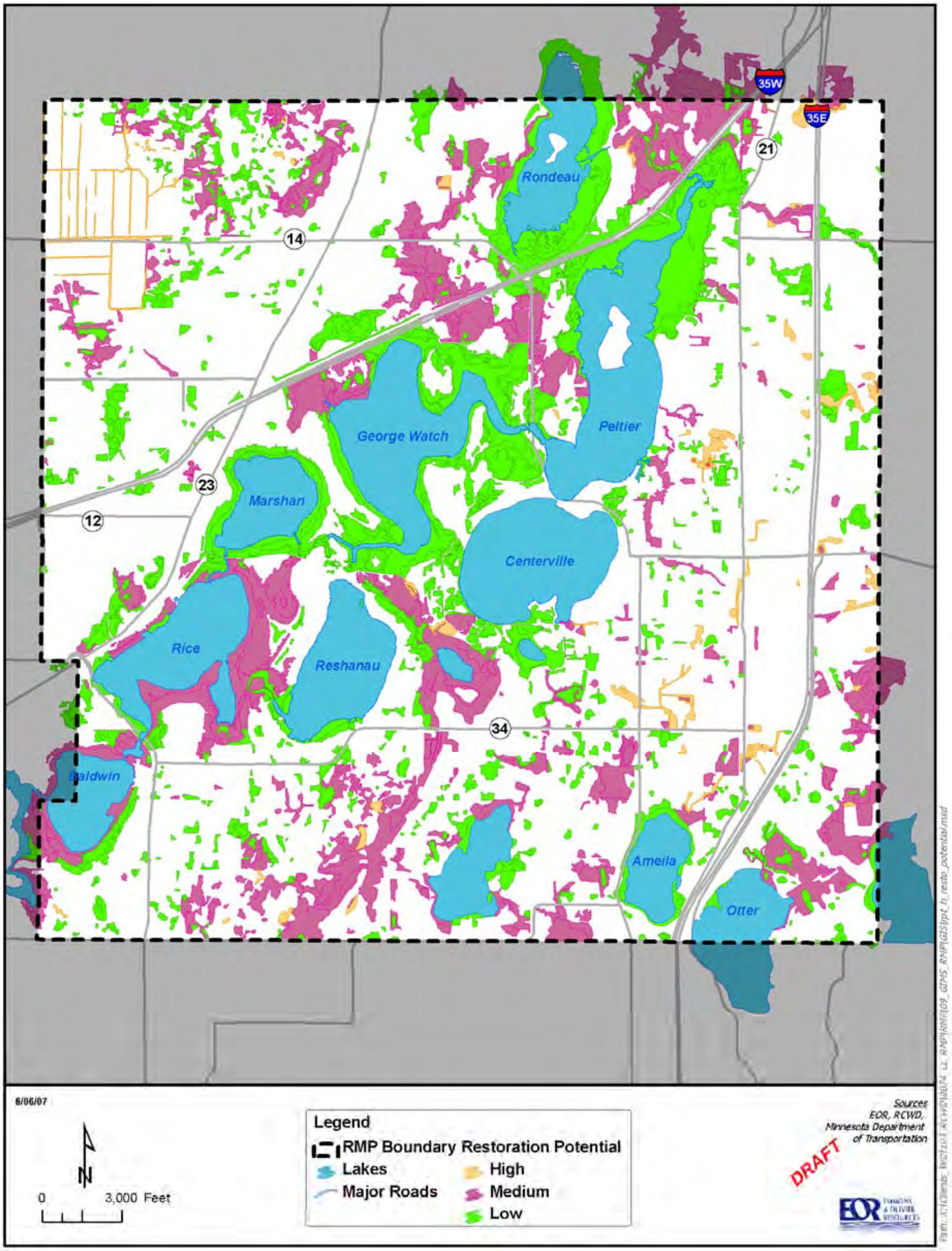


**Figure 9. Partially Drained or Impaired Wetlands.**

## HIGH PRIORITY RESOURCES

State and federal wetland protection laws apply to wetlands in Lino Lakes. Both regulatory programs can be adapted to provide additional protection to these high quality resources. Additional protection can be afforded to those wetlands that exhibit high vegetative quality, high potential for restoration, create habitat connections, or harbor rare species. The high priority wetlands and associated high quality upland resources in Lino Lakes are shown in Figure 10 (see Reference Section for companion documents and details). These upland resource preservation areas are higher quality oak woodlands and forests. Additionally, the City has recently completed a development suitability analysis for upland areas.

The high priority resources were selected based upon a landscape-scale functional assessment recently completed by the watershed district and numerous past studies by the City that include

- Orchid monitoring,
- City conservation easements,
- Rare species points,
- Tamarack basins,
- Cedar Lake floodplain, and
- Rare plant community sites.

The RMP Rule for Lino Lakes will provide additional protection measures to the high priority wetlands, and low quality, low priority wetlands will be afforded lower mitigation ratios and sequencing flexibility. From a Clean Water Act Section 404 perspective, the USACE will likely consider the high priority wetlands as wetlands not suitable for fill, and apply more stringent review requirements. Non-priority wetlands will remain under the protection of standard wetland regulatory requirements, and will be evaluated in the context of watershed needs and how retention or establishment of wetland types in specific locations can fulfill those needs.

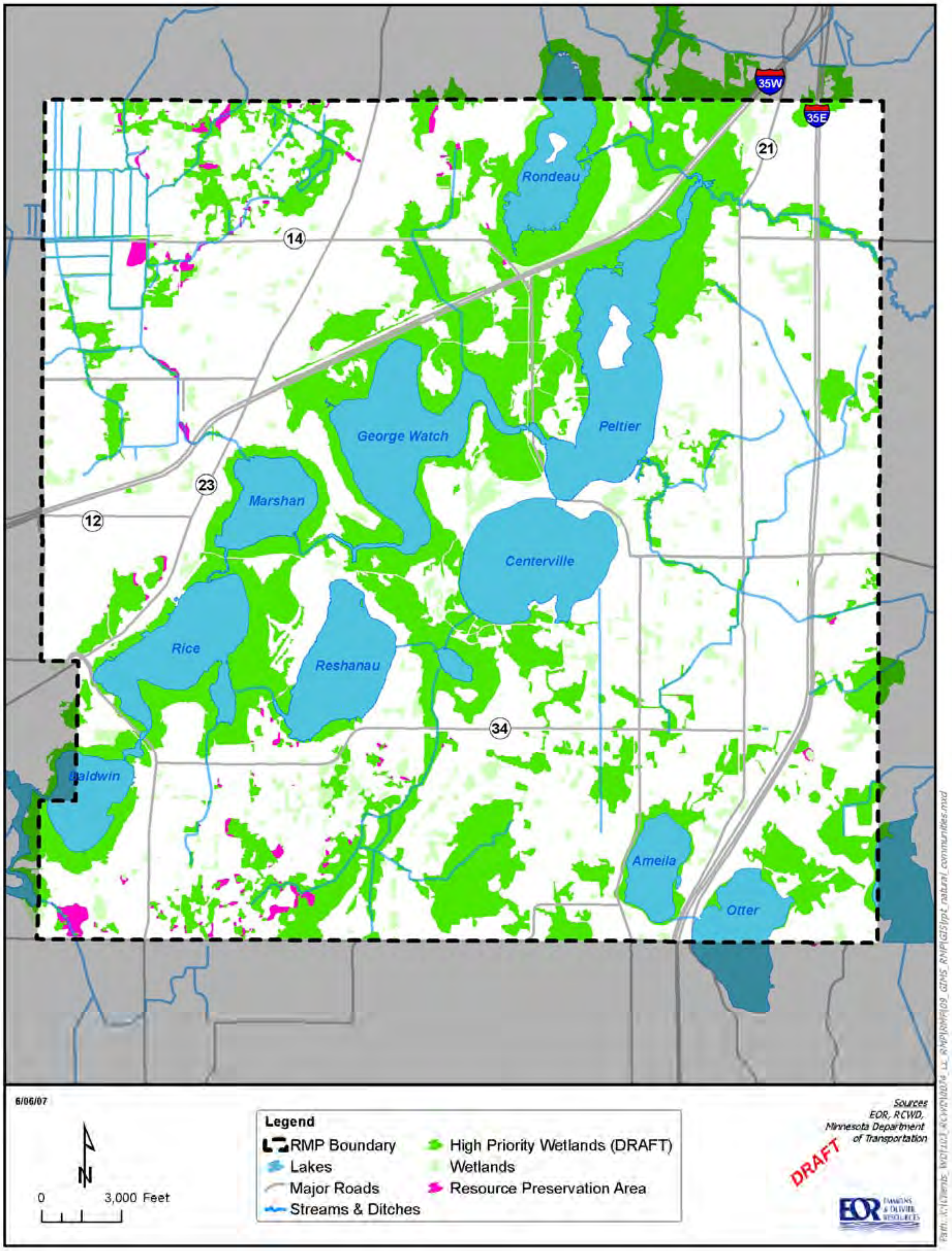


**Figure 10. Lino Lakes High Priority Wetlands.**

# SECTION 2. FUTURE CONDITIONS

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# FUTURE WATERSHED CONDITIONS

## DESIRED FUTURE CONDITION

Future land use and watershed management policy affects watershed runoff volume, nutrient load, locations of open space and connected greenways and in turn affects the future quality and functioning of lakes, wetlands, and ditches.

The two future conditions scenarios evaluated were the full build-out (FBO) and the RMP (Figure 11). Each scenario is defined by dovetailing land use information from the City and watershed policy information from RCWD. FBO uses full build out land use and 2007 District rules. The RMP scenario uses proposed full build out land use and 2008 Watershed District rules. During the process of developing the LL RMP, results of the existing conditions and FBO modeling scenarios guided RMP land use and identified potential environmental impacts.

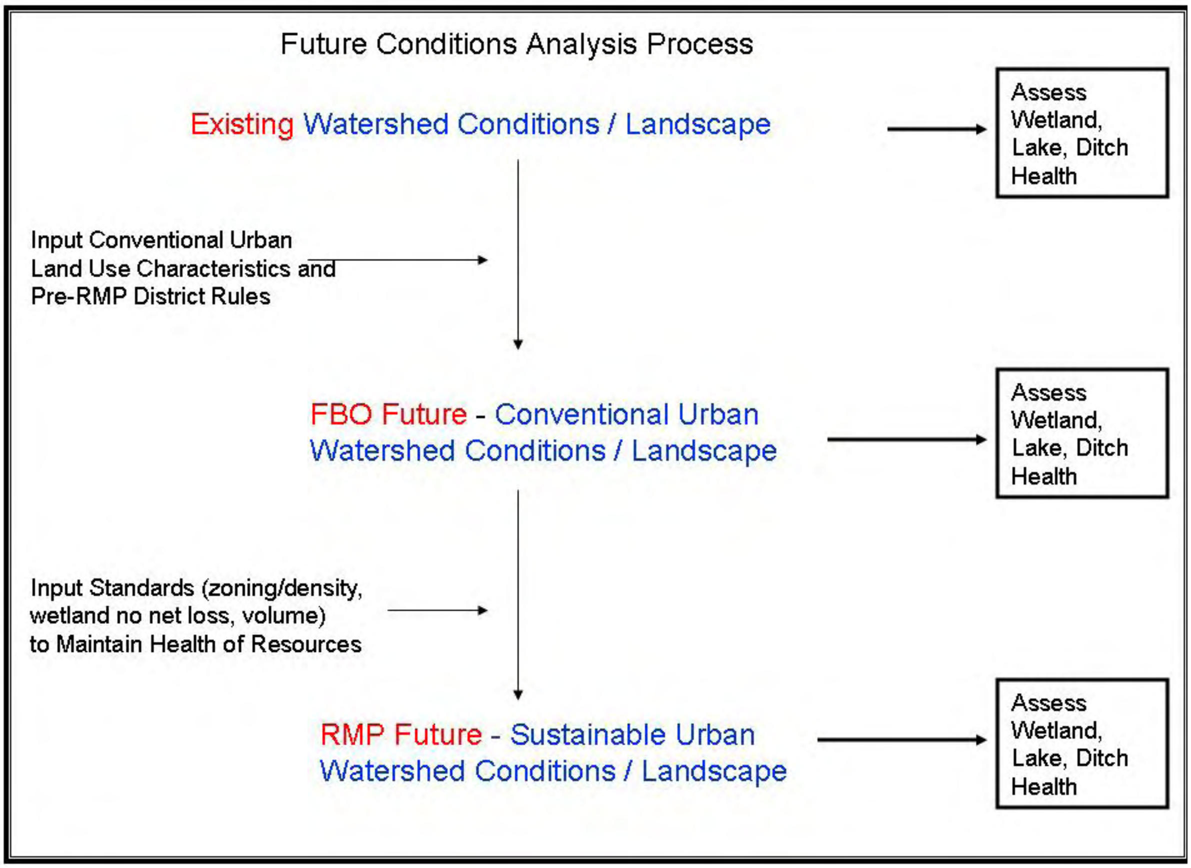


**Figure 11. Future Conditions Assessment.**

## RMP Future Condition Goals and Strategy

The primary issues for Lino Lakes to address through the RMP process are restoring groundwater hydrology to groundwater-dependent wetlands, restoring naturally fluctuating hydrology to wetland open space systems, maintaining ditch systems being used for agricultural benefit, establishing habitat complexes and connected greenways, mitigating flood-prone areas, and reducing phosphorus loading to impaired lakes. Urban land use most notably affects these resources through stormwater volume. As such, a strategy of broad-based source reduction in volume is needed.

Green infrastructure is the unifying strategy to address volume effects. Stormwater is considered an asset to 'retain for recharge' instead of a waste to 'collect and dispose'. In this strategy, retained storm water at its source eliminates downstream flooding and recharges shallow aquifers to sustain wetlands and lakes during drought. A long-term monitoring program to accompany green infrastructure implementation will evaluate quantitatively the strategy's long-term environmental and cost benefits. According to the National Association of Flood and Storm Water Management Agencies, funding and administration at the local level requires a paradigm shift (see Section 4 References, Guidance for Municipal Stormwater Funding). To implement a green infrastructure program a partnership is needed between the City and private property owners for shared water retention. Natural resource management in a green infrastructure strategy means linking and integrating resources and compatible land uses. Trails may follow an interconnected system of corridor nodes and linkages. Wetland/upland habitat and stormwater management features work in concert to sustain ecological processes.

***Implementation Funding***

With the paradigm shift to a partnership between public and private landowners, the funding vehicles also need to be revised. A green infrastructure strategy utilizes a large network of runoff retention sites or system components. The first shift is to move beyond a planning partnership between the City (local government unit, LGU) and watershed district (WD) to a capital improvement partnership. Currently the Watershed District has a cost-share program for infiltration, although the eligible practices are not restricted to a green infrastructure strategy. This cost-share program is open to the LGU as well as private landowners. Watershed organization cost-share is designed as an incentive program. The cost-share program is not funded to support LGU infrastructure. In the case of green infrastructure the LGU will need to redesign its existing stormwater infrastructure construction and maintenance funding to involve many system components that necessarily are in association with private landowners. For existing urban areas, this might involve a utility payback fund for landowners able to construct and maintain their own system components, although there are downsides (indirect penalty to those unable and changing landowners). In any case, redirecting existing funds earmarked for constructing expansions of existing conveyance infrastructure is the first source of funds for green infrastructure. Once the overall shift of money from old into new funding items is designed, the role of the Watershed District in education and incentives should be considered.

## POLICIES AND PROCEDURES

Boundary locations shown in this plan are at a low resolution compared to that required for regulatory site plan review. The watershed scale of this analysis is needed to demonstrate how landscape connections between sites can be maintained. Field investigations and finer scale mapping will be required to accurately implement ordinances and rules at the site plan scale.

### Municipal Ordinance and Watershed Rule Coordination

The LL RMP proposes a plan to address municipal and Watershed District rules at the same time. This requires updating of local ordinances and Watershed rules that effectively implement the plan. Green infrastructure or conveyance infrastructure are the two overarching surface water system alternatives, with the former focused on runoff volume reduction and the latter on runoff volume conveyance to downstream endpoints. Capital investments ought to principally focus on one or the other alternative on an overall city and related subwatersheds basis. Blending the two is not feasible, because subwatersheds are interrelated, with one feeding another. The RMP modeling scenario was performed on a volume reduction basis and demonstrates the feasibility of implementing the green infrastructure alternative on a city-wide basis. Implementing green infrastructure ought to consider the particular modeling results on a subwatershed (RMU) basis, and also the feasibility of various green infrastructure strategies as they relate to various land uses. Green infrastructure strategies are more and more grouped according to whether the land area under consideration is ‘developing’ from rural to urban, is currently urban, or is part of open space corridors. These groups can be the basis of green infrastructure implementation and are recommended to be incorporated into the city plan review process, public works organization, and capital improvement funding. As part of the RMP, green infrastructure implementation will be pursued in the city, with the following three initiatives refined to be incorporated into programs and ordinances.

***New Urban Areas Low Impact Development (LID) Planning Assistance***

As agricultural area land uses convert to urban commercial, industrial, and residential, the parties involved in approving plans, such as the planning commission and city council, need tools for evaluating plans for whether all green infrastructure design parameters were utilized. For example, a project design with onsite pipes and holding ponds would presume an offsite stormwater conveyance system for the ponds to overflow to. Project-level design needs to be consistent with an overall city-level green infrastructure alternative to managing surface water. Green infrastructure as defined by the USEPA utilizes numerous features (see References, USEPA Green Infrastructure) that collectively operate to retain and recharge water where it falls. A green infrastructure backbone does not include an RMU-scale stormwater conveyance system constructed in advance of and in anticipation of project-level conveyance systems that can then all be linked together. Green infrastructure in practice will at first require more upfront plan review and project-level design, but reap savings from significantly reducing capital costs of constructing conveyance systems and the costly maintenance of ponds and associated devices.

1. Provide guidance for the planning commission regarding low impact development.
2. Use of site planning and stormwater management features described for LID: (see Section 4 References, Judicial Ditch 4 Resource Management Plan Appendix E).
3. Zoning and flexibility tools to be identified in the Comprehensive Plan.

***Existing Urban Areas Green Infrastructure Program***

These kinds of lands shall be approached as an infrastructure redevelopment strategy that is coupled with particular water bodies which may be currently affected in negative ways by pipe discharge. In addition, the green infrastructure strategies for existing transportation network maintenance can be geared towards eliminating existing outfall structures into nearby water bodies.

1. Address joint responsibility areas between county highway dept and the City.
2. Restructuring of the City street program: Shift the stormwater component of street reconstruction to a separate stormwater management program that relies primarily on less capital and energy intensive post-construction BMPs. Neighborhood stormwater planning should precede the street project design in order to develop the agreements with residents for the residential components (disconnected downspouts, driveway runoff) and street side infiltration and biofiltration areas.
3. Establish a clean lakes fund (similar to a stormwater utility) through a City fee that is used to pay for local stormwater plans (see References, Portland RAIN). The City designs, installs and maintains the stormwater features included in the neighborhood plan. To those willing to agree to maintenance agreements, a fee reduction would serve as an incentive (see References, Portland Clean River Rewards)
4. Establish the green infrastructure program with City staff able to conduct design, inspection, and maintenance.
5. Establish Clean Water Act Nondegradation compliance program to include the established goals for each aquatic resource, the timetable for eliminating stormwater discharges, a resource monitoring schedule, and reporting program.
6. Establish a volume reduction overlay. Volume reduction will lead to nutrient load reduction which will contribute to meeting TMDL load reduction goals. Some areas of the volume reduction overlay will serve to reduce volume effects on sensitive wetlands under existing conditions. In other areas, the overlay will reduce existing or potential future flooding and capacity exceedance of the agricultural ditches and other conveyance systems.

***Wetland Corridor Overlay***

In open space and park land areas of the City, the green infrastructure program will protect high priority wetlands, their biological condition, and will balance their function as high quality habitat, natural flood reduction and water quality improvement components in the landscape. Further refinement of corridor linkage areas, shape, and size shall occur with green infrastructure implementation, through a combination of planning commission review of plats and City initiatives for setting aside multifunctional linkages (volume reduction stormwater features, passive trails and open space, wetland and volume banking sites). Where rare and endangered animal species movement patterns (e.g. Blanding's turtle) need to be considered, corridor linkages will be established in consultation with wildlife habitat specialists.

The process for establishing the Wetland Preservation Corridor, including wetland regulatory requirements and permitting process is detailed in the Lino Lakes RMP Rule.

## Wetland Rules: Coordinated Local, State, and Federal

The LL RMP incorporates emerging regulatory concepts. This includes new guidance on state and federal wetland regulatory streamlining on mitigation requirements, changes to Section 404 to be watershed-based in permit decision-making, standards and guidance on wetlands quality and impaired waters status, changes to local stormwater management to comply with nondegradation requirements in the upcoming MS4 general permits, and watershed district rule revisions. The RMP also allows for resources to be integrated by using a watershed-based approach to TMDL implementation.

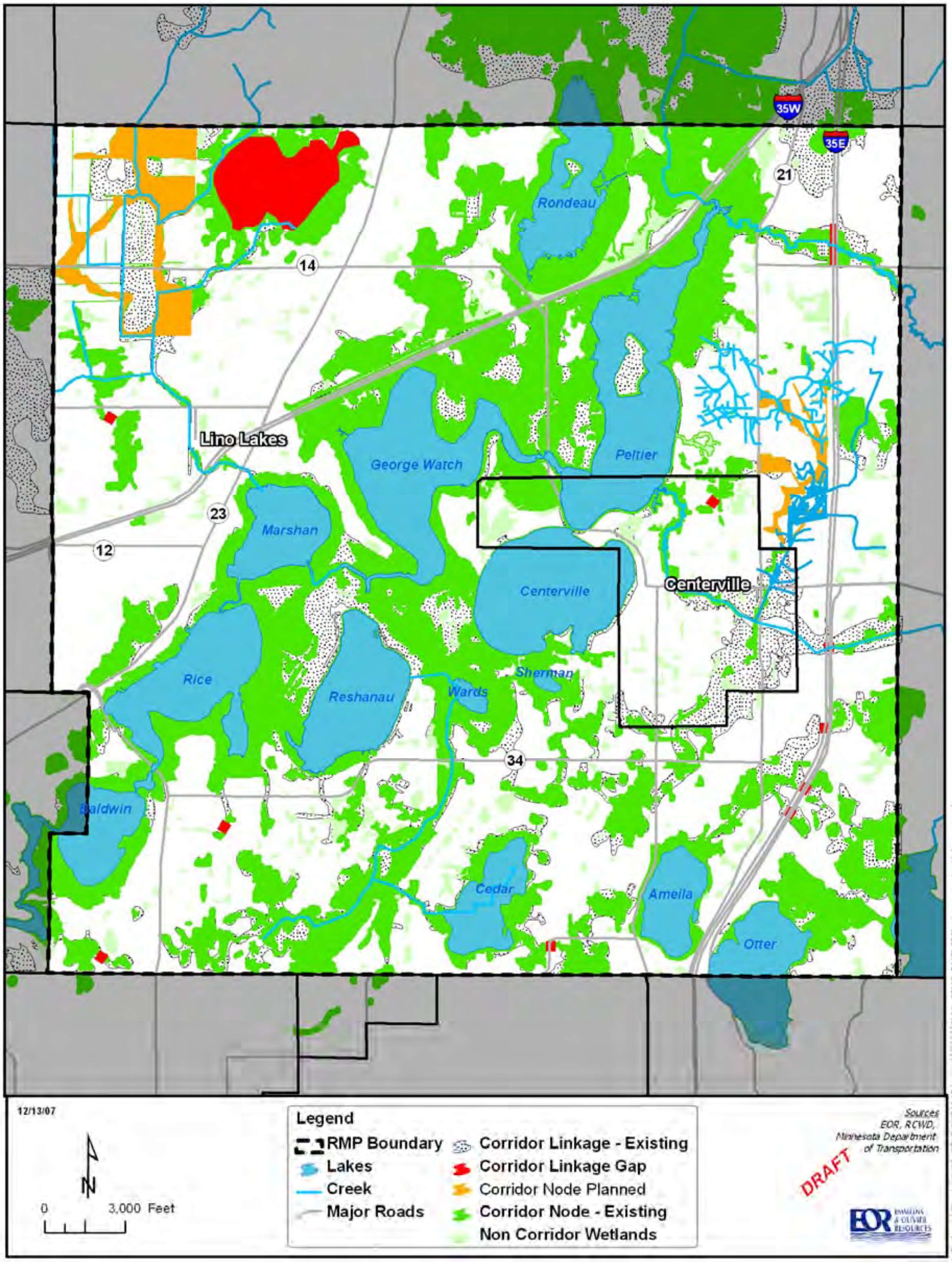


**Figure 12. Wetland Corridors and Linkages.**

***Federal Clean Water Act Wetland Rules***

Under Section 404 of the Clean Water Act, high priority wetlands can be subject to special provisions that identify them as not suitable for fill. Impacts may be permitted to other wetlands if all Clean Water Act Section 404 requirements are met. Impacting high priority wetlands will trigger significant environmental effects. If there are applications for a permit that include some wetland impact, there will need to be consideration of suitable replacement locations based in the local watershed.

In April of 2008 the new federal rule on compensatory mitigation describes a "watershed approach" to replacing losses of aquatic resources (Department of the Army, Corps of Engineers 33CFR Parts 325 and 332; Environmental Protection Agency 40 CFR Part 230). Subpart J §230.92 defines a watershed approach as well as watershed plan. The Lino Lakes RMP meets the obligations identified in the federal rule such as:

a. It meets the specific watershed needs
b. It describes preferred locations of mitigation activities
c. It includes a landscape scale assessment
d. It considers of historic and future impacts
e. And it considers aquatic and terrestrial connections.

By utilizing a watershed planning approach, the Lino Lakes RMP can vary standard compensatory mitigation requirements written for areas without a plan in place.

The new federal rule also establishes mitigation priority for banks and in-lieu programs over individual project site mitigation. Identification of potential mitigation bank sites is included in the Lino Lakes RMP. Those sites could either be restored through the bank process if up-front funding exists or a future in-lieu program could be initiated.

***State Wetlands Conservation Act Wetland Rules***

The RCWD implements the Minnesota Wetlands Conservation Act (WCA) and local wetland planning. The Minnesota Board of Water and Soil Resources (BWSR) must review the LL RMP as a local Comprehensive Wetland Management Plan under Wetland Conservation Act rules. If approved as a Wetland Management Plan by BWSR, the LL RMP will be used in the WCA permitting process. The LL RMP identifies what is needed to meet the Minnesota WCA objective of no net loss in quantity and quality of wetland resources.

This plan and district rules will provide the local implementation requirements of the state rules. The district rules address state wetland requirements while also setting standards for control of runoff volume.

RCWD policies and guidance for resource management planning and interagency coordination have been developed for other RMP areas. The JD4 RMP and 53-62 RMP policies and guidance are incorporated here by reference. The RCWD Board previously adopted Rule RMP-1 and Rule M to address development design standards in particular watersheds of Rice Creek. The Rule implementing the JD4 RMP is scheduled for adoption in early 2008. The rules provide details on development standards that must be followed and the required review process. The RMP rule provides standards for surface water runoff, BMPs, buffers, and wetlands.

The Lino Lakes RMP will be governed by a set of rules similar to the JD4 RMP Rule (RMP-2). However, in some subwatersheds in Lino Lakes, sensitive wetlands will need additional controls to reduce the potential for storm water impact and increase the groundwater recharge needed to support their hydrology. The rule standards are based on meeting the resource quantity and quality objectives of the RMP under the land use conditions projected for the future to provide a cumulative no net loss of wetland resources. To manage runoff, future land use plans and designs will be required to incorporate a variety of best management practices (BMPs) (described in more detail on the RCWD BMP Browser at (see References, RCWD BMP Browser).

Wetland restoration activities provide many stormwater management and ecological benefits. If an applicant is proposing restoration of partially drained wetland then the scale of degradation will be required to determine the extent of drainage and potential restoration credit. The RMP Rule will require that future maintenance and repair of the public ditch system comply with restrictions placed on mitigation wetlands. Policies regarding these issues are described in the JD4 RMP found at (see References, Judicial Ditch 4 Resource Management Plan).

A study called the Rule Economic Analysis was performed in 2007 to assess the cost-benefit of the RMP Rule covering the JD4 watershed when compared to existing WCA rules. This study found that the JD4 Rule does not create economic losses compared to state rules.

The RCWD groundwater program is incorporated into the LL RMP by reference in that restoring groundwater hydrology is a key factor for Lino Lake resource protection.

Mn/DOT and County Transportation

The Minnesota Department of Transportation (Mn/DOT) is the WCA LGU for wetland impacts within its right-of-way (ROW). Mn/DOT and County projects that propose to disturb wetlands within their ROW will continue to apply the wetland mitigation standards found in WCA, not the wetland mitigation standards specified by the watershed rules, unless it elects to apply the RMP Rule. All other Rules adopted by RCWD will continue to apply for Mn/DOT and County projects within the District boundary.

Volume and Impervious Reduction

The RMP rule will provide overall runoff volume reduction standards. The standards can be met using a wide variety of measures. In urbanizing areas the first goal will be reducing impervious area using LID site design. Minimizing impervious surface through LID will lower the required infiltration volume. Green roofs are included here as a runoff volume reduction technique.

Upland volume reduction measures are:

- BMP Infiltration Features
- BMP Biofiltration Features
- Buffers/Conservation/Restoration Areas
- Impervious Disconnection
- Upland Greenway Connections

For a description of volume reduction measures, please go to Chapter 11 of the Minnesota Storm water Manual: Applying Storm water Credits to Development Sites, (see References, Minnesota Stormwater Manual Chapter 11).

Volume Banking

A parcel which meets its volume reduction requirement and has an opportunity to utilize additional stormwater reduction strategies can generate volume credit. It is important to recognize that naturally vegetated grasslands and forests around wetlands are eligible to provide volume reduction credits. Thus, good site design can accomplish some of the volume requirements and meet high priority wetland buffer requirements at the same time.

Allowable activities for volume banking are wetland re-establishment, restoration of partially drained wetland, protection of naturally vegetated uplands and restoration of compacted upland soils.

The bank will account for volume reductions above and beyond the project-specific requirements. During the growing season, consistent with the natural hydrologic cycle, volume of surface runoff in any particular rainfall event is reduced via vegetated landscape depressions that can do either one of two things, depending on underlying soils. They can trap and slow down flow-through water (biofiltration) and also allow for evapotranspiration into the atmosphere via vegetation. Or, they can trap and retain water to allow for evapotranspiration and also infiltration through underlying soils and into the surficial groundwater. In either case, the volume reduction is heavily dependent on very healthy vegetation. Infiltration capacity is associated with highly developed root systems. The key to success, healthy and vigorous vegetation is consistent with the quality of vegetation typically anticipated for successful landscape depressions definable as wetlands. As such, restoration of wetlands will be allowed for volume banking only to the extent that wetland vegetative integrity and other functions are maintained for all of the wetland plant communities in a particular wetland complex proposed for credit. Only partially drained wetlands are eligible, and the characteristics of the restored wetland will be determined by wetland replacement permit/banking requirements, although restoration can be done for volume banking alone and does not have to be part of wetland permitting. Once the wetland meets the wetland permitting standards, it is eligible for the volume bank. Banking requirements will be further codified in the rule.

Volume credits may be used to offset increases in volume output only after all BMPs for a particular development have been utilized. These credits may also be purchased and transferred within the same subwatershed in Lino Lakes. Credit will be tracked and accounted for by the RCWD and will only be granted after assurance of success of the storage capacity of a constructed system can be verified.

A single restored wetland may receive credit in the volume bank as well as the wetland bank. The relationship of volume banking to wetland banking is illustrated below in Figure 13.

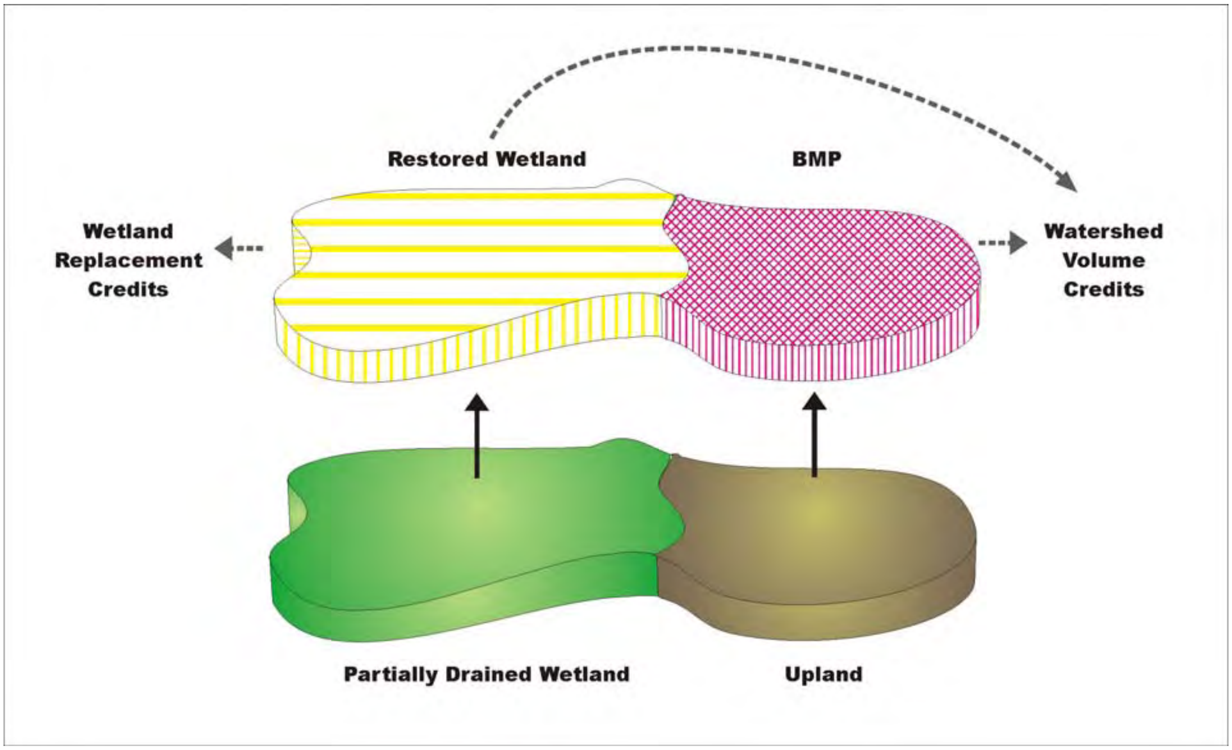


**Figure 13. Relating Volume and Wetland Replacement Credits to Landscape Features.**

Volume banking is not the same as nutrient banking. Nutrient credit trading has been applied to certain effluent discharge permits, and there is interest in its use for nonpoint source nutrient reduction requirements which may be required in the future. Wetlands have been discussed as a possible component, but, at present, knowledge gaps exist that prohibit this. In the future, when adequate data are available, the District may consider the feasibility of developing a nutrient banking program.

## State Drainage Law

***Management under the RMP***

RCWD is the ditch authority for all public ditches in Lino Lakes. Governed by the statutes specified in MN Statute, Ch. 103E, created many years ago for the development and maintenance of agricultural ditches, the RCWD is given authority for managing and repairing the public ditch system. Following is a list of goals to be incorporated into the repair of these ditches:

- Minimize future ditch maintenance costs by utilizing a self-sustaining design
- Protect against wetland functional losses and downstream flooding through volume control in the headwaters
- Account for future development by ensuring adequate stormwater controls are in place such that ditch capacity is not exceeded, creating flooding conditions and loss of drainage efficiency.
- Maintain hydraulic efficiency to which benefited landowners are legally entitled by removing ditch obstructions

Ditch management project locations have been identified for preservation and maintenance of agricultural ditches and attributable property benefits and are described in the resource management units (RMU) section of this report.

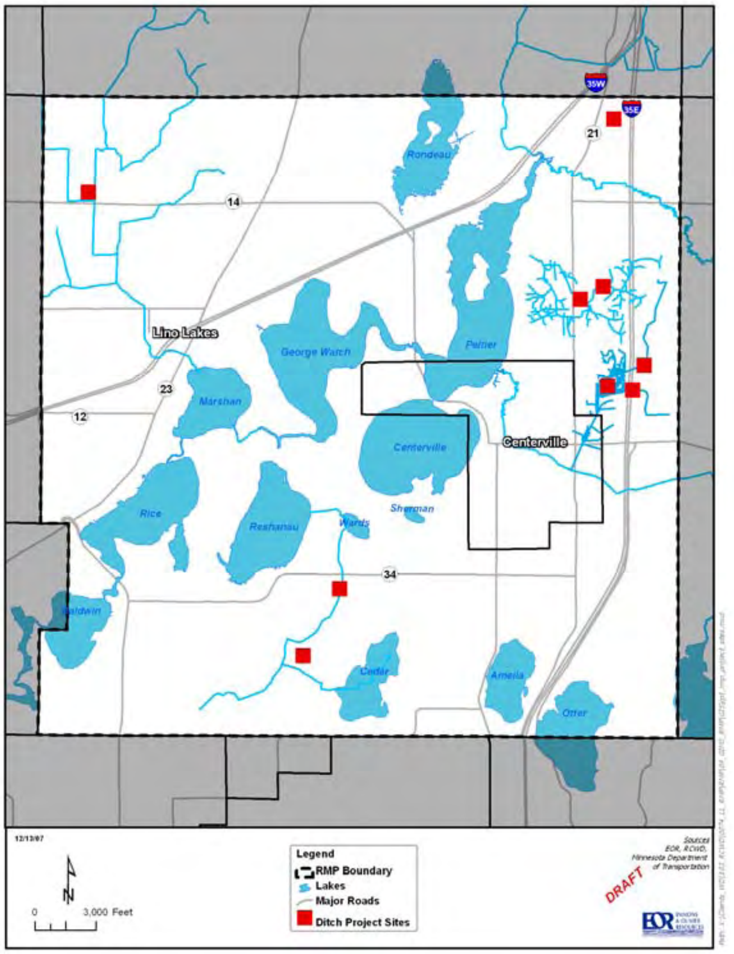


**Figure 14. Ditch Maintenance Project Locations.**

### *Benefits under the RMP*

Traditionally, landowners "benefited" from repair of agricultural ditches because the increased drainage efficiency of the ditch enhances the use of portions of wetland areas for agricultural purposes and also drains nonwetland areas more quickly. Traditionally, ditches were repaired through excavation of the entire length of the ditch. In the case of ditches in Lino Lakes, it was determined that a traditional repair of ACD 25 and ACD 10-22-32 was unfeasible, both from a cost and legal perspective. In addition, the fully repaired ditch drainage estimates have shown that the potential dewatering would drain inaccessible narrow strips of land within a large wetland basin or simply convert an existing wetland to a less wet type. In either case, for the purposes of land development, little benefit can be gained for such a repair project.

The RMP provides expanded benefit opportunities to landowners, in addition to the traditional benefit of wetland drainage. As the watershed land uses affecting these ditches continue to lose agricultural use to urban use, each parcel can derive benefits differently depending on the specific land characteristics of the parcel. Benefits are available for landowners who may need opportunity areas for volume control and also landowners who have volume control opportunities to offer. The RMP provides the wetland and open space corridors sought by potential buyers of new, suburban lots which benefits landowners of both developable and preservation land. It also provides landowners who own extensive partially drained wetlands a framework to benefit from watershed-based volume control banking and wetland mitigation credit banking. The volume and wetland banks are eligible for use by landowners in other parts of the watershed and the state metro wetland bank program.

Additionally, the RMP provides the following tangible benefits to property owners within the RMP:

- Streamlined or consistent processing of local, state and federal permitting
- Clear stormwater management expectations
- Expanded range and flexibility of replacement options
- Expanded opportunity for wetland credits
- Increased land value for properties associated with preserved open space

## Other Regulations

***Clean Water***

This plan provides guidance on watershed-based clean up of the nutrient-enriched Peltier Lake and the Chain of Lakes (George Watch, Marshan and Reshanau). The Chain of Lakes is being studied in order to establish the clean water TMDL goals required for impaired waters of the state.

The RMP also provides a watershed-based approach to meeting the federal nondegradation requirements for stormwater discharges that are being implemented across Minnesota. The City can use the RMP to develop the plans for their MS4 permit application to comply with nondegradation.

***Watershed Runoff***

The RCWD adopted new District-wide rules in 2008. Additional controls within Lino Lakes may also be necessary to protect sensitive resources within different parts of the City. The RMP rule for Lino Lakes will not be identical to the two other RMP rules in RCWD, but custom-fit the resources of the city. Volume of water leaving a land area is addressed in all of these rules, and includes ways to earn credit for containing runoff volume onsite. Preserving natural vegetative cover, especially around wetlands, is one of the more valuable volume credits because it also protects wetland habitat areas. Another especially valuable volume credit is to restore hydrology to partially drained wetlands in a way that provides natural wetland conditions.

# FUTURE CONDITIONS MODELING RESULTS

## Watershed Runoff

Both the FBO and RMP modeling criteria (see Modeling Appendix) were used to examine effects of land use and district standards on future flooding and wetland hydrology. The results are discussed in terms of volume effects. Wetlands classified as highly sensitive to stormwater bounce and duration of flooding (Storm Water Advisory Group classification in RMP Existing Conditions) were evaluated using the 1-year 24-hour rainfall event. Structures were evaluated using the 100-year rainfall event. Runoff volume can have two effects on wetlands. The first occurs when the runoff creates too large of a jump (bounce) in the wetland water level. The second occurs when excess water is retained in the wetland for a period of days.

The RMP scenario runoff effects are shown in Figure 15. For wetlands, a broad overview is shown of the general areas to anticipate volume effects. The areas are high and low potential catchments for possible negative effects on wetlands. From this analysis, individual wetlands were examined, and those which are not expected to be protected by the RMP 2.8-inch infiltration standard are identified on the RMU maps in the next section of the report. The catchments labeled ‘unknown’ were not evaluated because highly sensitive wetlands were not present. The other set of information on Figure 15 is sensitive water level points. All of the data on Figure 15 were used to identify potential projects. Volume reduction as opposed to capacity expansion was evaluated for the sensitive water level points. For example, a potential project area is the private agricultural ditch in the southern part of Centerville where several roads are expected to overtop. The overtopping is at farm road crossings of the ditch, and the ditch system is potentially a high priority for wetland restoration and banking. In this example, restoring wetlands upstream of the overtopping culvert reduces downstream volume, peak flow and flood elevation, thereby avoiding the construction of capacity expansion.

## Wetlands

High priority wetlands were established under existing conditions using the features identified in Figure 16. These wetlands were then used by the City to formulate the Lino Lakes future land use types and subsequent zoning. The results were then provided to use for scoring the input parameters for the future conditions wetland assessment. Essentially, the land use was ‘tested’ in the process illustrated in Figure 11 for its effects on wetlands. The results are described below (page 46) under Future Scenario Alternatives Analysis.

The first outcome of high priority wetland designation was to create the Wetland Corridor Overlay (Figure 12). The buffer width standard for high functioning wetlands according to the Wetland Conservation Act (WCA) is 300 feet to maintain habitat and 50 feet to maintain water quality (MNRAM buffer width metric). A customized variable width buffer area is incorporated into the overlay, giving each wetland complex individual attention, rather than using a one size fits all approach. The combination of high priority wetlands and variable width buffer area with the City’s defined low development suitability areas produces nodes, and the 100-year floodplain area produces the diffuse corridor linkage areas. The diffuse corridor linkage areas tie together corridor nodes.

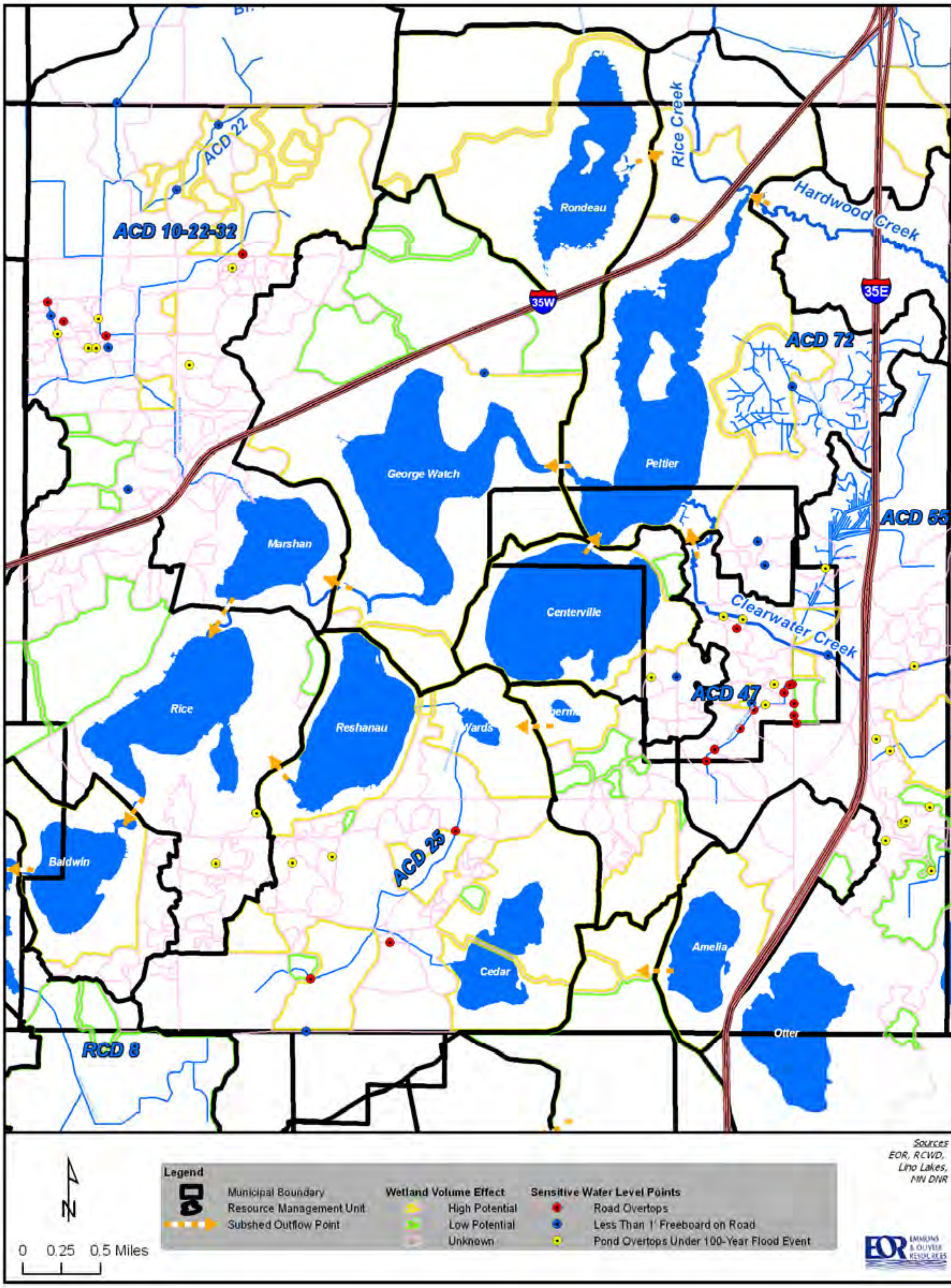


**Figure 15. FBO Scenario Volume Effects on Wetlands and Structures.**

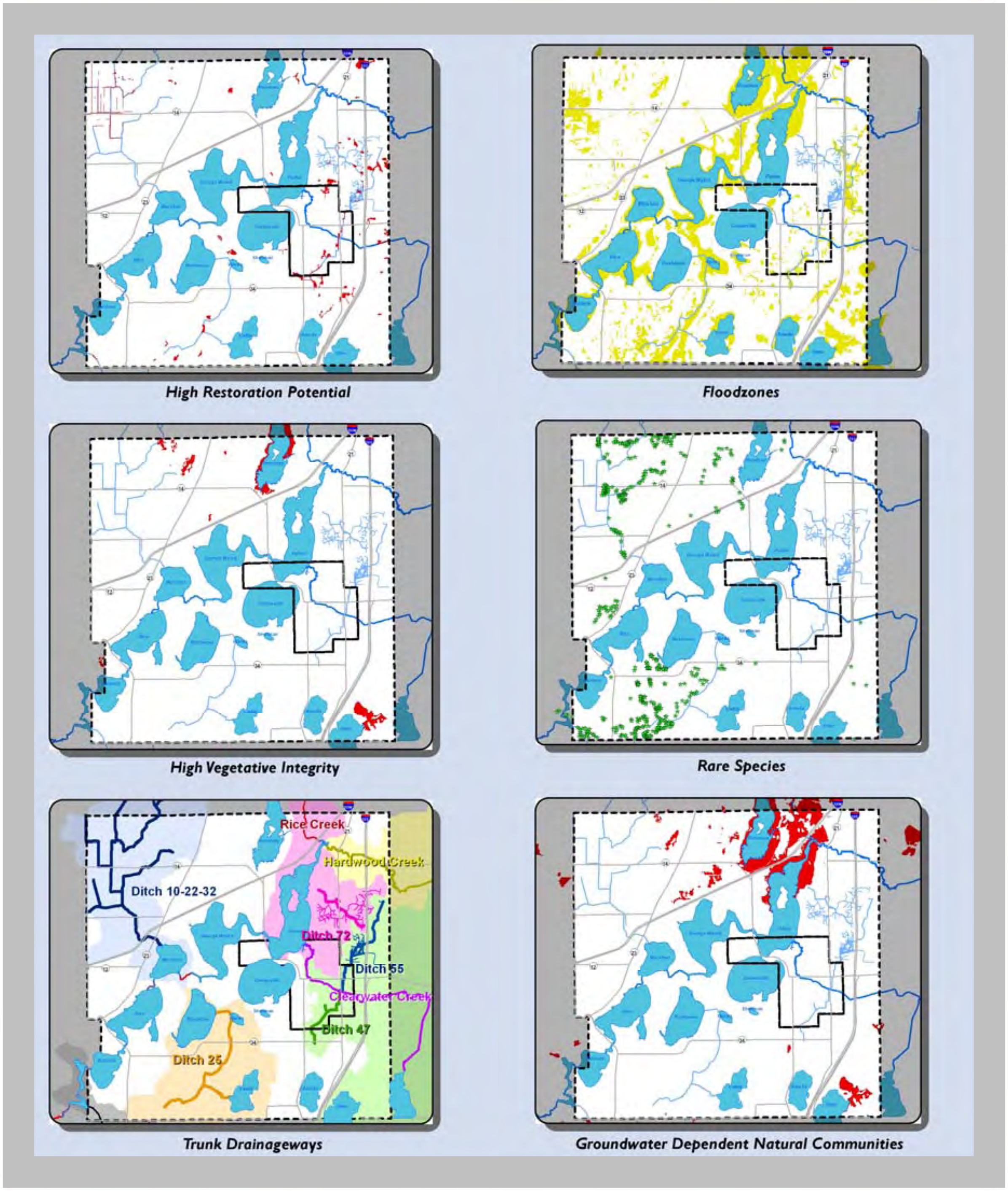


**Figure 16. Factors Used in Establishing High Priority Wetlands.**

## Lakes

Phosphorus loading is a primary indicator of lake condition and is evaluated to establish goals for restoring impaired lakes in a total maximum daily load (TMDL) study. The FBO scenario shows an increase in subshed external loading to all lakes (Figure 17). As discussed in Existing Conditions, subshed loading in Lino Lakes is already high compared to a reference condition watershed. The new findings show particularly large load increases for Peltier, Clearwater Creek and Rondeau subsheds. The Rondeau and Peltier subsheds have the lowest existing loading and should be very high priority for reducing volume. As such, addressing volume effects for the benefit of the agricultural ditch systems, reducing flooding, and sustaining sensitive wetlands will also provide the benefit of nutrient load reduction.

## Agricultural Ditch Systems

The Anoka County Ditch 10-22-32 branch system is the largest and most complex (figure 18). The headwaters of the ditch are in Columbus where traditional agricultural land use is principally in practice, and drainage is an important benefit. Aggressive implementation of a ditch system management plan will incorporate the need for agricultural benefit practices that maintain drainage in the headwaters and also respects the shift away from agricultural land uses downstream, incorporating and recognizing the new urban ditch benefits. The new urban benefits will provide ancillary benefits for subwatershed-wide flood reduction and wetland protection where such benefits are desired. The nutrients in runoff under existing conditions already produce high loadings. The branches will be managed according to the general strategies feasible for land use (Table 2 for ditch branches, see Marshan RMU for future land use). The ditch management plan will use branch maintenance in rural areas, retrofits in urbanizing areas and master planned communities with greenways and open space to reduce downstream flooding and retain and reuse water in the local catchments. More detailed descriptions of 10-22-32 and 25 can be found in the RMU section of this report and in the Ditch Repair Reports for each system (see References, Anoka County Ditch 25 & 10-22-32 Repair Reports).

## Creeks

Hardwood Creek and Clearwater Creek, both TMDL-listed streams, are directly impacted by development activities in the Lino Lakes and Centerville portions of their drainage area. For both of these streams, stormwater volume and sediment load are stressors to biotic life. The Hardwood Creek TMDL is expected to be finalized in 2008. In 2007 the Clearwater Creek went through the stressor identification process. The TMDL project for Clearwater Creek is expected to be funded by MPCA in 2008.

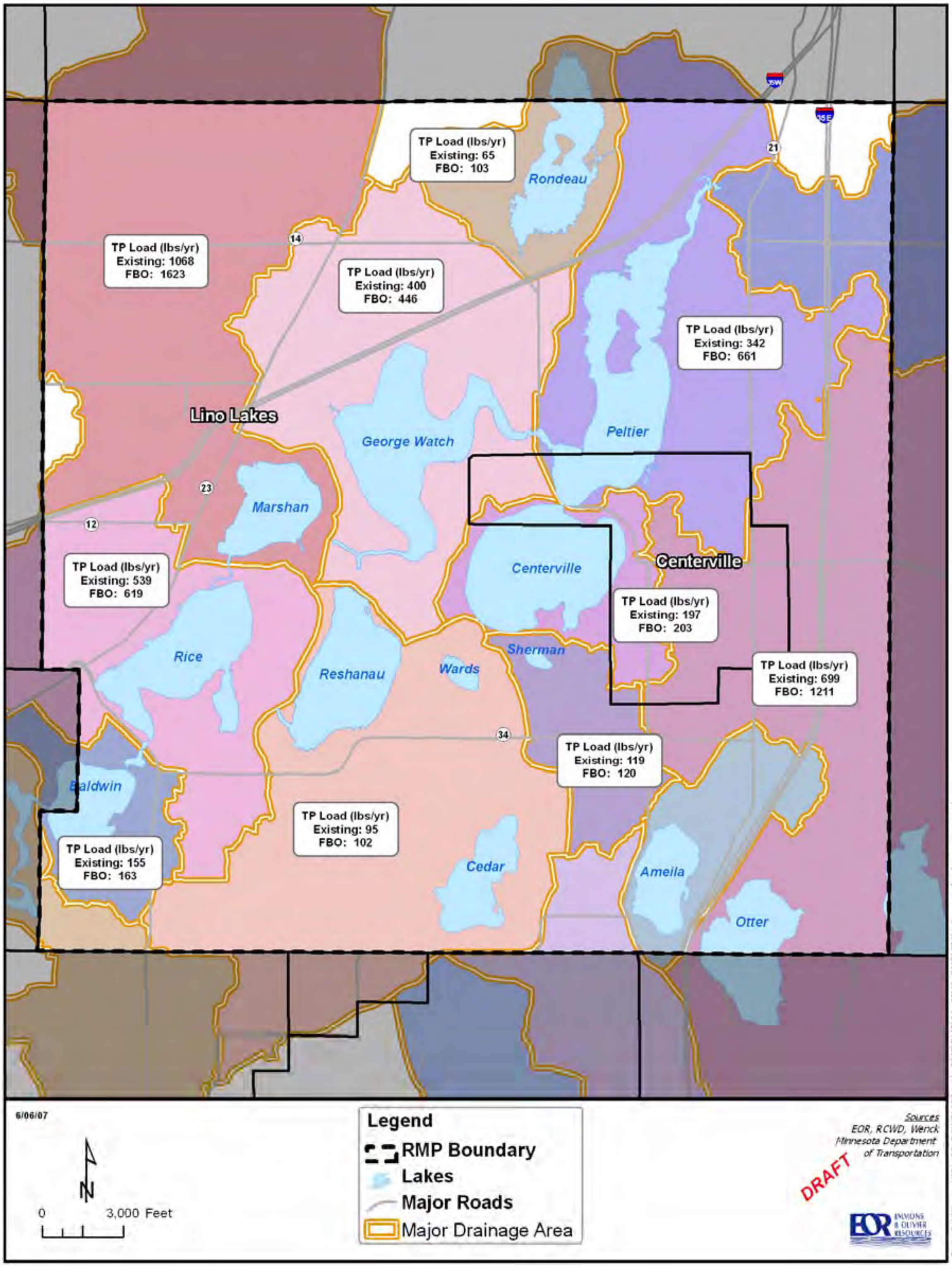


**Figure 17. Future Conditions Increases in Phosphorus Loading for Each Subshed.**

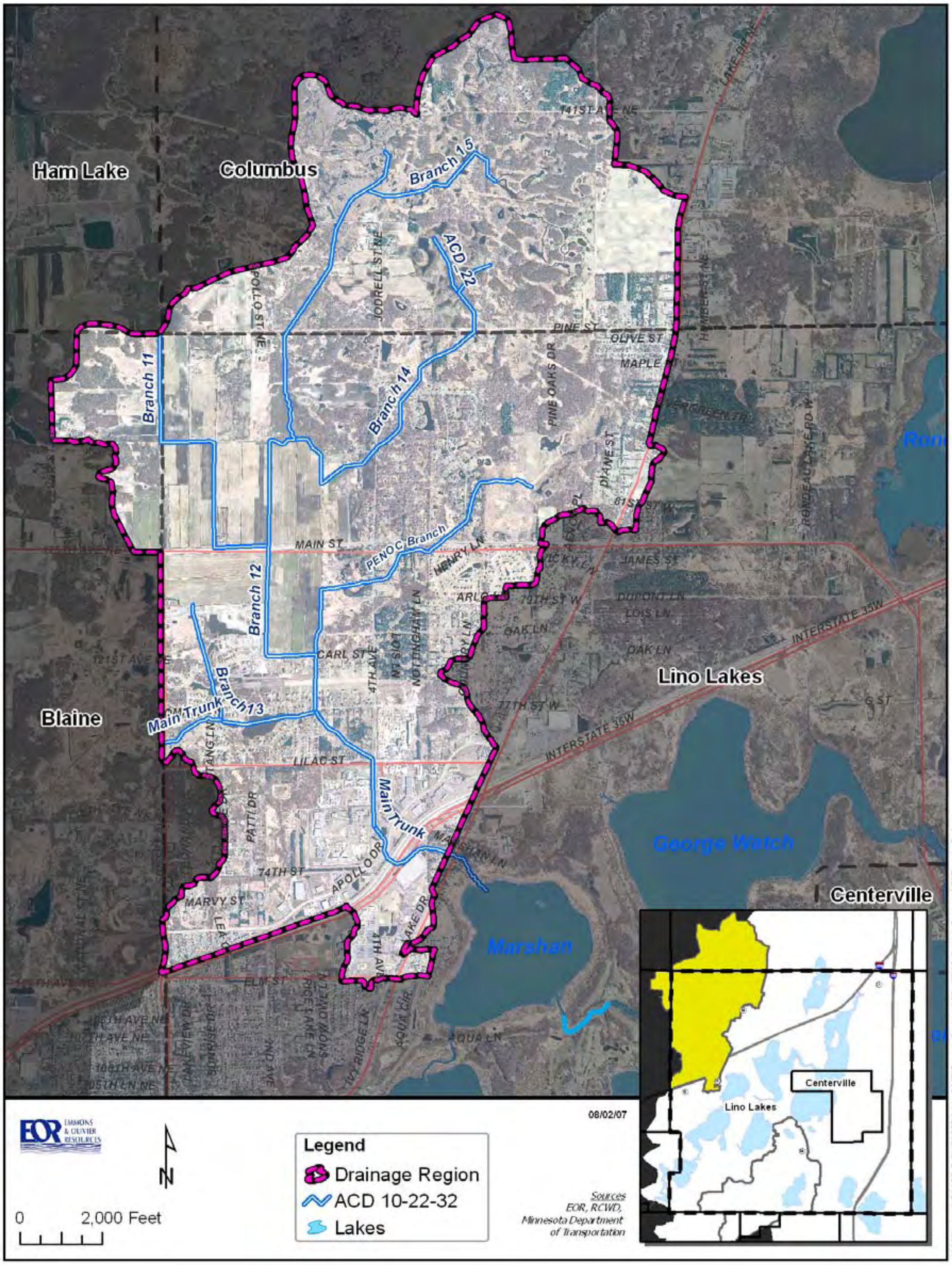


**Figure 18. Ditch 10-22-32 Branch System.**

**Table 2. Ditch System 10-22-32 Branch Management.**

| 10-22-32 Ditch System Branch | Current Land Use | Potential for Flooding or Wetland Restoration (current land use) | Future Branch Management |
|---|---|---|---|
| Branch 11 | Agricultural/sod farms | High restoration potential | For urban land use and LID stormwater plan, not agricultural benefits |
| Branch 12 | Agricultural/sod farms | Flood prone in downstream urbanizing segment; high restoration potential in upstream segments | For urban land use and LID stormwater plan that alleviates the downstream flood prone points, not agricultural benefits |
| Branch 13/Branch 11 south | Urban and Agricultural (11 south) | Flood prone points on 13; several wetlands with medium restoration potential on 11 south; flows through urban lakes | Branch 11 maintenance concurrent with agricultural use or for urban land use conversion by restoring wetlands for downstream protection; alleviate flood prone points using urban volume reduction strategies in contributing catchments |
| Old Main Trunk | Urbanizing | None | None |
| Main Trunk | Urban | Medium restoration potential upstream segment | Evaluate restoration potential if valuable for system wide nutrient load reduction to Marshan |
| Penoc Branch | Partially urbanized | Some medium and low restoration potential; no flooding | Integrate into greenways and urbanizing LID stormwater management plan |
| Branch 14 Lower | Forested/wetland and urbanizing | A lot of medium and low restoration potential, no flooding | Integrate into greenways and urbanizing LID stormwater management plan; plan to accommodate Upper segment agricultural benefits |
| Branch 15 Lower | Forested/wetland primarily | A lot of medium and low restoration potential, no flooding | Integrate into greenways and urbanizing LID stormwater management plan; plan to accommodate Upper segment agricultural benefits |
| Branch 14 Upper(Columbus) | Rural Residential | Flood prone areas, high restoration potential | Coordinate with City of Columbus and agencies on maintenance of ditch-obstructing roadway crossings. |
| Branch 15 Upper (Columbus) | Rural Residential | Flood prone areas, high restoration potential | Coordinate with City of Columbus and agencies on maintenance of ditch-obstructing roadway crossings. |

## Future Scenario Alternatives Analysis

The Lino Lakes RMP is unique in the comparison of city-wide planning and zoning alternatives and their effects on several aquatic resources. The alternatives comparison uses a wetland corridor overlay, park and open space overlay, and some variance in type and location of land use type to make the comparison. Land use designations (i.e. the wetland corridor overlay and land use type) were formulated out of the process of examining existing and future conditions resource data. The first comparison is of existing land use and the future full-build out without the RMP conditions (Figure 19 and 20). Distinctions in existing and future land use type are evident at various smaller and larger locations. Several land use types change, along with their distribution. Changes were factored into the resource models. Not shown are the sensitive water level points under existing conditions. All wetlands and the District volume reduction standard remained the same between existing and FBO without RMP conditions. A comparison of Figure 20 and Figure 21 show differences between the FBO, with and without the RMP conditions. The land use types stay the same, but their distribution changes slightly. Most notably, the RMP incorporates the wetland corridor overlay and park and open space corridor overlay. The wetland corridor overlay includes the high priority wetland 50-foot buffer, custom-fit buffer in certain locations, and the high quality upland resources. Several of the sensitive water level points or flood prone areas are eliminated in the RMP as a result of the 2008 volume standard used in the RMP model.

The comparison was then made of land use alternatives and their effects on wetland functional capacity, runoff volume, and nutrient loading (Figure 22). The land use map shown in Figure 22 is the RMP scenario, and for the purpose of this discussion, the land use map information is irrelevant. The bar graphs in the lower right of Figure 22 show wetland functioning for each of three land use alternatives. The future conditions wetland technical memorandum describes the method used in this analysis (see References, Companion Documents). This is a landscape level examination of all wetlands in Lino Lakes regardless of wetland type. It is reasonable at this scale to lump together all wetlands because the ecoregion is the same and on a watershed scale most of them are similar in type (see Section 1 plant community type map). Five wetland functions were used to compare alternatives. The functioning (high, medium, low, exceptional) can be compared between the three land use scenarios. The total acres of wetland evaluated does not change between functions or scenarios. Each bar graph cluster thus represents absolute numbers. They do not represent means or averages. Comparing existing conditions to full build out generally shows a shift from high and medium functioning for 4 of 5 functions to predominantly medium. For vegetative integrity the shift is to mostly low. The RMP and existing conditions functioning are more similar in large part due to the buffer criteria and volume standard. The vegetative integrity for RMP is predicted to be better than existing, if the standards for vegetative restoration are met. The next section on resource management units is particularly important for looking more closely at individual wetlands that potentially could be negatively affected by the increase runoff volumes predicted for both future scenarios. These effects on individual sensitive wetlands are below the level of detection in this landscape-scale analysis.

The runoff volume and external phosphorus loading were expressed on a subwatershed or RMU basis. The data are shown as bar graphs for each RMU in figure 22. For some of the RMUs, the TMDL goal information is shown and areas exceeding the goals are identified as areas where reductions will need to occur through projects in addition to meeting the standards introduced through the RMP (buffers, infiltration volume reduction, etc.) The runoff volume comparisons are given for a small rainfall (1-year) and large rainfall (100-year). The latter was used for the calculation of sensitive water level points shown on the land use scenario comparison maps, and volume increases are associated with RMU areas which are ‘developing’, meaning that the land use is shifting from rural agricultural to urban.

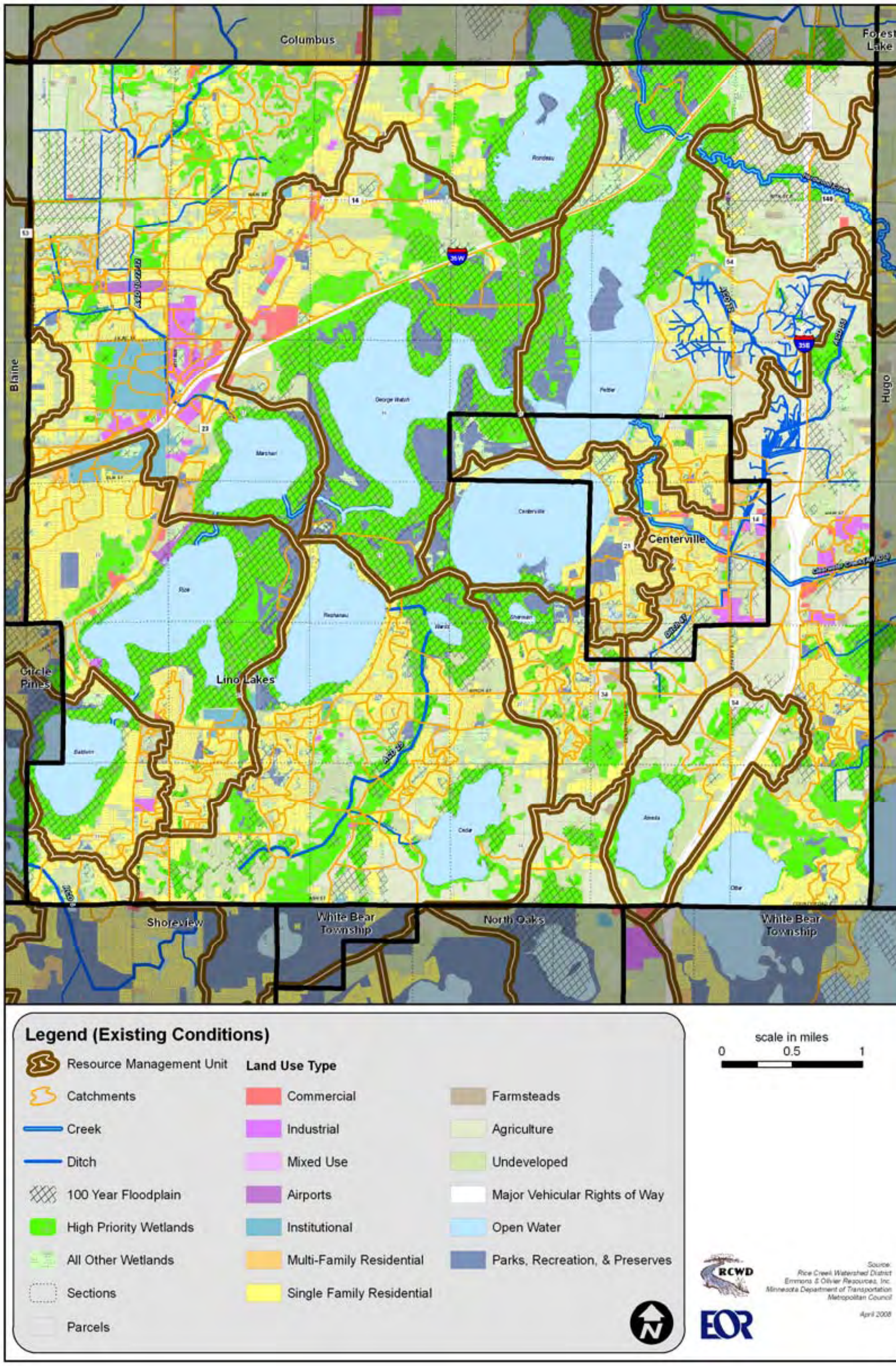


**Figure 19. Land Use Alternatives Analysis: Existing Conditions.**

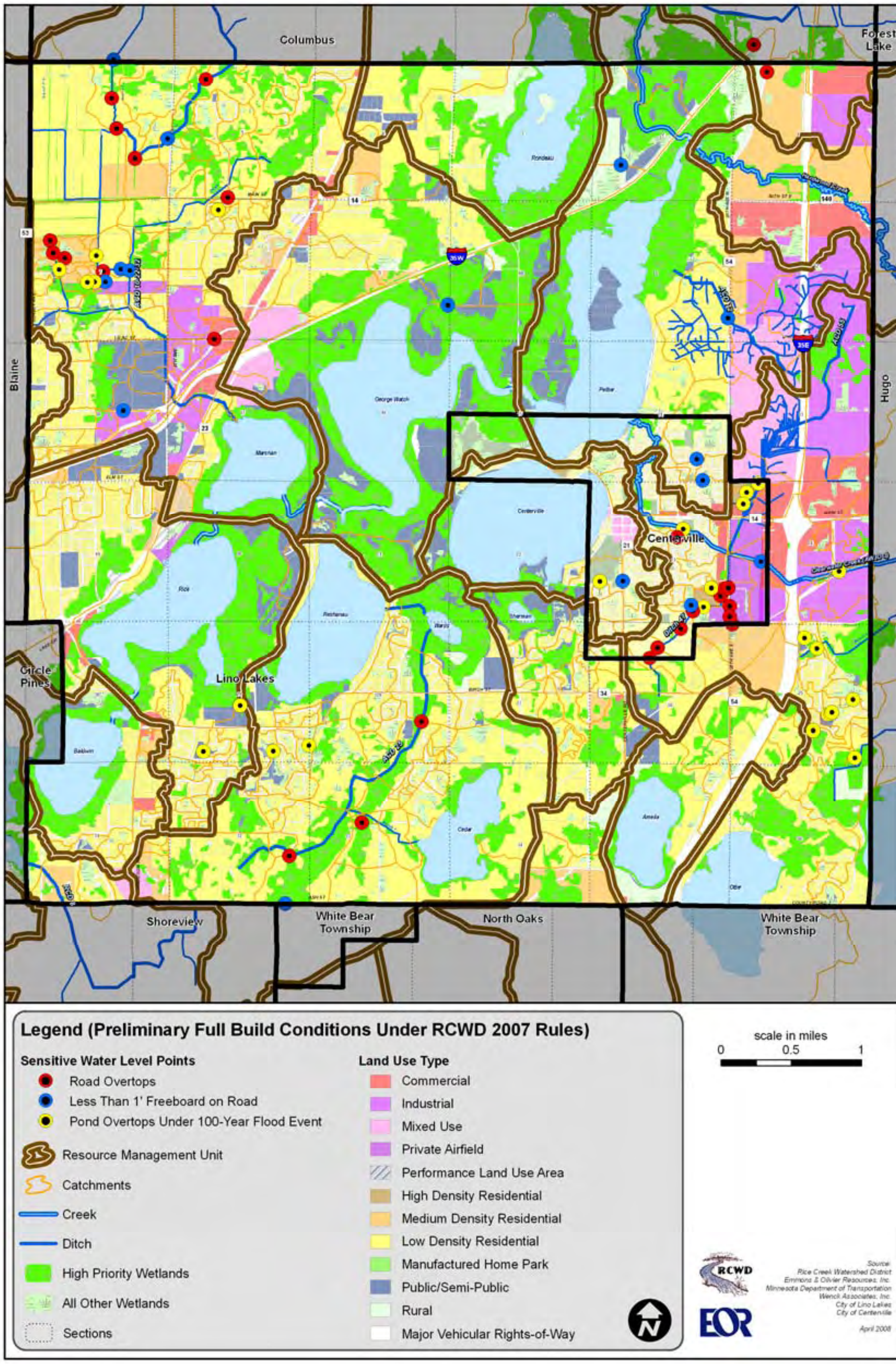


**Figure 20. Land Use Alternatives Analysis: FBO Without RMP Conditions.**

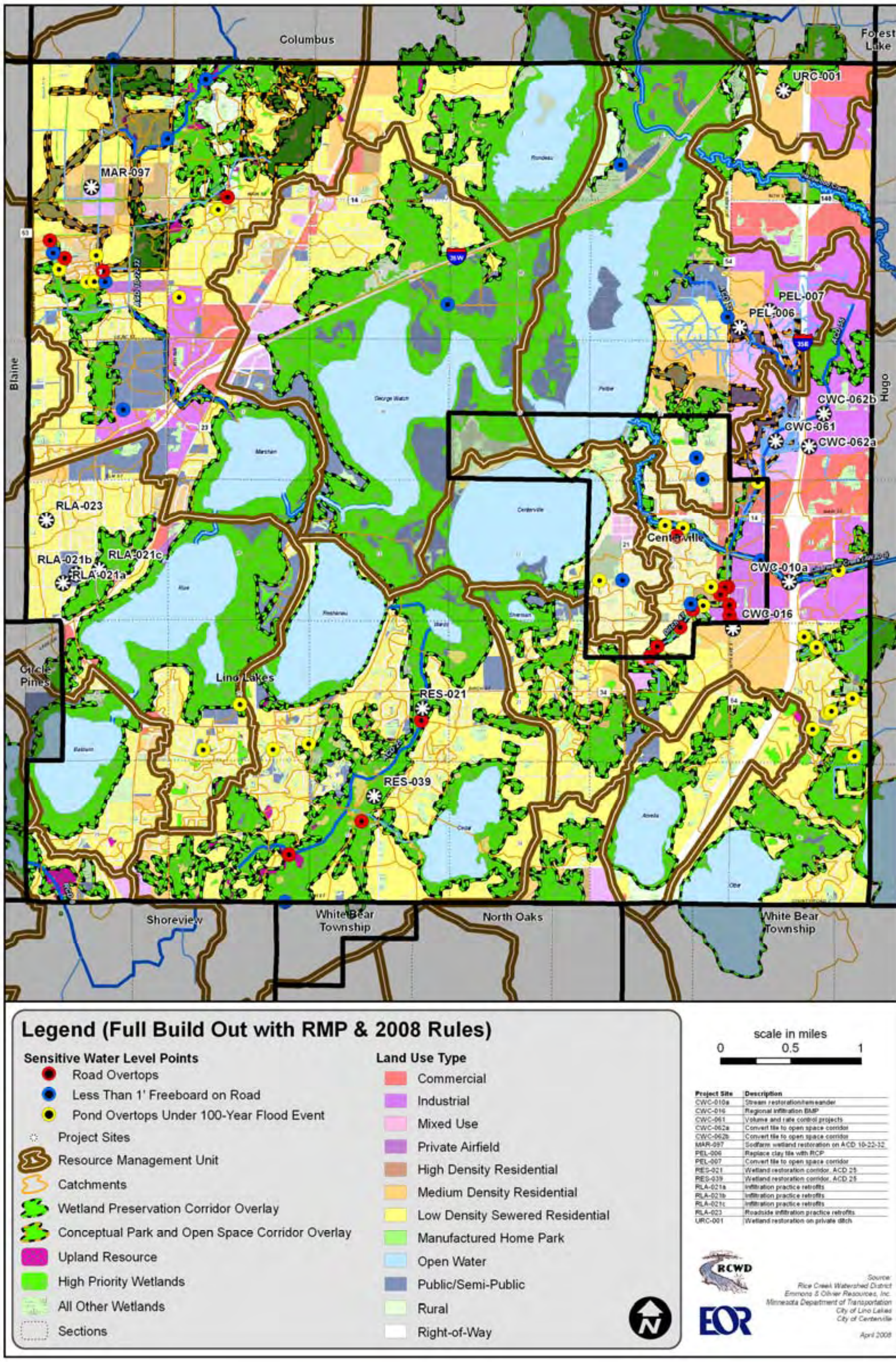


**Figure 21. Land Use Alternatives Analysis: FBO With RMP Conditions.**

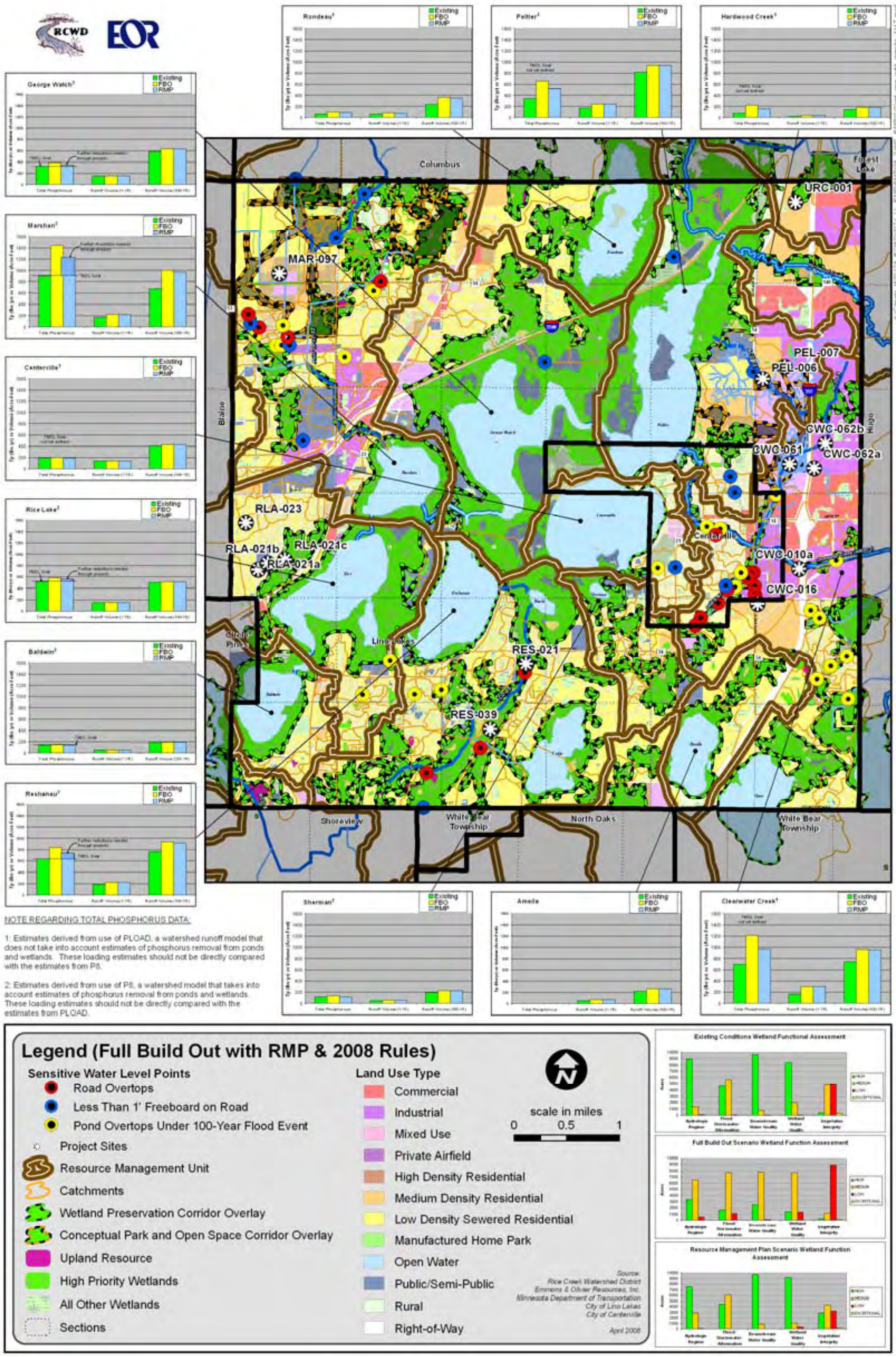


**Figure 22. Effects of Land Use Alternatives on Runoff Volume and Phosphorus Loading.**

# SECTION 3. RESOURCE MANAGEMENT UNITS

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# RESOURCE MANAGEMENT UNIT RECOMMENDATIONS

Resource Management Units (RMUs) are subwatershed based drainage areas that break the City of Lino Lakes into distinct hydrologic units. The purpose of creating RMUs is to provide drainage-area specific management recommendations that address the unique conditions of the area. This level of analysis requires a full understanding of the resources and the stressors that cause impairments. For some RMU's stormwater volume is a stressor, for others it is nutrients, for example. Existing and future conditions were analyzed. This section provides recommendations on management strategies for each RMU. All of the feasible RMU strategies evaluated are based upon volume reduction, not capacity expansion, and the protection of existing drainage divides as shown on Figure 23. All drainage routes are natural gravity-fed pathways with no reliance on manufactured materials such as pumps to move water from one area to another.

These Resource Management Unit recommendations are intended to meet RMP goals for aquatic resource protection and management and satisfy a watershed approach to high priority wetland and flood protection. Although impaired waterbody TMDL goals have not been finalized, the recommendations provided herein follow the expected implementation strategies to work towards meeting the loading reduction goals.

## EXISTING AND FULL BUILD OUT DATA SUMMARY

As shown in the Existing Conditions and Future Conditions sections of this report, stormwater volume and quality impact wetlands under existing conditions and even more so under full build out conditions. A summary of the subwatershed scale analysis conducted for the existing and full build out conditions is provided in Table 3. For existing conditions in each RMU, the table lists:

- Constructed Conveyance – the existing conditions conveyance features such as a ditch, tile system, stormwater pipe or combination pipe and pond series.
- Conveyance Endpoint – the aquatic resource (lake, wetland, creek) that the conveyance system discharges to.
- Endpoint of Concern – if the endpoint is a high priority or groundwater-supported wetland; or an impaired lake and stream.
- Flooding – areas where flooding is an issue along the modeled conveyance network.
- Partially Drained Wetland – areas that provide opportunity for wetland restoration
- Land Use – description of land use, (Rural/Urban)

For full build out conditions in each RMU, the table lists:

- Land Use – illustrates proposed change from existing.
- Flooding – areas where flooding under future conditions will be of concern.
- Loading – areas where nutrient loading will be an issue.

Endpoints of concern (a natural wetland, lake or stream) are addressed in the recommendations for each RMU.

Full build out wetland functions data are shown in the Future Conditions section and not in this recommendations section. To summarize, at the landscape scale, full build out without RMP conditions produces a decrease in the functions analyzed.

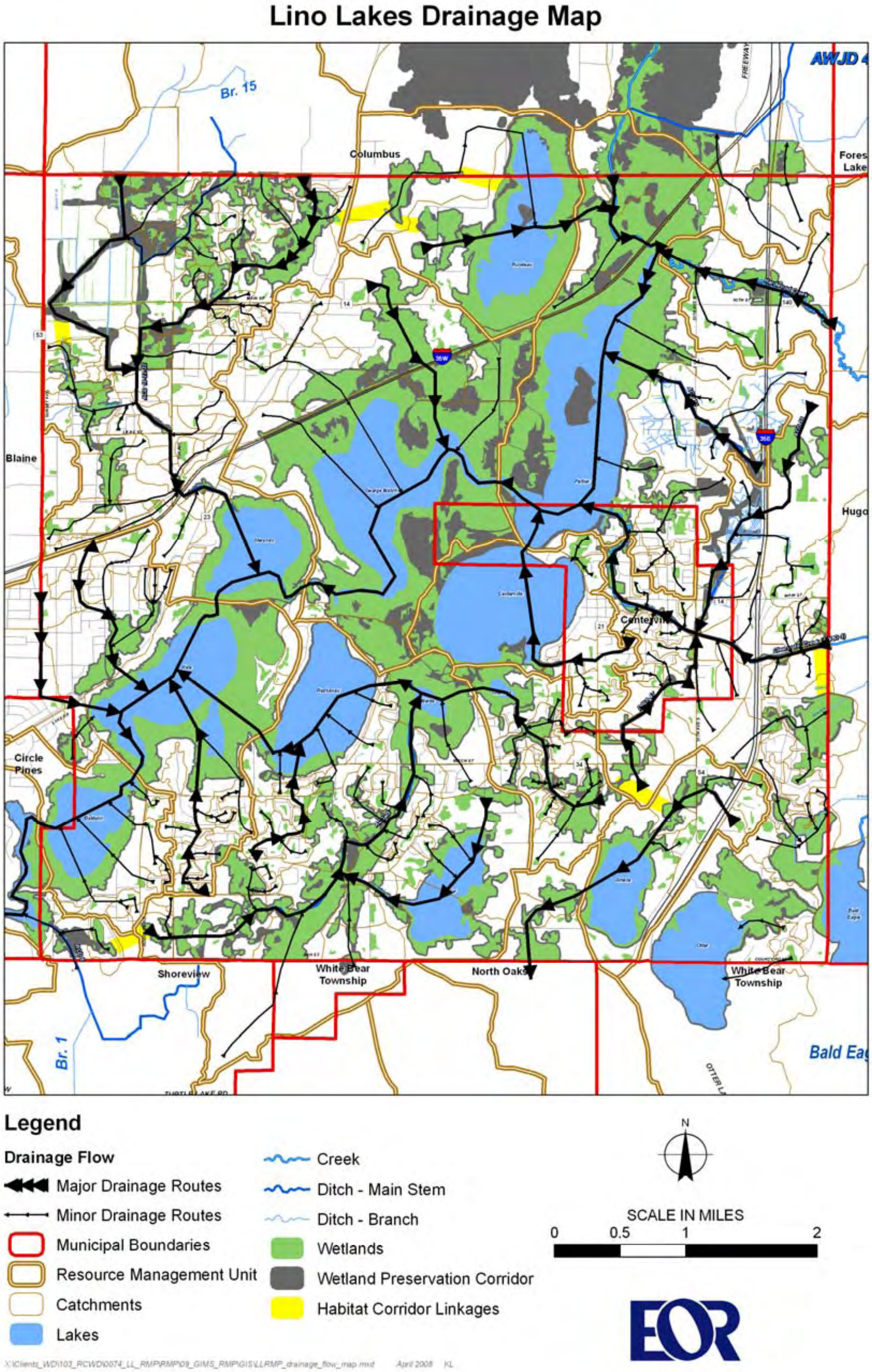


**Figure 23. Lino Lakes Drainage Routes.**

## EXISTING AND RMP CONDITIONS DESCRIPTIONS

The RMP scenario analysis showed a reduction in volume effects on sensitive wetlands and stormwater conveyance structures. To provide this reduced impact on sensitive resources, the RMP identified ditch management project areas and key wetland corridors for protection. The strategies and projects included in the RMP are summarized in Table 4 for each RMU.

RMP map features are described in Table 5. Existing Condition maps show the break out of stormwater sensitive wetlands (Storm Water Advisory Group, SWAG). SWAG classification was established by an interagency wetland group in the 1990s and ranks wetlands according to the susceptibility to be negatively altered by stormwater. The RMP modeling for the LL RMP evaluated volume effects on the high SWAG wetlands only, therefore RMP maps showing wetlands with the potential for stormwater effects only show wetland in this highly sensitive group. The SWAG classification of all wetlands is shown on the Existing Conditions maps for each RMU. The RMP hydrologic modeling method is described in the Appendix.

For this analysis, those RMUs that are already in urban land use were not evaluated as subject to the new 2.8-inch volume standard. Therefore, in RMUs with existing urban land use, wetlands at risk from stormwater under existing conditions are also at risk under RMP conditions. Catchment-scale projects to address the potential for adverse impacts to these wetlands can be evaluated with the information provided in this section. It should be noted that wherever possible, buffering of wetlands should be recognized as multi-purpose preservation of function, volume control credit, and passive park and open space. An important note is that high SWAG wetlands are typically of high vegetative integrity if the community has not been adversely affected by excess stormwater or other disturbances. The specific recommendations for each RMU are shown following each set of Existing Conditions and RMU maps. The maps of Existing Conditions show the location of and SWAG classification of wetlands.

**Table 3. RMU Existing and FBO Conditions Summary.**

| RMU | Existing Conditions | | | | | | Full Build Out | | |
|---|---|---|---|---|---|---|---|---|---|
| | Constructed Conveyance | Conveyance Endpoint | Endpoint of Concern | Flood-ing | Partially Drained Wetlands | Land Use | Land Use | Flood-ing | Load-ing |
| Upper Rice Creek | None | n/a | n/a | no | yes | rural | urban | yes | yes |
| Hardwood Creek | None, Natural Channel | Peltier Lake | yes | no | no | rural | urban | yes | yes |
| Clearwater Creek / Ditch 55 | Ditch and pipe | Clearwater Creek/Peltier Lake | yes | yes | yes – Ditch 47 and Ditch 55 | urban (Centerville); rural | urban | yes | yes |
| Rondeau | None or private ditch | n/a | n/a | no | no | rural | urban | no | yes |
| Peltier / Ditch 72 | Pipe and pond; ditch and pipe; private ditch | Peltier wetlands | yes | yes | yes Ditch 72 | urban (Centerville); rural | urban | possib ly | no |
| Centerville | Pipe and pond | Centerville wetlands and lake | yes | minor | no | urban (Centerville) and rural | existing | no | no |
| George Watch | Pipe and pond; private ditch | George Watch groundwater-supported wetlands and lake | yes | no | no | urban and rural | urban | no | yes |
| Marshan / Ditch 10-22-32 | Ditch and pipe | Marshan wetlands and lake | yes | yes | yes | urban and rural | urban | yes | yes |
| Reshanau | Pipe and pond, ditch | Reshanau wetlands or lake | yes | minor | no | mainly urban | existing | no | yes |
| Rice | Pipe | Groundwater-supported wetlands and Rice wetlands and lake | no | no | no | urban | existing | no | yes |
| Baldwin | Pipe | Baldwin wetlands | yes | no | no | mainly urban | existing | no | no |
| Sherman | Pipe | Sherman Lake and high priority wetlands | yes | n/a | no | mainly urban | existing | no | no |
| Amelia | Pipe | Amelia Lake and high priority wetlands | no | n/a | no | mainly urban | existing | no | no |
| Wilkinson | None | n/a | n/a | n/a | no | mainly urban | existing | no | no |
| Middle Rice Creek | pipe | High priority wetlands | yes | n/a | no | mainly urban | existing | no | yes |

**Table 4. RMP Scenario Projects Summary.**

| RMU | Strategies | Potential Projects |
|---|---|---|
| Upper Rice Creek | Overall use of runoff volume reduction to reduce runoff into confined tile system | Repair culverts and tiles with obstructions |
| Hardwood Creek | Wetland Preservation Corridor, source control; volume reduction; loading reduction | None recommended |
| Clearwater Creek / Ditch 55 | WPC, urban retrofit, partially drained wetland restoration, area-wide volume reduction, urban ditch management; loading reduction | Ditch 47 tile system replacement with flow-through wetland system; creek restoration between 20$^{th}$ Ave. and 35E; possibly ACD 55 corridor restoration; Otter Lake urban retrofit investigation to protect high quality wetlands; Clearwater Creek instream habitat improvement for the TMDL; for the Bald Eagle area, no specific strategies recommended |
| Rondeau | Wetland Preservation Corridor multi-use buffer zones; source control; flexible zoning; loading reduction | Develop long-term plan with the private duck club; examine the city's development suitability analysis for this area to ensure volume effects do not occur to sensitive wetlands |
| Peltier / Ditch 72 | Urban ditch management, WPC multi buffer; flexible zoning; volume reduction | ACD 72 tile system to convert to flow-through; west of 20$^{th}$, convert to reinforced concrete pipe; volume reduction at 20$^{th}$ and in the Hardwood Creek proposed development; develop example of variable buffer habitat complex in the high swag wetland area |
| Centerville | City continuing with load reduction urban retrofits | Centerville TMDL project in process: stormwater reuse for ball fields; evaluate effectiveness of Lamotte pond treatment; investigate for urban retrofits |
| George Watch | Groundwater-dependent rule/ eliminate surface water discharges to wetlands; urban retrofit infiltration | Source control plan for areas north of 14 to prevent loading to wetlands; source control retrofits in drainage area to the groundwater-dependent wetlands; detailed evaluation of infiltration feasibility |
| Marshan / 10-22-32 | Urban ditch management; volume reduction, flexible zoning, WPC multi buffer; loading reduction | Proposed master community plan for sod fields; volume reduction for catchments MAR-059, MAR-108, and MAR-110 |
| Reshanau | Urban ditch management, partially drained wetland restoration, loading reduction to remove lake from TMDL list, volume reduction | ACD 25 greenway corridor; investigate water quality benefits of a control structure for Cedar Lake; reduce nutrient loading to Wards Lake |
| Rice | Groundwater-dependent rule/eliminate surface water discharges to wetlands, urban retrofit infiltration, loading reduction | Investigate infiltration opportunities in catchment RLA-021 on the north side of Lake Drive; fully implement RMP standards to protect sensitive wetlands |
| Baldwin | Urban retrofit | No projects proposed; investigate at-risk wetlands and volume reduction |
| Sherman | Urban retrofit; slight load reduction | No projects proposed |
| Amelia | WPC | Wetland restoration potential for the private ditch entering the north side of the lake in catchments AME-004 and AME-005; investigate at-risk wetlands and volume reduction |
| Wilkinson | WPC, North Oaks coordination | No projects proposed; investigate at-risk wetlands and volume reduction |
| Middle Rice Creek | Intergovernmental coordination, WPC | No projects proposed; investigate at-risk wetlands and volume reduction |

**Table 5. RMP Map Features.**

| Map Legend Feature | Description |
|---|---|
| RMP Boundary | The municipal boundary for Lino Lakes. |
| Pipe | Existing subsurface stormwater conveyance component. |
| Subshed Outflow Point | Runoff point for all water from the hydrologic subshed shown. |
| Peltier/Centerville TMDL Boundary | Line between the study area for Centerville Lake and Peltier Lake. |
| Resource Management Unit | Watershed-based management unit; based on subshed-scale hydrologic modeling area |
| Catchments | The small scale land area used for hydrologic modeling; may represent the direct drainage area to an individual wetland complex. |
| Project Sites | Implementation locations for ditch management, water quality protection, or volume reduction. |
| High Storm Water Impact Potential | Volume effects on wetlands vulnerable to stormwater that will not be protected using the RMP 2.8” infiltration standard and proposed land use; additional measures above those modeled for the RMP will be needed to protect these wetlands from storm water bounce and duration. |
| Corridor Node Planned | New land use planning is in process; proposed nodes. |
| Corridor Linkage Gap | Barriers to potential corridor linkages from roads or other structures; opportunity areas to create diffuse barriers for animal movement patterns. |
| Corridor Node - Existing | The total area of high priority wetlands and variable width habitat areas. |
| Non Corridor Wetlands | Wetlands without high priority status. |
| Corridor Linkage - Existing | Floodplain-based opportunity area to link together corridor nodes; the shape of linkages varies widely depending on whether it is an in-fill link surrounded by connected nodes or a coupling link joining disconnected nodes. Linkages should be designed as valued-added features to not only provide habitat linkages but also trails, volume reduction features, and passive park space. |
| Sensitive Water Level Point | Volume effects on structures (roads, ponds) during a very high rainfall event (100-year storm); white circles represent reduced effect under RMP conditions when compared to existing conditions. |

## UPPER RICE CREEK RMU RECOMMENDATIONS

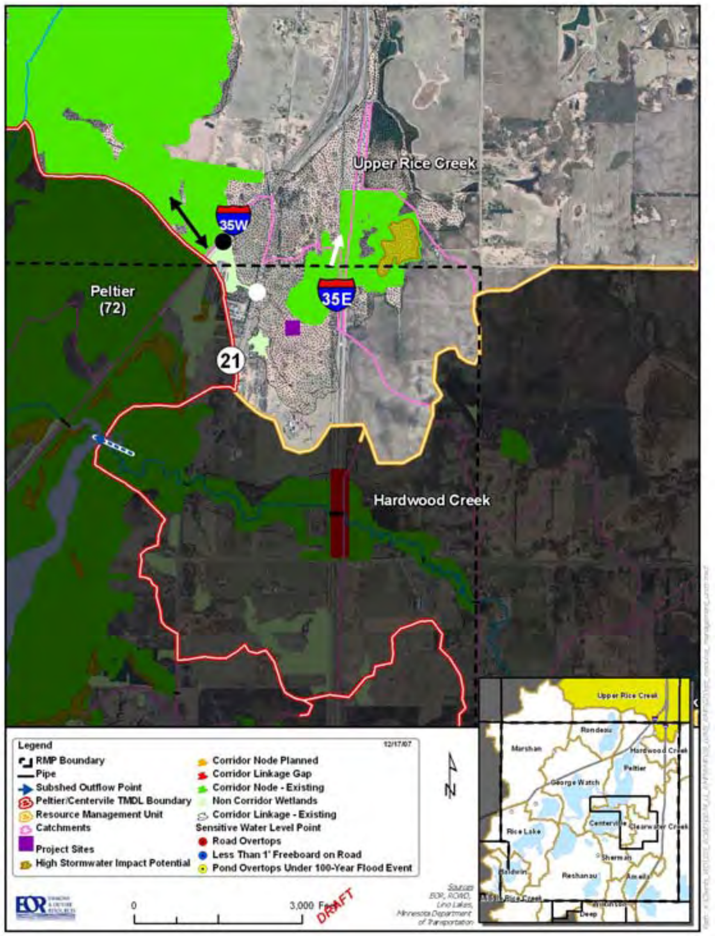


**Figure 24. Upper Rice Creek RMP.**

**RMP Future Conditions:** The Upper Rice Creek subwatershed within Lino Lakes was previously evaluated in the Repair Report for Judicial Ditch 4 and Resource Management Plan August, 2007. Catchments URC_001 and URC_002 were defined as part of catchments P_1 and B4_1, respectively, in that report. The report evaluated TP load from each catchment and identified URC_001 as in the middle one-third for TP load and URC_002 as the highest one-third of all areas evaluated. Wetlands throughout each catchment were classified as low restoration potential. Each catchment contains small areas of wetlands that are highly susceptible to stormwater discharge. This RMU is covered by the JD4 RMP Rule.

URC_001 and URC_002 are planned for industrial, commercial and medium density residential land use. Two areas become a concern under full build out and RMP future land use scenarios and precautions must be taken to prevent flooding of major roads. The first, and most important, is the culvert that conveys water from the private ditch south of 35W in URC_001 to JD4 on the north side of 35W. Another drainage route along the south side of 35W must be maintained under future developed conditions or overtopping of 35W could occur. Furthermore, this drainage route will likely see an increased frequency of use under future conditions due to increased flows from URC_001 and should be inspected regularly to assure that it is free of erosion. The second area of concern is the private ditch crossing of 20$^{th}$ Ave N in URC_001. An outlet for this wetland occurs along the west side of 35E. This outlet must be maintained and regularly inspected when this drainage area develops to avoid overtopping at 20$^{th}$ Ave N.

## HARDWOOD CREEK RMU RECOMMENDATIONS

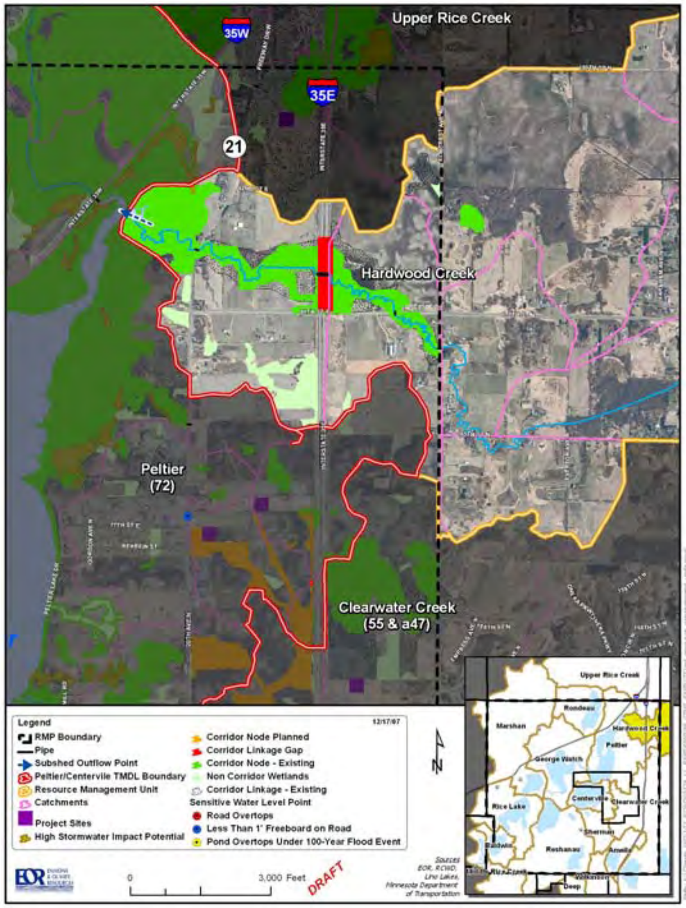


Figure 25. Hardwood Creek RMP.

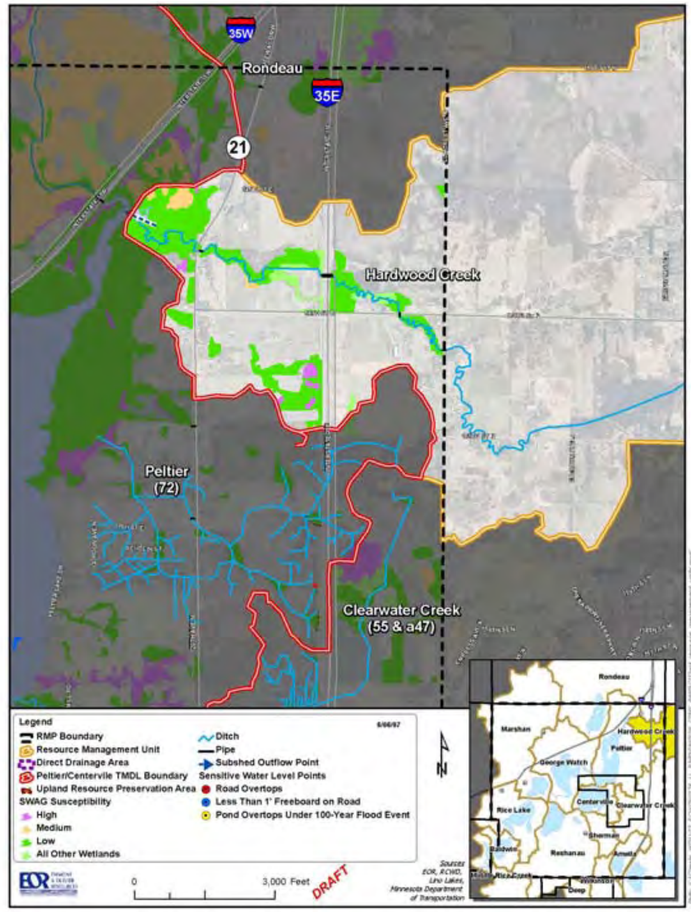


Figure 26. Hardwood Creek Existing Conditions.

**Existing Conditions:** Upstream communities will greatly affect the resources in Lino Lakes that are part of the Hardwood Creek RMU. The creek flows through a diverse wetland complex fringing Peltier Lake. The wetland and creek should be examined to determine the extent of hydrologic interaction between the wetland and the creek, restoring the interaction if needed, and increasing the functioning of the wetland for downstream water quality protection.

Land use planning should ensure that the existing culvert crossings (shown in black) will function under future conditions. In part, this requires maintaining existing runoff levels in this RMU that affect those crossings. This also requires that upstream flows from Hardwood Creek be maintained.

Upland runoff levels should be maintained so as not to negatively affect the few high and medium SWAG wetlands. These areas provide an opportunity to maintain wide multiple use upland buffers.

**RMP Future Conditions:** Hardwood Creek RMU will experience a high level of development intensity consisting primarily of medium density residential and commercial uses. The majority of flow in this unit comes from outside of the city and no further projects are proposed. Stormwater volume control will be an important issue because of the negative effects it causes to natural stream courses.

The high priority wetlands not associated with the creek should be a top priority for protection and integration into compatible land use complexes. The interstate creates a large wildlife barrier. Mn/DOT should be part of discussions about future opportunities to make this culvert a safer crossing for vehicles and wildlife.

## CLEARWATER CREEK RMU RECOMMENDATIONS

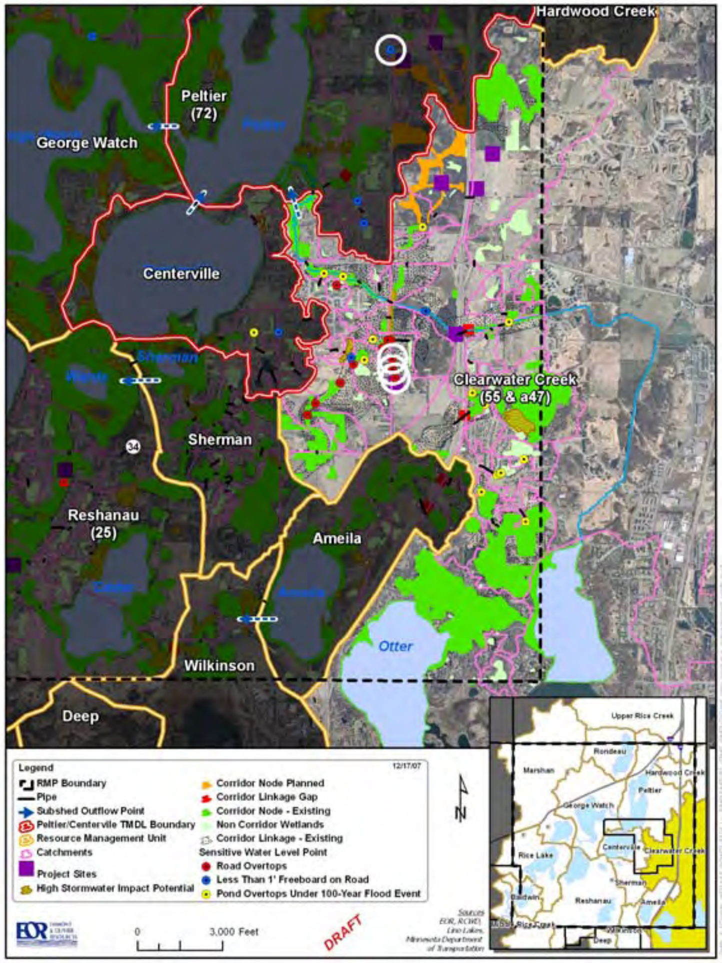


Figure 27. Clearwater Creek RMP.

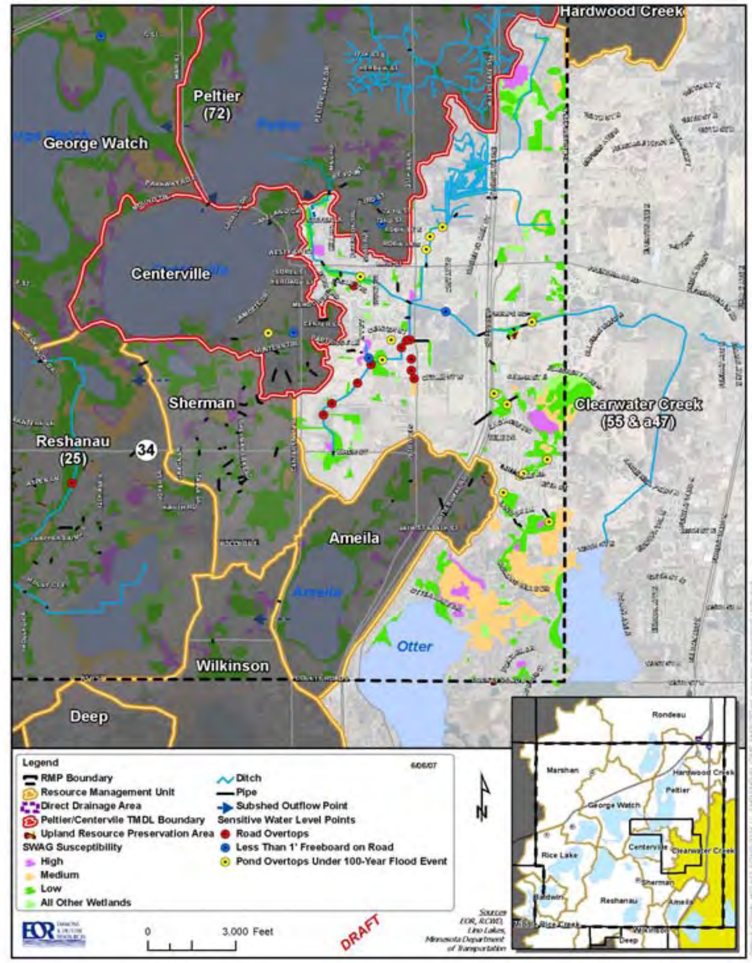


Figure 28. Clearwater Creek Existing Conditions.

**Existing Conditions:** As with Hardwood Creek only a small portion of the Clearwater Creek subwatershed is in Lino Lakes, and activities in upstream communities will have an effect on the resources in Lino Lakes.

Portions of the City of Centerville urban storm drainage discharge to the creek. There are two potential flooding points in the developed area of Centerville and close to the creek. One location predicts overtopping of a road, and another predicts overtopping of a pond. There are a number of small catchments in this area. They should be investigated for urban retrofit BMPs in the urban parts of Centerville to reduce the potential overtopping.

Near Centerville, the southern drainage ditch (abandoned ditch 47-district Rule I applies but no longer state drainage law 103E) has several agricultural field roads identified as overtopping during high rainfall events (see the number of red dots on the ditch). One of the highest concentrations of drained wetlands in Lino Lakes is associated with this abandoned ditch. This is a big opportunity area for obtaining wetland mitigation credit for use in a bank and establishing a greenway corridor. The existing land use is rural, but the open space, water quality, and flooding value of planning a ditch 47 restoration corridor will be great.

The urban area just east of I35E and south of Cedar Street has several ponds that are expected to overtop in a high rainfall. They are part of a pipe and pond system that is also integrated with the large wetland complex on the boundary with Hugo. A private ditch diagonally crosses I35E (see black line) and drains towards the series of wetland ponds. These connect to the large wetland complex and a channel across the wetland complex that travels to the northeast and eventually on to Clearwater Creek. The current and future effects of the pipe and pond drainage system should be investigated for effects on the condition of this wetland complex. The highly susceptible portion of the wetland complex is a hardwood swamp.

Bald Eagle Lake drains into Clearwater Creek. There is a wetland complex off to the northwest of Bald Eagle. A private ditch system remains in these wetlands, but several new pipe and pond systems are connected to these wetlands from interspersed urban development. As shown in Figure 23 and Figure 28, several parts of the wetland are moderately sensitive to stormwater inputs. These should be monitored for signs of deterioration from the new urban drainage system.

Bald Eagle Lake is nutrient-impaired and being considered for a TMDL study. Urban discharges will likely be addressed in implementing TMDL goals. Clearwater Creek is currently under investigation for a biological impairment and will likely be funded in 2008 for a biological TMDL. These efforts will identify additional subwatershed areas to investigate for source reduction of nutrient loading to both the creek and lake.

The wetland complex north of Otter Lake contains rare and high quality vegetation, including a cranberry bog. They are very sensitive to changes in water chemistry from urban runoff, and formed under groundwater discharge conditions. Localized urban discharges that started occurring in the last 15 years should be investigated and the wetlands monitored for signs of stress. Source reduction measures should be employed to infiltrate urban discharge and remove it from the wetlands.

The northern drainage ditch (ACD 55, a tile system) is under consideration for repair needs. There is an enormous amount a fully drained wetland in the area. Given the potential pond flooding problems during high rain events (see yellow dots), consideration needs to be given to target wetland restoration projects. This will alleviate the flooding problem and could potentially generate mitigation credit. In addition, it can be anticipated that under a future urban land use scenario, significant attention needs to be given to runoff volume control. Since heavy hydric soils underlay the area, noninfiltration-based BMPs will need to be incorporated. This planning is important since the catchments will ultimately affect Clearwater Creek and the downstream impaired water, Peltier Lake.

**RMP Future Conditions:** Areas north of Clearwater Creek are primarily served by the existing agricultural drain tile system 55. This area is zoned for mixed, industrial and commercial uses. This has the potential to result in significant volume increases without implementing control measures. The tile system has a small fixed capacity, therefore mitigation measures will need to be taken within proposed developments to ensure that flooding does not occur onsite or upstream. It is anticipated that large flow-through wetland systems will be created to replace the tile system. The storage within these systems will need to be sized to retain development runoff volumes and allow for storage and evapotranspiration while the system is slowly drawn down by the tile system. The ditch system collecting drainage and flowing from the south used to be known as Anoka County Ditch 47. This system is highly drained and provides opportunity for wetland restoration as the area converts from agricultural use to residential. The system could be converted to a flow through wetland system providing rate and water quality benefits. Soil types are favorable for infiltration near the corner of Cedar and 20$^{th}$. This could help address culvert overtopping issues along 20$^{th}$ Avenue. Clearwater Creek was historically a naturally meandering stream prior to being straightened and lowered as part of Judicial Ditch 3 (JD-3). Because of the infrastructure built around JD-3 and the use of JD-3 as a major conveyance way through Hugo, Lino Lakes, and Centerville, restoration of the stream to pre-settlement conditions is not practical at this time. However, there are opportunities to improve ecological and hydraulic function of Clearwater Creek, while increasing the economic and social value of the parcel. One area of particular interest is the stretch of stream located between I-35E and 20$^{th}$ Avenue located within both Centerville and Lino Lakes. It is recommended that as these parcels develop, a geomorphology approach be employed to enhance/restore Clearwater Creek as part of the development. Restoration solutions should re-establish the floodplain and mimic a natural stable channel. The number of new creek crossings should be minimized. Existing and proposed crossings should be designed using a stream simulation design method. If designed correctly this system could address both floodplain and wetland mitigation needs for these sites.

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## RONDEAU RMU RECOMMENDATIONS

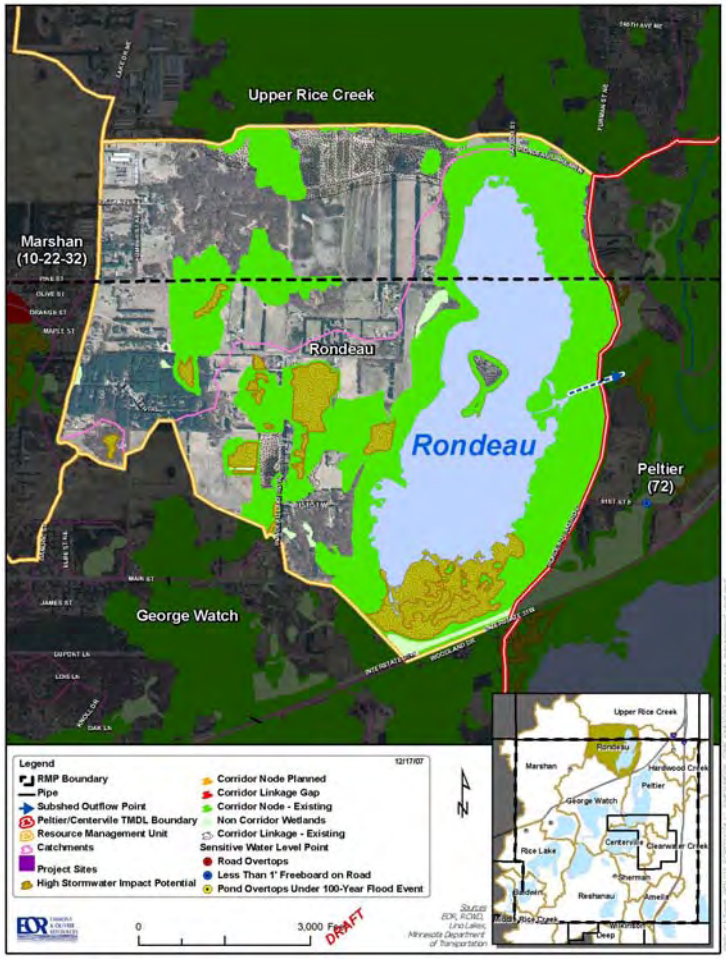


Figure 29. Rondeau RMP.

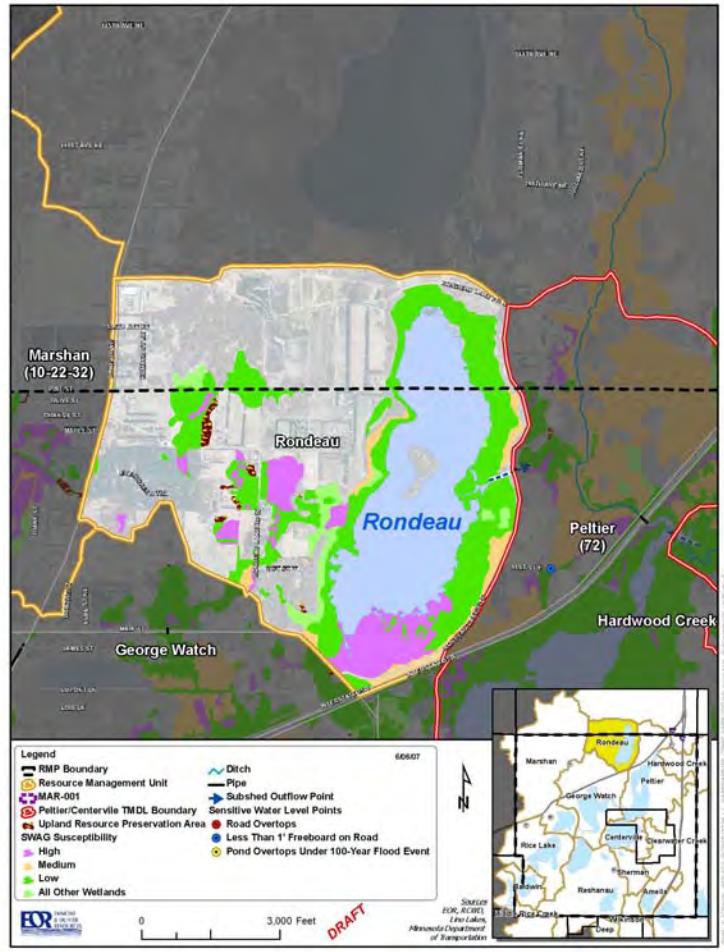


Figure 30. Rondeau Existing Conditions.

**Existing Conditions:** Rondeau has a small surface drainage area and an inlet from Crossways Lake. The drainage area west of the lake is in agricultural use. A private ditch network in Columbus terminates in near shore wetlands. A separate ditch network in Lino Lakes also outlets to near shore wetlands. There are large wetlands in the drainage area west of the lake that contain plant communities highly susceptible to urban stormwater. Future land use should not use these wetlands for stormwater treatment. A future scenario might earmark a 300-foot wide upland habitat area around these sensitive wetlands for use as park, volume reduction credit, trails, and stormwater infiltration. There are also associated high quality upland habitats that should be incorporated as wetland habitat areas in future land use planning. LID strategies to maintain recharge and avoid stormwater discharges to Rondeau will need to be employed in any future urban land use.

**RMP Future Conditions:** No specific projects are proposed. Stormwater sensitive wetlands will be at risk under future conditions and their catchments should be evaluated to reduce the volume effects.

## PELTIER RMU RECOMMENDATIONS

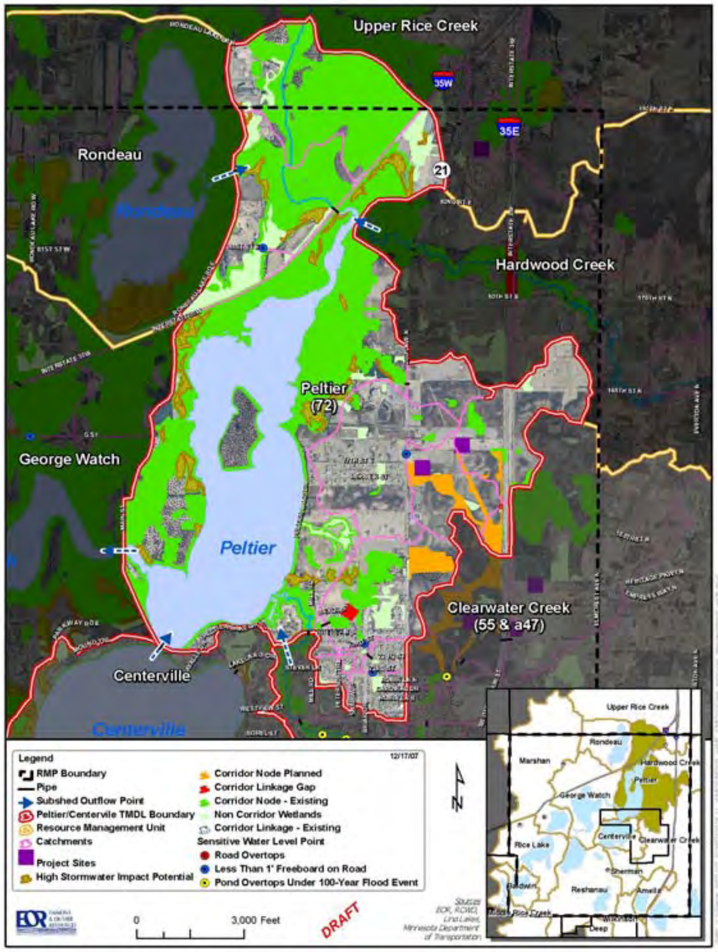


Figure 31. Peltier Lake RMP.

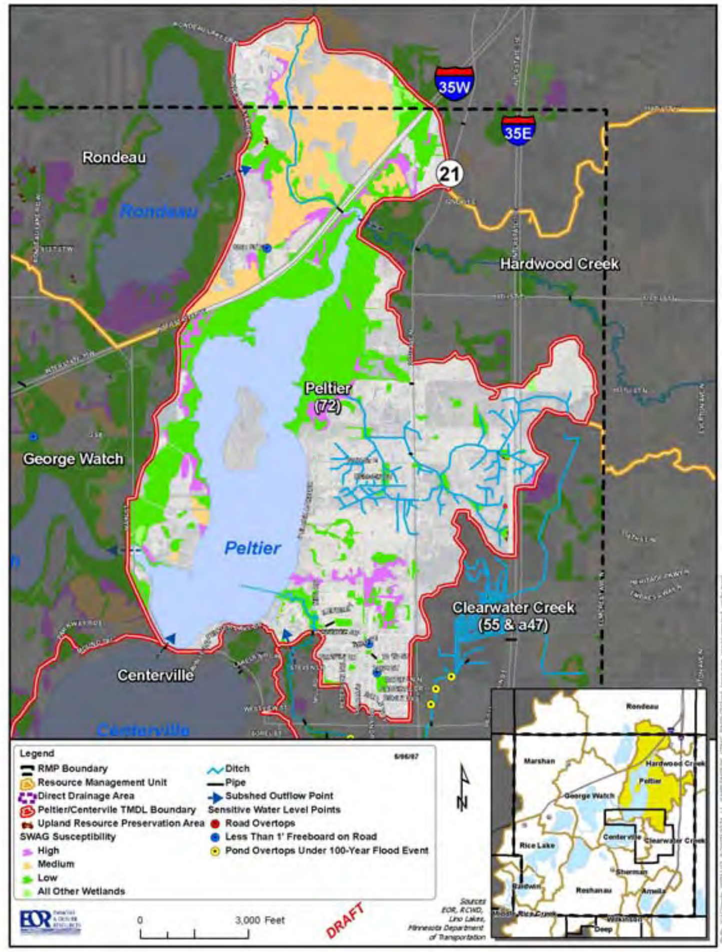


Figure 32. Peltier Lake Existing Conditions.

**Existing Conditions:** The direct drainage area to Peltier Lake is mostly within the City of Lino Lakes. The City of Centerville in the south might experience some high rainfall flooding in two locations, but otherwise this fully developed area is functioning hydrologically. The Peltier Lake TMDL will address loading from this area. Redevelopment BMPs may ultimately be necessary to meet TMDL goals.

To the east of the lake, ditch 72 (a tile system) seems to be functioning, given the extent of fully drained wetland. The current drainage system is not anticipated to be able to serve future capacity (see future conditions), and the drained soils are poor for infiltration BMPs. Conversion of the tiles to an open channel and biofiltration system and buffered as a greenway corridor will more effectively serve future land use conditions.

Just north of downtown Centerville is a corridor of highly susceptible wetlands. In order to preserve functions, this should not become part of a pipe and pond system. The catchments directly affecting these wetlands should be examined in detail to determine the appropriate LID strategies for future land use conditions.

There are scattered pockets of upland all along the western boundary of this subwatershed. Each of these is currently non-urban land use. Some of this land consists of hydric soils and drained wetland. If this area becomes urban, the nonhydric soil upland area must employ infiltration BMPs, and the hydric soil areas will need to employ small site storage and biofiltration to avoid discharges to the lake.

**RMP Future Conditions:** The Peltier RMU is primarily served by the existing agricultural drain tile system 72. This RMU will see some of the most intense development in the City consisting primarily of mixed use, industrial and commercial uses. This intense development could result in significant increases in volume without proper volume reduction measures. The tile system has a small fixed capacity, therefore volume reduction measures will need to be taken within proposed developments to ensure that flooding does not occur onsite or upstream. A large flow-through wetland system has been evaluated and is feasible for replacing the tile system. The storage within these systems will need to be sized to retain development runoff volumes and allow for storage and evapotranspiration while the system is slowly drawn down by the tile system. It is assumed the portion of the system west of 20$^{th}$ Avenue North will remain piped. Most of the segment west of 20$^{th}$ Avenue North has been converted to concrete pipe. There is about 620 feet of tile west of 20$^{th}$ Avenue North that is still clay. It is recommended that this clay tile, about 100 years old, be examined for functionality. The city could then consider replacing it as part of a city infrastructure project, using what is most feasible for the expected future upstream flows in the subwatershed and assuming flows will be routed into the downstream and adjacent storm sewer pipe. Transferring this ditch and tile system to the City of Lino Lakes is also a reasonable consideration that would require using the state drainage law 103E abandonment proceedings and hearing.

Additional volume reductions above the RMP standard will be needed to protect certain wetlands from stormwater impacts. One corridor gap is identified in this area. Multiple use features (dedicated open space, volume reduction requirements) for closing the gap should be considered.

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# CENTERVILLE RMU RECOMMENDATIONS

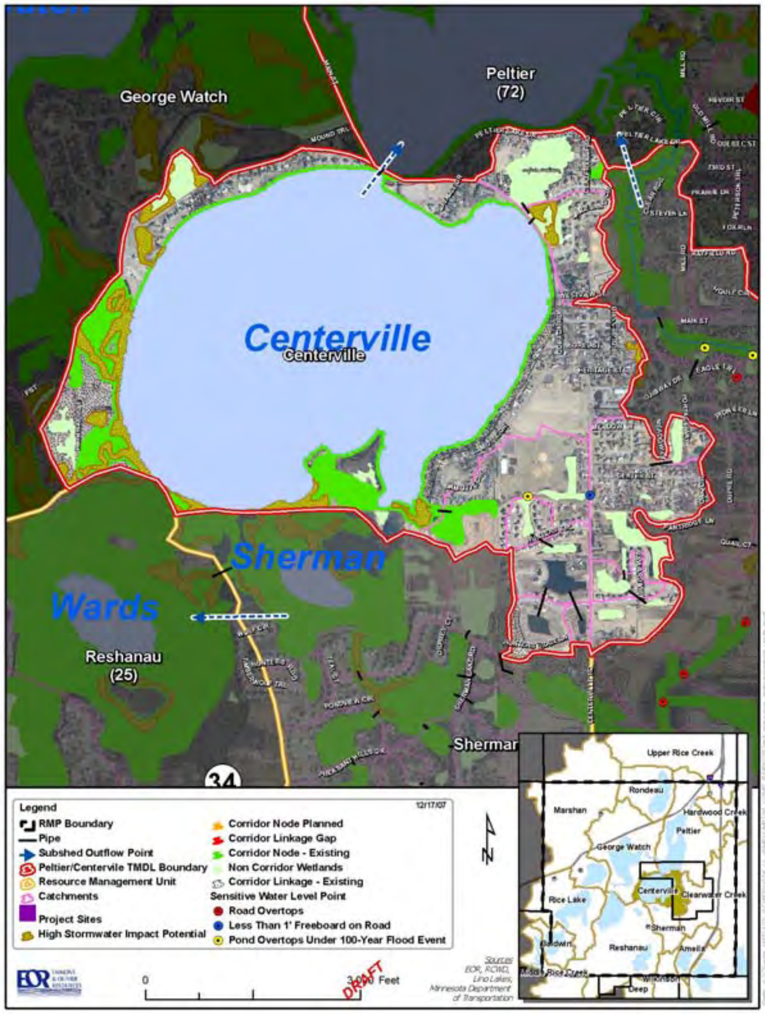


Figure 33. Centerville Lake RMP.

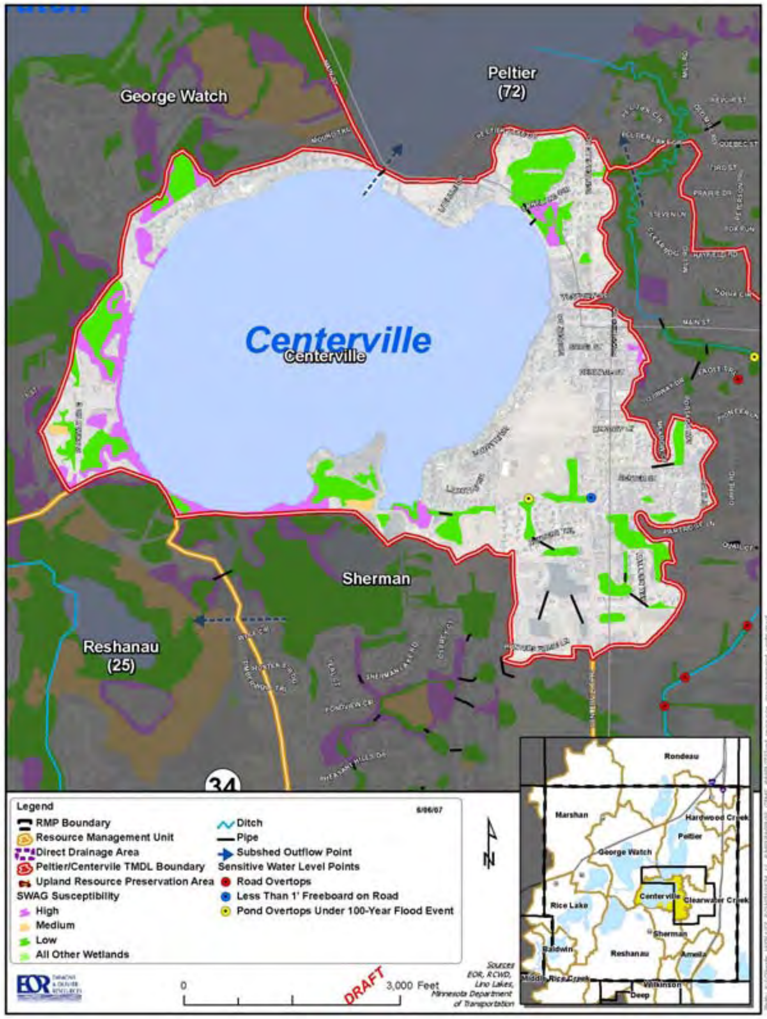


Figure 34. Centerville Lake Existing Conditions.

**Existing Conditions:** Parts of this drainage area are in Lino Lakes and Centerville. Lino Lakes has jurisdiction over land use in the narrow western and southern areas directly draining to Centerville Lake and several highly susceptible wetlands. Direct stormwater outlets into Centerville Lake are found in both cities. The LaMotte Ditch Water Quality Improvement Project was implemented within the Anoka County Park property in Lino Lakes. It is located off the southeast side of the lake and south of Lamotte Drive. It includes two water quality treatment wetlands prior to the channel outlet to near-shore wetlands. Centerville has a pipe and pond stormsewer system. The Lamotte project helps to mitigate some of the effects of this on the lake and near shore wetlands. An artesian well is found in the pond immediately west of the Lamotte water quality project.

The wetland complex along the northeast side of the lake contains a highly susceptible area of forested wetland. The wetlands are part of a storm water pipe and pond system that ultimately discharges to the lake. Pipe and pond systems sometimes lead to channelized runoff through the wetland, losing the benefit of wetland storage and retention. The functioning of the wetlands in retaining runoff and storing nutrients has not been investigated.

**RMP Future Conditions:** Urban retrofits are being designed by the City of Centerville in conjunction with the CSAH 14 rebuild. For the Centerville Lake TMDL, the City of Centerville is proposing reuse of stormwater for irrigation. The model is not updated to reflect these retrofits because it is outside the scope of this project and no additional projects are proposed.

An assessment of nutrient reduction effectiveness for the Lamotte Water Quality Improvement Project is needed. As seen on the RMP Scenario map, a number of wetlands around the lake may still be subject to volume or stormwater runoff effects, even with the RMP volume standard. Some of these wetlands are associated with other wetlands that did not meet the threshold for high priority wetlands. Additional volume control is recommended through projects developed by the City and/or the Watershed District, and projects that address the whole wetland complex are expected to be successful for the sensitive wetland areas.

## GEORGE WATCH RMU RECOMMENDATIONS

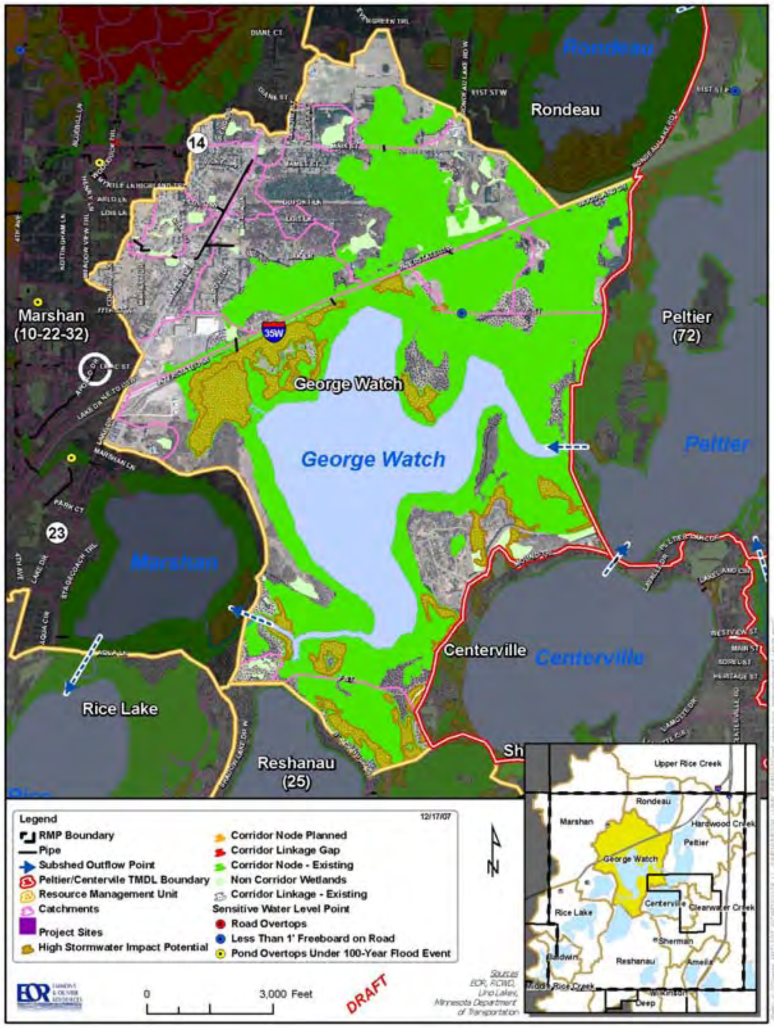


Figure 35. George Watch Lake RMP.

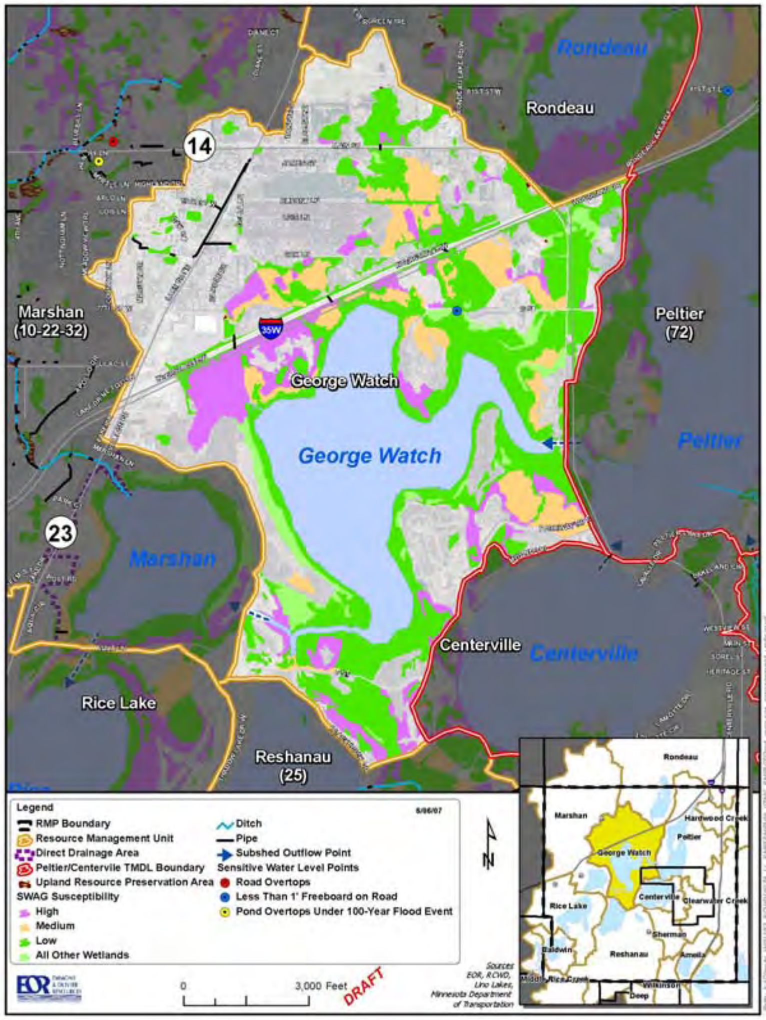


Figure 36. George Watch Lake Existing Conditions.

**Existing Conditions:** George Watch Lake is being investigated for excess nutrient loading as part of the Chain of Lakes. Once the nutrient reduction goal is established, watershed-based measures to reduce the inputs from the direct drainage area can be formulated. Several important groundwater-dependent wetland complexes are found in the drainage area.

North of 35W and south of Oak Lane is an important wetland complex with coniferous and hardwood swamps and alder thickets. These classifications are a signature for groundwater inputs, and so maintenance will rely upon knowledge of the local groundwater. Stormwater discharge to these wetlands will alter the chemistry and eliminate the characteristic vegetation. Stormwater management should not include this wetland in a system of pipes and ponds. The existing stormwater conveyance system along Lake Dr NE discharges to a pond that outlets to a channel and ultimately enters this wetland complex. Measures should be taken to reduce stormwater conveyance by implementing a network of BMPs in the conveyance area.

North of 35W and north of Oak Lane is a larger wetland complex dominated by alder thicket, a moderate indicator of groundwater. There is no pipe and pond system discharging to this wetland and planning should employ alternative stormwater management systems.

South of 35W and next to the lake is a large and highly susceptible coniferous swamp surrounded by wooded and shrub wetlands. A small catchment that consists of the large commercial area to the north drains to a treatment pond onsite (mapped here as wetland) and then to a pipe under the interstate to a channel (not seen here) that travels through the swamp directly to the lake. The loading to the lake should be investigated. To mitigate the loading, the swamp cannot be an alternative discharge point for the stormwater, without significantly altering the water chemistry and composition of the swamp. The commercial area is underlain by excessively draining sandy soils and thus becomes an ideal opportunity site for investigating onsite infiltration BMPs such as rain gardens and pervious pavement.

To the north of G Street are two catchments. At G Street a channel flows south directly to the lake. Land use north of this should therefore be planned to dissipate runoff into the ground through multiple onsite BMPs. This will avoid additional pressure on the volume-constrained culvert on G Street. The soil in the uplands is well-draining sand.

**RMP Future Conditions:** The George Watch RMU will see moderate levels of development consisting primarily of low density residential with small areas of more intensive use. The high infiltration capacity soils (HSG A) in this area make the proposed 2.8-inch infiltration standard very effective in controlling future runoff in this subwatershed, however, some of the most stormwater-sensitive wetlands are found in this area and will require additional standards to protect them. Opportunities for infiltration retrofit exist within this subwatershed. A feasibility study that finalizes potential locations and completes a preliminary evaluation of the final sites is the next step in quantifying the potential for retrofit projects in this area.

## MARSHAN AND 10-22-32 RMU RECOMMENDATIONS

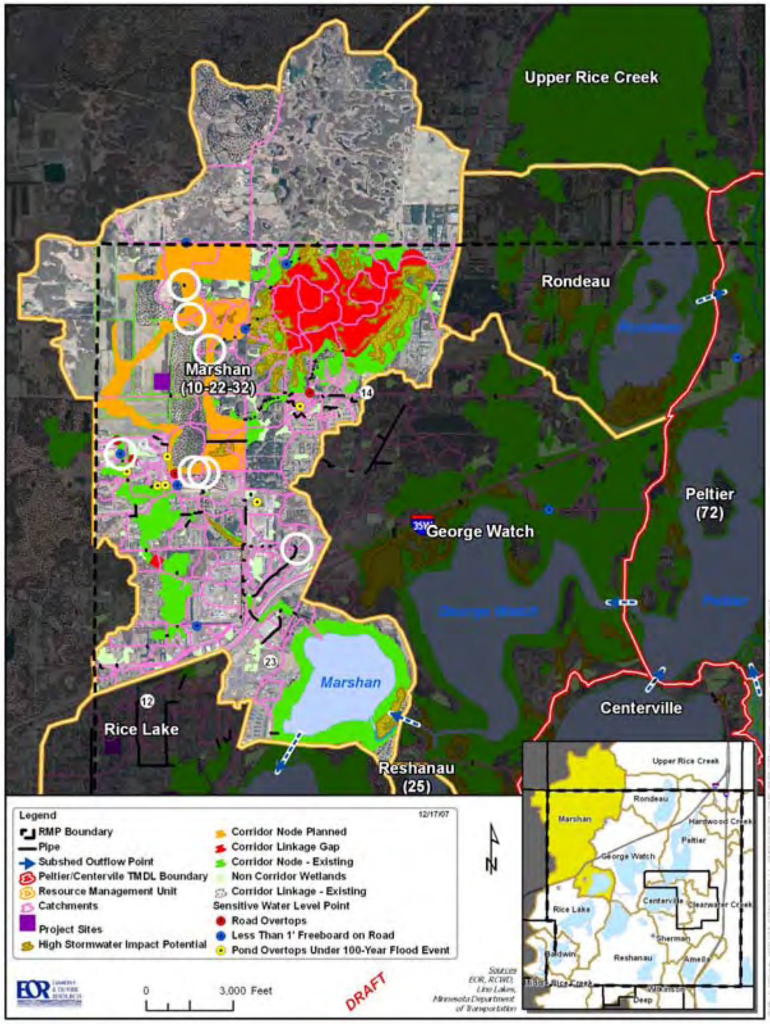


Figure 37. Marshan/Ditch 10-22-32 RMP.

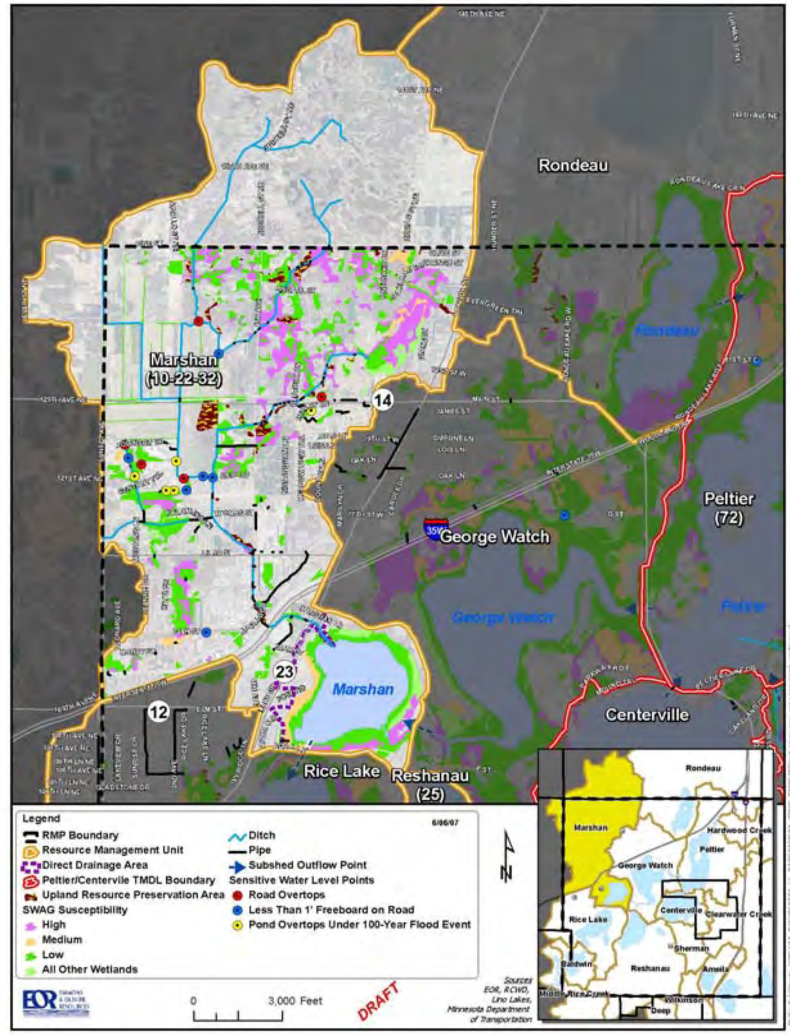


Figure 38. Marshan/Ditch 10-22-32 Existing Conditions.

**Existing Conditions:** There are many sensitive water level points along the ditch branches in the west part of this subwatershed. Runoff management is a pipe, pond, and ditch system. To alleviate the potential flooding without increasing downstream discharge of urban hydrology to Marshan Lake, onsite volume controls should be evaluated. The land use is already fully built out, there is no need to anticipate additional stormwater inputs to the ditch branches, and so evaluation can use the existing conditions model. Numerous small catchments comprise this area, making it ideal for addressing individual, small areas independently. The soils in these neighborhoods are well drained and suitable for infiltration.

The 10-22-32 ditch system has been used as the backbone of the urban drainage network in the urbanized portion of this subwatershed. It may be presumed that continued urbanization in a northward direction, will also look to the ditch system as the primary conveyance. In order to retain a functional ditch system, without exceeding capacity, particularly in the cluster of potential flooding points, volume regulation will most likely be required.

The downstream end of the ditch system is also within an urban landscape. Pipes in this area are functioning under high rainfall events. The nutrient loading to Marshan Lake will need to be investigated as part of TMDL implementation. One option will be to investigate the functioning of the wetland on the north side of Lake Drive NE. Downstream of this the channel flows within a sandy drainage way, and additional investigation is needed on the potential for expanding storage and nutrient retention and removal from the existing loads. There is no large area available for ponding and load reduction at the end of the ditch, and so it may be that upstream redevelopment BMPs may be the best solution.

Wetland mitigation banking is very feasible in the upper branches of the ditch system. This area is one of the highest concentrations of fully drained wetland in the City.

**RMP Future Conditions:** Anoka County Ditch 10-22-32 conveys the majority of the flow to Marshan Lake. This ditch has issues that could be resolved by modifying culverts in catchments MAR-059, MAR-108, and MAR-110. None of these locations are overtopping paved roads, so the culvert modifications are not urgent. There is a large area in northwest Lino Lakes that is currently used for sod production for the most part. This area is guided to be developed into low, medium and high-density residential housing while incorporating some mixed-use facilities. This area has significant opportunity for wetland restoration credit and flexibility in design due to lack of priority natural resources. In addition to addressing volume effects, the design can incorporate an open space connection between Columbus and Blaine as preferred in the DNR Metro Greenways corridor.

The wetland restoration for northwest Lino Lakes under the RMP scenario (shown in orange) has been used to model the effect of the design in addressing downstream volume effects. The plan is shown in Figure 39. The concept plan increases the viability of development by lowering the water level for the majority of the property while increasing the opportunity for wetland creation, preservation and habitat protection.

The RMP standards modeled for this subwatershed provide protection for many of the highly susceptible wetlands, but not all.

By comparing the RMP and Existing Conditions maps, the large area in red on the RMP map identifies both upland and wetland. This is an upland/wetland habitat complex, and it is considered a corridor gap area because of fragmentation by existing and planned housing and roads. Fragmentation effects on the habitat functioning should continue to be evaluated and addressed through landscaping strategies, wildlife movement strategies, use of rural road design and minimal runoff, and homeowner education.

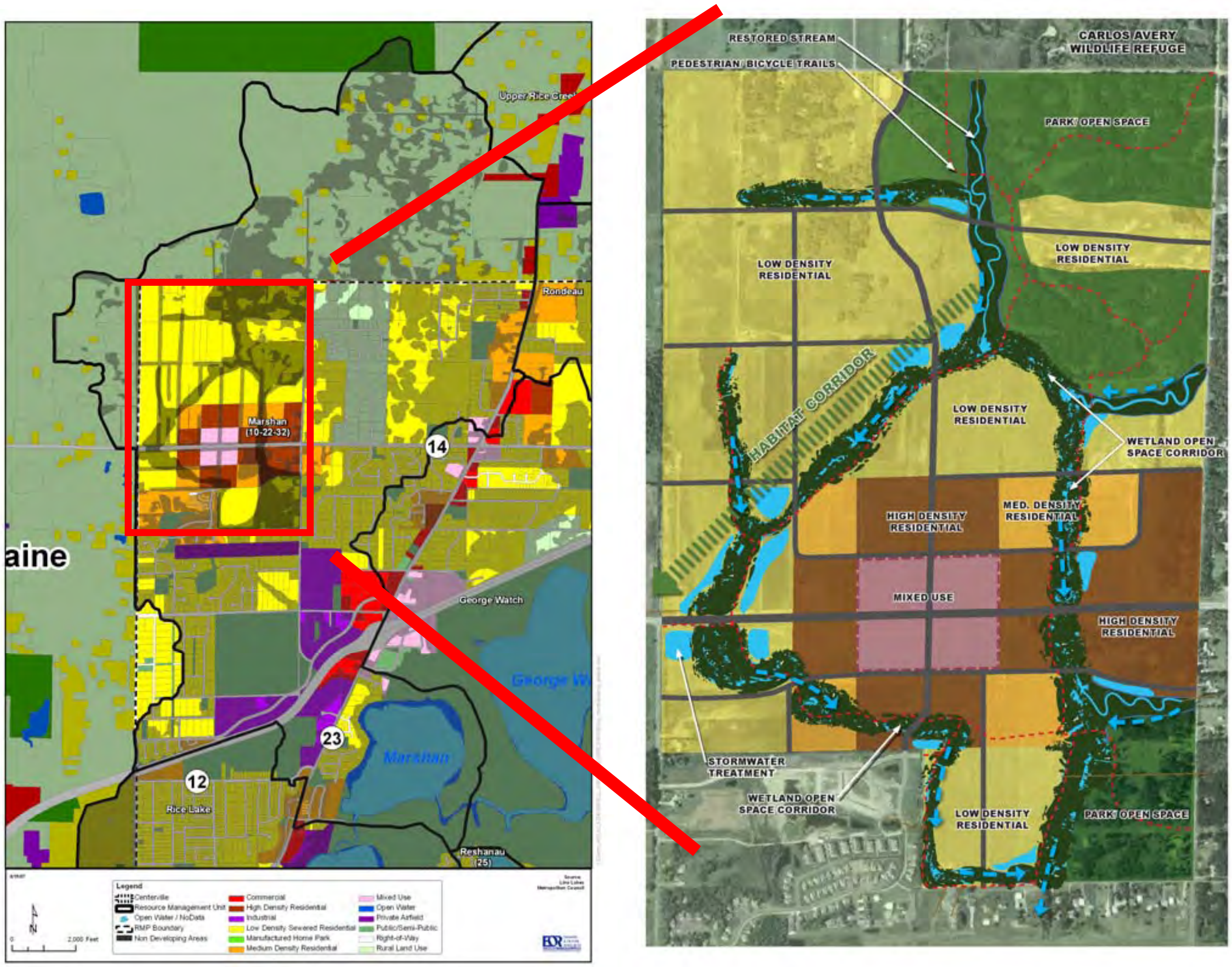


**Figure 39. RMP-based Land Use for NW Corner.**

## RICE LAKE RMU RECOMMENDATIONS

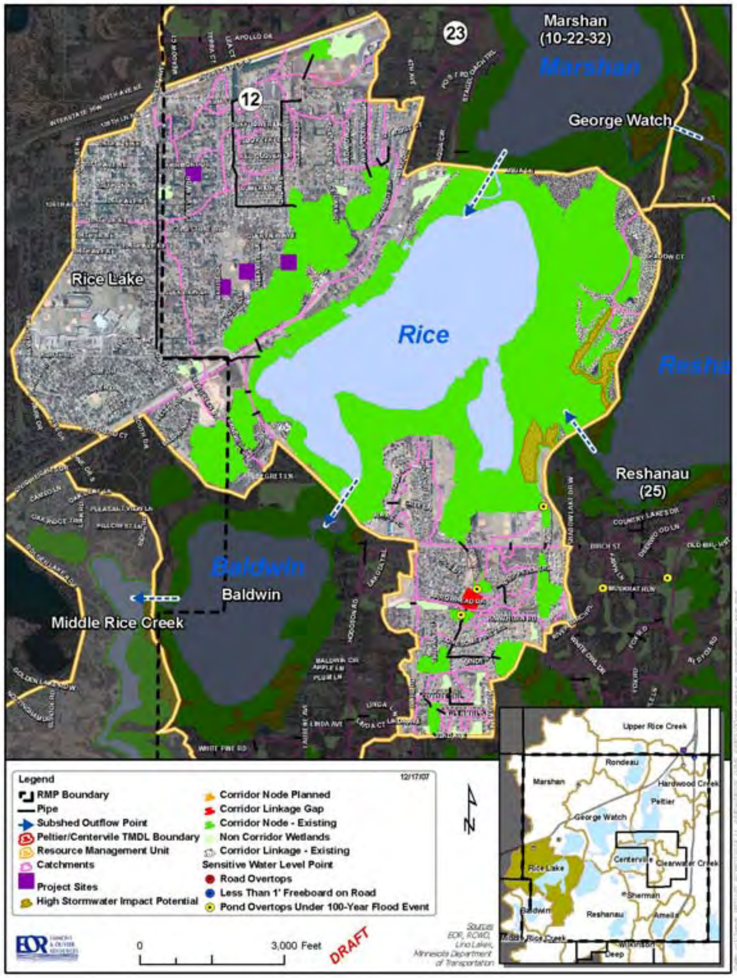


Figure 40. Rice Lake RMP.

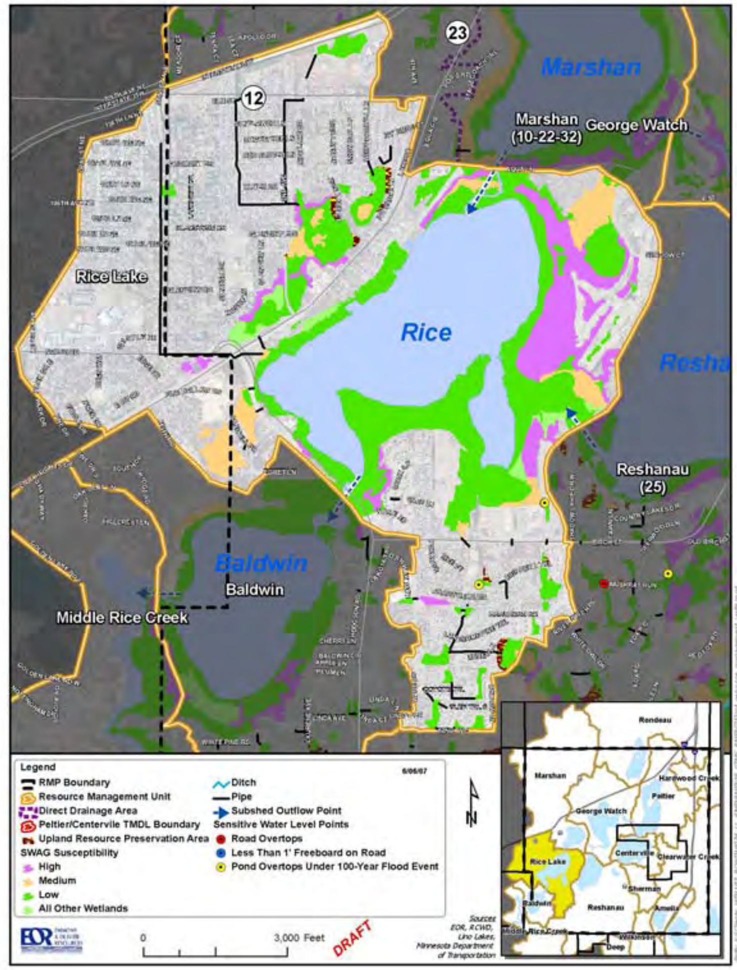


Figure 41. Rice Lake Existing Conditions.

**Existing Conditions:** This subwatershed is a nearly fully developed urban land use. Solving resource management problems will thus depend on implementing green infrastructure urban retrofit.

To the northwest of Rice Lake, three large stormsewer conveyance lines discharge to area wetlands and Rice Lake. The municipal boundary line discharges to Rice Lake. The nutrient loading is unknown and if reductions are needed, then partnership with Blaine will be needed. The other two stormsewer lines discharge to the large wetland complex. There are fringing regions of hardwood swamp (in purple). Primarily the system consists of shallow and deep marsh with open water pockets. This wetland system will continue to be dominated by urban hydrology. No channels are known from this wetland to the lake, thus urban nutrient loads are not directly discharging to Rice Lake. If there is an interest in nutrient load reduction to this wetland, then neighborhood infiltration BMPs would need to be integrated into the conveyance system.

To the south of Rice Lake, a lobe of upland juts into the lake. The stormsewer discharges to a central pond without a channel to the lake. On the far southeast the stormsewer conveyance system discharges to a pond and then the fringing wetland. The pond outlet is channelized to the lake and shows negligible interaction with the fringing wetland. Nutrient loading may be reduced by optimizing the wetland and channel interaction and should be investigated. The two sensitive water level points in the south Rice Lake neighborhood are at ponds, and all wetlands in the neighborhood are already being used for stormwater. Urban retrofit (on site volume control measures) is most likely the only alternative for reducing the potential for flooding at the two pond locations.

**RMP Future Conditions:** Rice Lake RMU is primarily fully developed but opportunity for retrofit projects exist. The runoff from the northwest portion of this subwatershed drains to the sensitive wetlands located in catchment RLA-021 on the north side of Lake Drive. Decreasing stormwater flows to these wetlands would be beneficial to restoration.

The northwest portion of this subwatershed is located on very sandy soils that are currently underutilized for stormwater infiltration. The projects shown on the map are a few of the possible locations that could be used for larger scale infiltration practices. A feasibility study that finalizes potential locations and completes a preliminary evaluation of the final sites is the next step in quantifying the potential for retrofit projects in this area. At this point the RMP standards and these projects are sufficient to provide protection for the high SWAG wetlands on the northwest side of the lake.

# RESHANAU RMU RECOMMENDATIONS

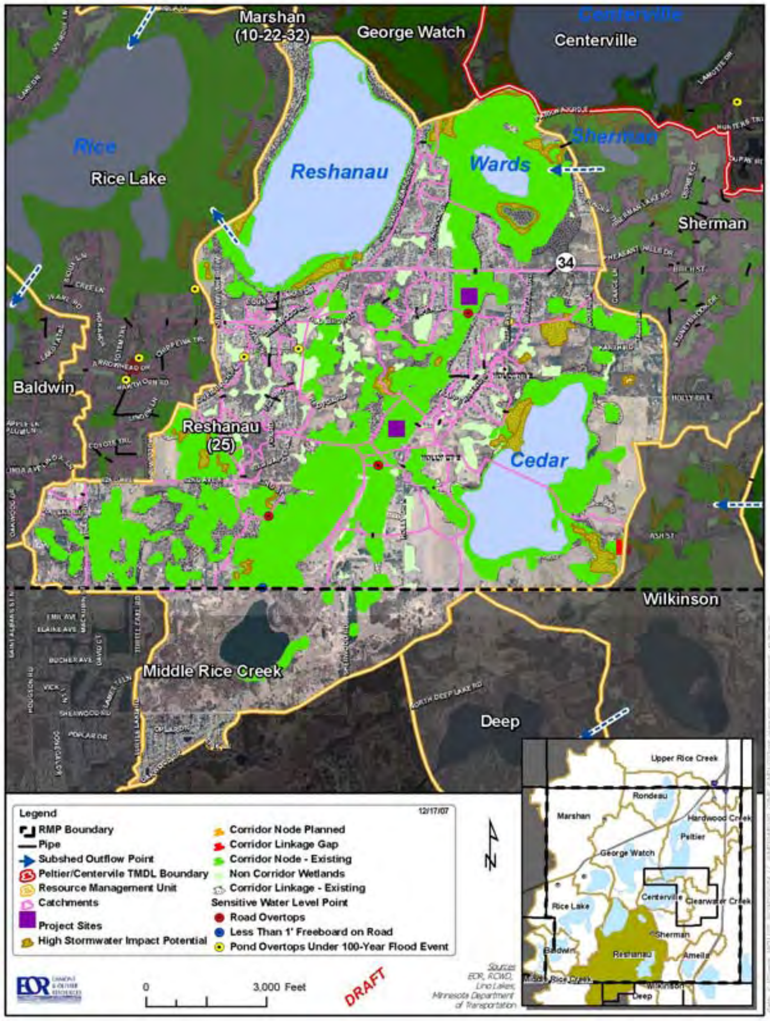


Figure 42.Reshanau/Ditch 25 RMP.

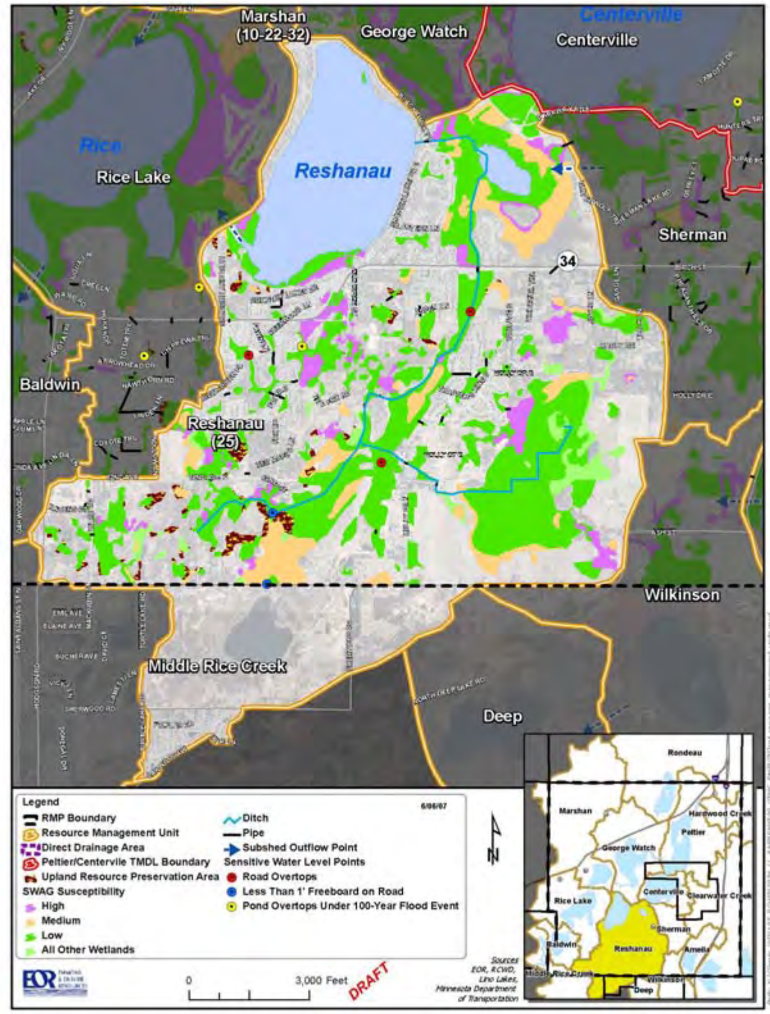


Figure 43. Reshanau/Ditch 25 Existing Conditions.

**Existing Conditions:** Reshanau Lake does not receive water from the upstream reaches of Rice Creek or the Chain of Lakes. This means implementation plans for the lake as an impaired water body need only examine the direct drainage area shown in Figure 42 and Figure 43. A portion of the drainage area is in North Oaks. Wetlands in North Oaks are not identified in Figure 42 and Figure 43.

The watershed condition is both urban and agricultural. Urban runoff follows a system of pipes and interconnected wetlands/ponds. One stormwater conveyance system discharges to Reshanau Lake (south side). The remaining storm sewer lines discharge to isolated wetlands or the Ditch 25 wetlands.

Wetland plant communities comprising the backbone of the Ditch 25 system are commonly marshes with fringing shrub and forested swamps. Groundwater signatures are not documented. The ditch system has not produced fully drained wetlands as in other areas of the City. All of the wetlands are considered partially drained to varying degrees. The system of wetlands provides a natural greenway corridor. Interspersed upland areas could be incorporated into the greenway corridor to increase habitat functioning of the wetlands and provide passive recreation. Wetland restoration credit is possible by restoring the hydrology of partially drained wetlands.

The potential flooding issues along the ditch (red dots) are limited to agricultural field crossings, and are not typical roads. Only one wetland pond may exceed its capacity in a large rainfall. The future full build out model will determine whether the ditch or pipe and pond system can accommodate increased volume and where onsite volume control practices should be implemented.

Ward’s Lake comprises the center of the large wetland complex at the receiving end of Ditch 25. Very limited information; depth, vegetative community, biotic community is known about Ward’s Lake. Cedar Lake is shown as wetland on the Existing Conditions map; it is at the head of the Ditch 25 drainage route.

**RMP Future Conditions:** The land use within the Reshanau RMU will primarily change from agricultural uses to low density residential. Much of this RMU is already developed as low density residential. The Reshanau RMU consists primarily of Ditch 25 (ACD-25) and its tributaries.

Full development within the Reshanau RMU has the potential for increases in rates and volumes along ACD-25. The ACD-25 corridor is largely continuous and provides excellent opportunities for a greenway corridor. Throughout the corridor there are opportunities for wetland restoration projects and vegetation management that would not only improve the ecological value of the corridor, but could also be designed in a way that could help mitigate the impacts of increased flows and volumes within the corridor.

Two specific project sites have been identified. These specific projects would entail eliminating the ditched conditions of the wetlands in these areas and restoring the hydrology to the wetlands by allowing more temporary and/or permanent ponding of water to occur.

This could be accomplished in two ways. The ideal restoration strategy would be to eliminate and or restrict the ditch therefore forcing water up into the existing wetland areas. Due to the flatness of the system this would have effects beyond just the project sites and would require additional landowner coordination and assessment of nearby properties. Should the more holistic restoration strategy be deemed prohibitive, then the alternative strategy is shallow scraping (including reed canary grass rhizome removal) of a wide low-lying area to allow water to pool and return hydrology to the adjacent wetlands. The alternative strategy cost-benefit analysis will include the wetland restoration credit opportunities.

It is recommended that road crossings of ACD-25 be discouraged in order to maintain a continuous corridor. It is also recommended that field crossings be eliminated or converted into trail crossings as development occurs. In some cases these crossing are serving as rate control features. At the time that they are proposed to be altered, downstream impacts would need to be assessed and a mitigation strategy would need to be developed if needed.

Wards Lake and Cedar Lake are currently controlled by ditched outlets. Management plans including outlet control structures and vegetation management should be considered. These plans will need to be coordinated with the DNR and should include citizen input.

Some stormwater-sensitive wetlands continue to be at risk even with the RMP standards. Specific analysis of their contributing catchments is needed.

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# BALDWIN RMU RECOMMENDATIONS

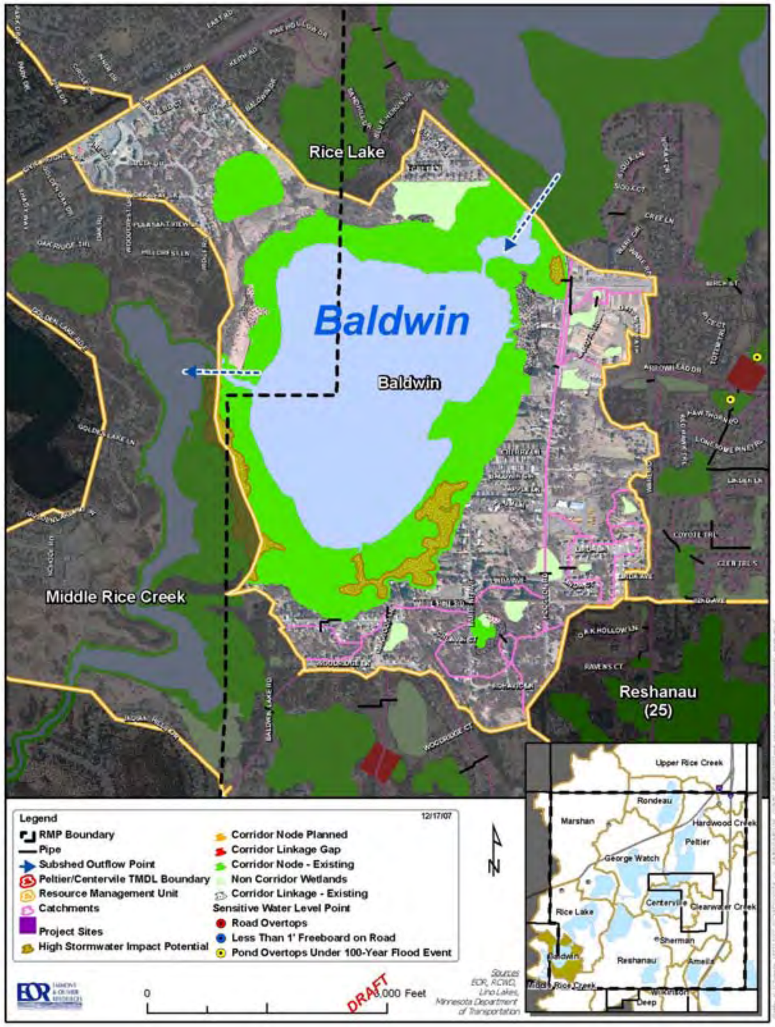


Figure 44. Baldwin RMP.

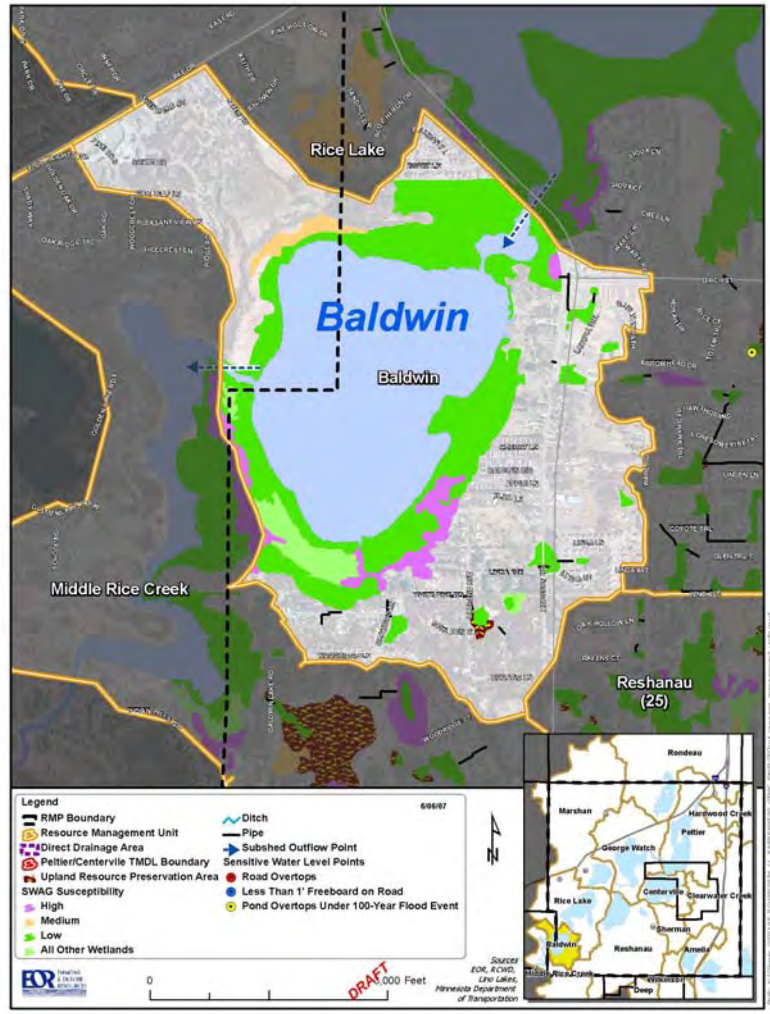


Figure 45. Baldwin Existing Conditions.

**Existing Conditions:** This small subwatershed has mixed land use and runoff characteristics. The fringing wetlands are mix of marshes, forest, and shrub. There are hardwood swamp areas which may be partially groundwater-dependent.

The drainage area is built out as urban area. Storm water conveyance is comprised of pipes and wetland ponds. One discharge point is on the north end of Baldwin Lake. Two discharge points are into the fringing wetlands on the south. It is not known if the discharge points channelize directly to the lake. These points will need to be investigated for nutrient loads to Baldwin.

Very limited land use change is predicted in this RMU. High rainfall events should not lead to flooding problems. The system currently shows no potentially flooding areas.

**RMP Future Conditions:** This resource management unit contains little developing area and has no known flooding issues. Therefore, no projects are proposed. The RMP modeling shows that stormwater sensitive wetlands are at risk. This is a result of existing conditions since the land use is not proposed to change in the area.

## SHERMAN RMU RECOMMENDATIONS

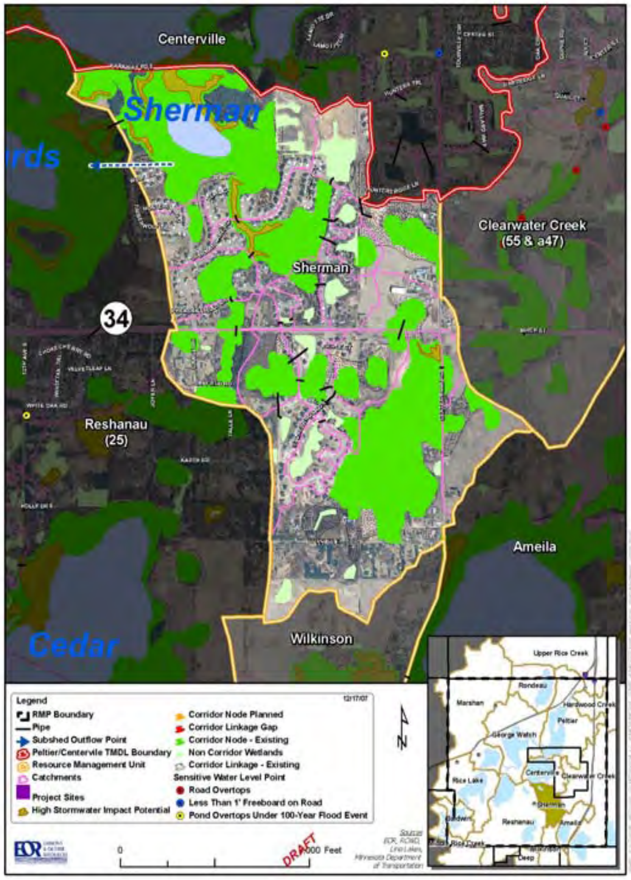


Figure 46. Sherman RMP.

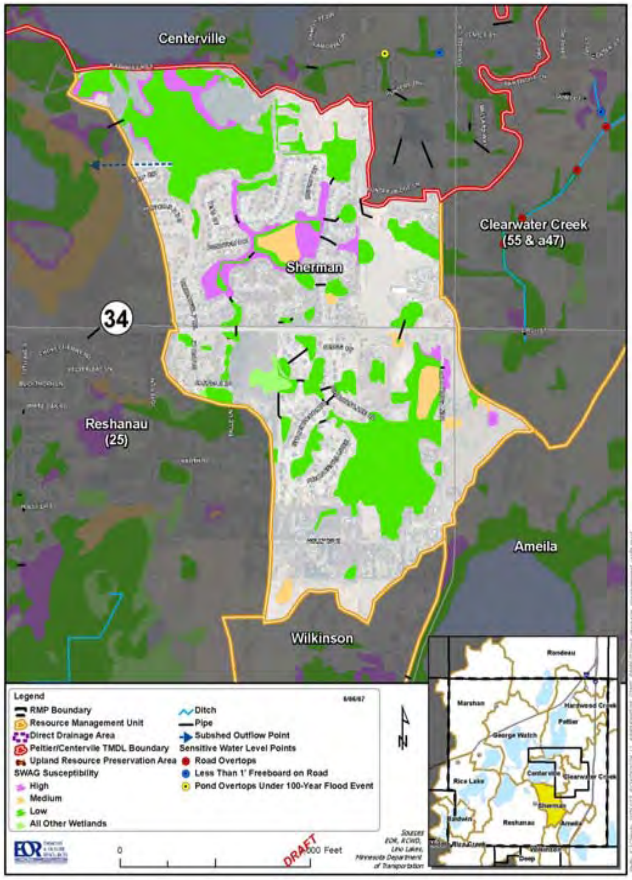


Figure 47. Sherman Existing Conditions.

**RMP Future Conditions:** No measurable land use changes will occur. Stormwater-sensitive wetlands are at risk under current conditions. The City can examine volume reduction practices in the catchments for the sensitive wetlands.

## AMELIA RMU RECOMMENDATIONS

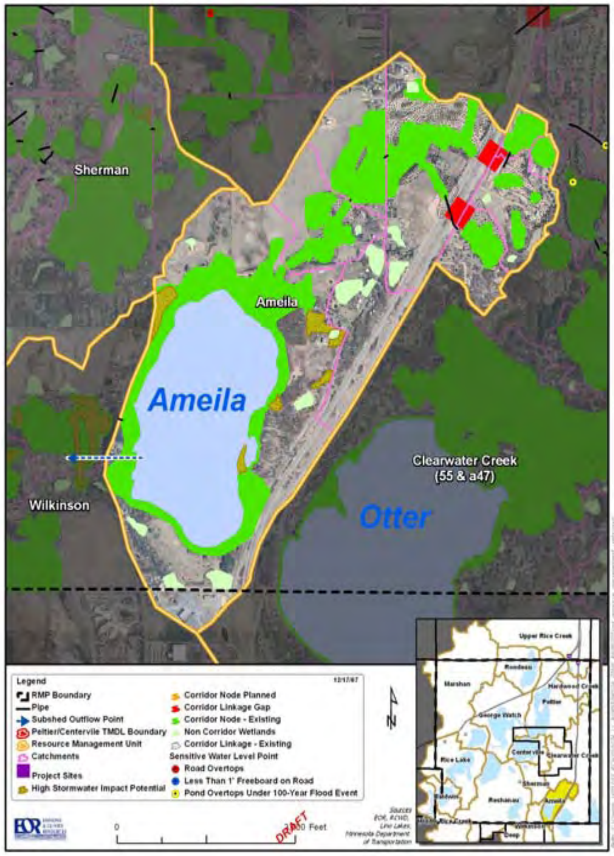


Figure 48. Amelia Lake RMP.

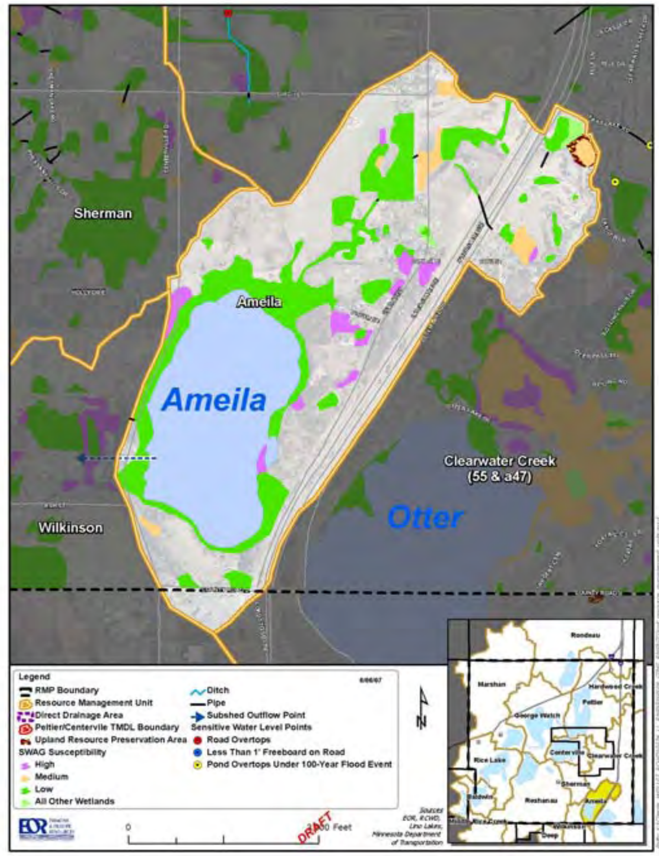


Figure 49. Amelia Lake Existing Conditions.

**RMP Future Conditions:** Amelia Lake is a shallow lake located within VLAWMO. Wetland restoration potential exists on the private ditch that enters the lake on the north side in catchments AME-004 and AME-005. Currently there are corrugated metal pipes (CMP) in poor condition controlling hydrology of these wetland complexes. If wetland restoration is used as a management tool then these culverts should be replaced with reinforced concrete pipe (RCP) as part of the restoration. Coordination with VLAWMO and landowners should be undertaken as the next step in determining the feasibility of projects in this system. Some wetlands are at risk from stormwater and those catchments should be evaluated to reduce the volume effects. Two large corridor gaps exist from the interstate. Mn/DOT should be notified that these are opportunity areas for a wildlife crossing to be considered in any future projects in this area.

# WILKINSON RMU RECOMMENDATIONS

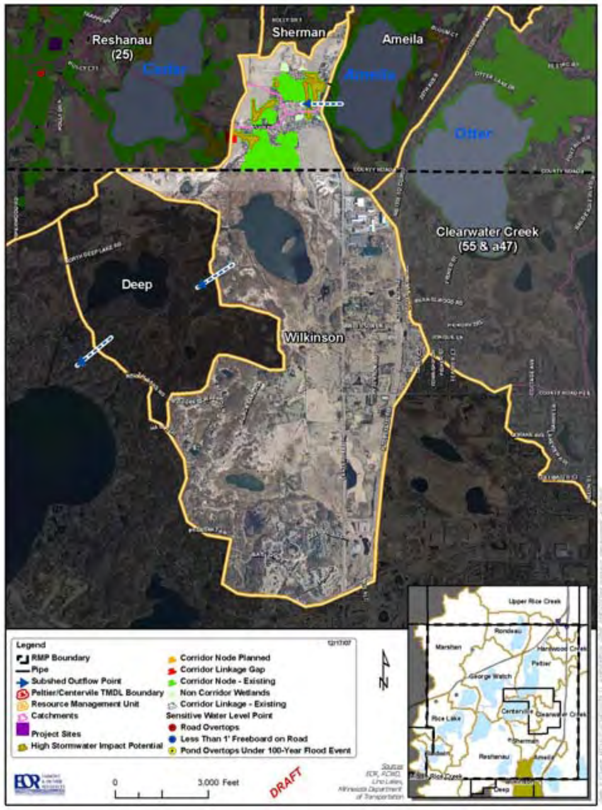


Figure 50. Wilkinson RMP.

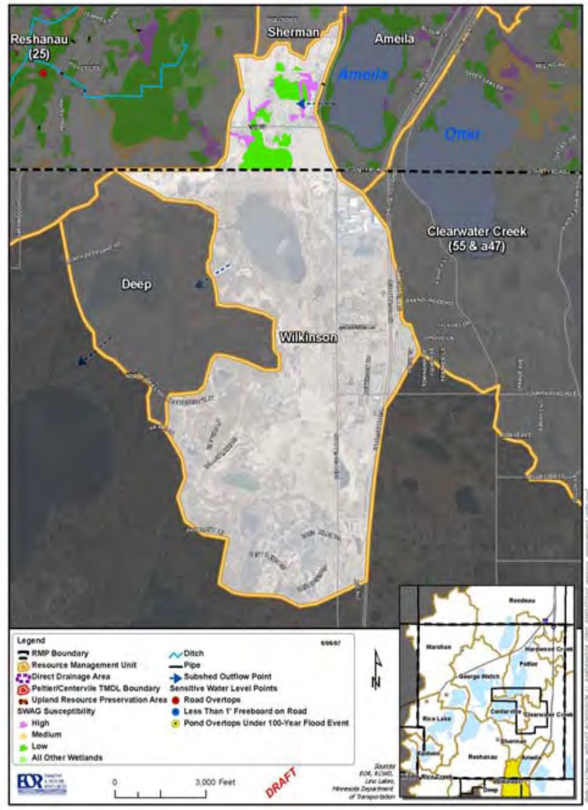


Figure 51. Wilkinson Existing Conditions.

**Existing and RMP Future Conditions:** This RMU is within the VLAWMO. No projects are proposed. Wetlands at risk from stormwater should be evaluated for reducing volume effects in the catchments.

## MIDDLE RICE CREEK RMU RECOMMENDATIONS

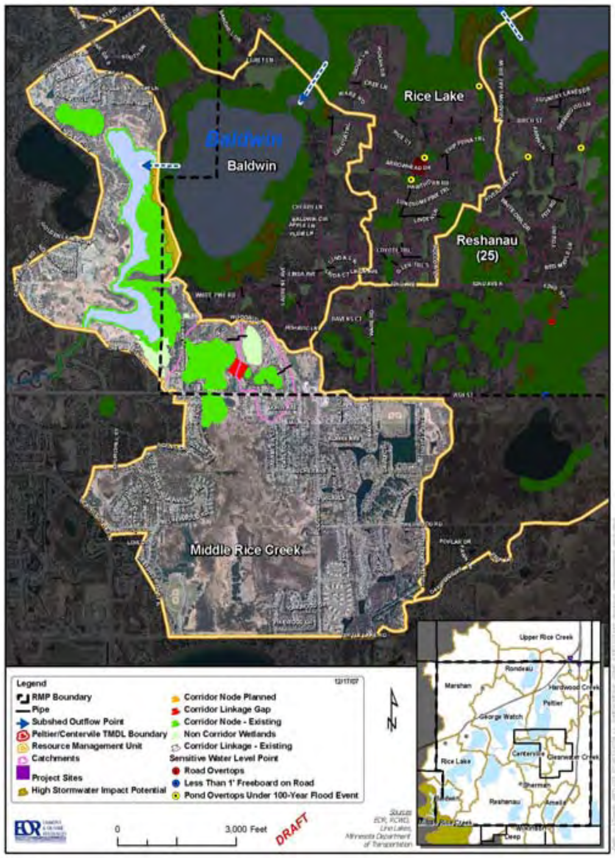


Figure 52. Middle Rice Creek RMP.

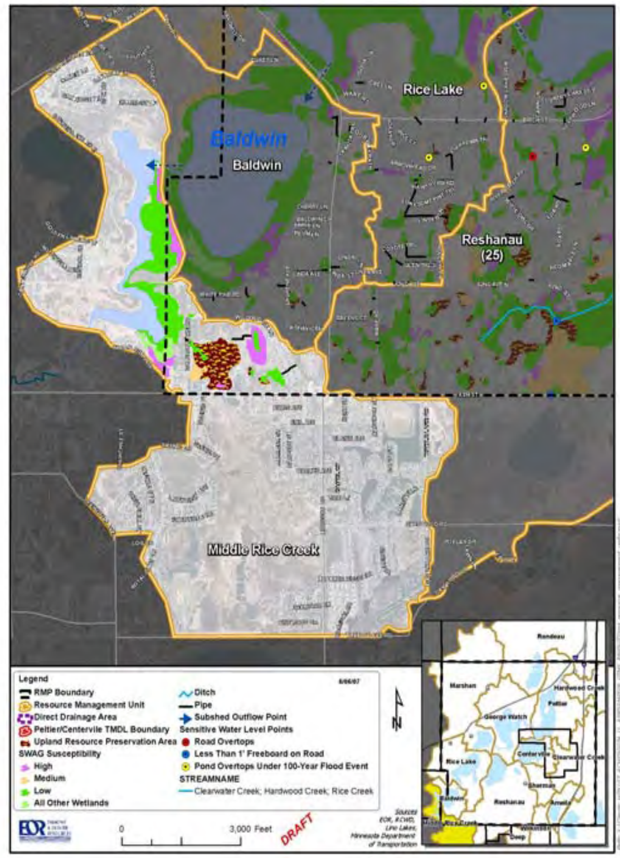


Figure 53. Middle Rice Creek Existing Conditions.

**RMP Future Conditions:** No specific projects are proposed. Wetlands at risk from stormwater should be evaluated for reducing volume effects in the catchments. One corridor gap was identified and should be evaluated during land planning, utilizing appropriate gap-infilling strategies. The small segment of County Ditch 8 that is located in this area will be evaluated as part of the RCWD's ongoing Ditch Inventory Program.

# REFERENCE MATERIALS

## COMPANION DOCUMENTS

Numerous studies were used to prepare this plan. They are listed below.

Provided by the watershed district

- Draft Lino Lakes High Priority Wetlands Memorandum (November 26, 2006)
- Lino Lakes RMP Landscape Scale Functional Assessment Existing Conditions Protocol (November 7, 2006)
- Draft Technical Report on Existing Conditions of Resources in the City of Lino Lakes, Minnesota (January 2, 2007)
- Lino Lakes Wetland Values Survey (April 9, 2007)
- ACD 25 Original Profile Assessment – Technical Memorandum (December 22, 2006)
- ACD 10-22-32 Original Profile Assessment Summary Memorandum (March 9, 2007)
- ACD 47, 55 & 72 Original Profile Assessment Summary Memorandum (April 5, 2007)
- SWAT Model Hardwood Creek TMDL (February 5, 2007)
- Draft Report Peltier Centerville Lake TMDL (May 5, 2007)
- Lino Lakes RMP Summary of Proposed Modeling Approach (for surface water modeling) (November 8, 2006)
- Memorandum on XP-SWMM Model Input Parameters (March 19, 2007)
- ACD 25 Repair Report
- ACD 10-22-32 Repair Report

Provided by the city

- o City of Lino Lakes 2030 Comprehensive Plan Update Background Document – Natural Resources Section (March 6, 2007)

## RELATED DOCUMENTS

Studies and RMPs not specifically undertaken to support the findings in this plan contain policies, rules, and methodology which are similar if not in fact the same as that for the LL RMP. They are listed below.

- Resource Management Plan for the 53-62 Drainage Area and RMP-1 Rule (approved)
- Resource Management Plan for the JD4 Drainage Area and RMP-2 Rule (in final review)
- RMP Rule Economic Analysis

## ACRONYMS

ACD – Anoka County Ditch

ADID – Advanced Identification

BWSR – Minnesota Board of Water and Soil Resources

CDA – Contributing Drainage Area

CWA – United States Clean Water Act

EPA – United States Environmental Protection Agency

EOR - Emmons & Olivier Resources, Inc.

MLCCS – Minnesota Land Cover Classification System

MNDNR – Minnesota Department of Natural Resources

MnRAM – Minnesota Routine Assessment Method (for wetland functions and values)

MPCA – Minnesota Pollution Control Agency

NHP – Minnesota Natural Heritage Program

NPDES – National Pollutant Discharge Elimination System

NWI – National Wetlands Inventory

PWI – Minnesota Protected Waters and Wetlands Inventory

RCWD – Rice Creek Watershed District

RMP – Resource Management Plan

TMDL – Total Maximum Daily Load

USACE – United States Army Corps of Engineers

VLAWMO – Vadnais Lake Area Watershed Management Organization

WCA – Minnesota Wetlands Conservation Act

WPA – Wetland Preservation Area

WPC – Wetland Preservation Corridor

## LITERATURE

Tucker, Scott; Harrison, Doug; Cyre, Hector; Burchmore, David; Reese, Andrew. January 2006. Guidance for Municipal Stormwater Funding. National Association of Flood and Stormwater Management Agencies. November 28, 2007 <www.nafsma.org>

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Rice Creek Watershed District. 2006. BMP Browser. http://ricecreek.org/bmp.

Rice Creek Watershed District. 2007. Anoka County Ditch 25 & 10-22-32 Repair Reports. http://ricecreek.org/node/394

## DEFINITIONS

The definitions provided are for the purpose of understanding the RMP text, and are not regulatory definitions. Definitions are generally consistent with terms in Minnesota Rules 8420.0110 (identified here as WCA), USACE guidance documents, or Section 404. Reference for the definition is provided in parentheses.

**Applicant –** a person, corporation, government agency, or organization that applies for an exemption, no-loss, wetland boundary, wetland type, replacement plan or banking plan determination or equivalent, or someone who makes an application to withdraw wetland banking credits from the wetland bank (WCA).

**Buffer –** 1. land areas of variable width that separate the resource from urban and agricultural areas to ensure that mitigation performance is met; and provide habitat functions; 2. an upland and/or riparian land area that protects and/or enhances aquatic resource functions associated with wetlands, rivers, streams, lakes, marine, and estuarine systems from disturbances associated with adjacent land uses (proposed Section 404).

**Creation –** gain in wetland area by converting non-wetland to wetland.

**Degraded wetland –** provides minimal function and value due to human activities such as drainage, diversion of watershed, filling, excavating, pollutant runoff, and vegetative or adjacent upland manipulation (WCA).

**Establishment (Creation) –** gain in wetland area by converting non-wetland to wetland.

**Impact** - a loss in the quantity, quality, or biological diversity of a wetland caused by draining, filling, excavating, or diverting water from a wetland, per the WCA, or conversion of an existing high functioning wetland type to some other type without equal or greater function by inundation or other means. An adverse effect (proposed Section 404).

**Partially drained –** effects of drainage ditches on the hydrology of wetland such that the wetland has a drier regime than under pre-drainage conditions; while climates change, the wetland is assumed to be partially drained if a ditch is functioning to any degree; the extent of partial drainage is determined using the Scale of Degradation or approved methodology by the TEP.

Wetlands that have had their original, natural hydrology altered, but have not been effectively drained; quantified by comparing the pre-altered condition to the existing altered condition, using monitoring and estimations such as lateral drainage effect models (USACE definition).

**Rehabilitation –** no gain in wetland acres; repairing natural or historic functions to a degraded wetland (USACE guidance).

**Restoration** – return natural or historic functions to a degraded wetland (USACE guidance); reestablishment of an area that was historically wetlands or remains as a degraded wetland (WCA).

Manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded aquatic resource. For the purpose of tracking net gains in aquatic resource area, restoration is divided into two categories: reestablishment and rehabilitation (proposed Section 404).

**Resource management plan –** (RMP) a plan to meet Minnesota state rules for a Comprehensive Wetland Protection and Management Plan (CWPMP); the process described in the Plan that is consistent with the Section 404 framework.

**Scale of degradation –** severe, moderate, or minimal level of degradation due to a human-induced activity; relates to credit allocated for enhancement; quantified using MnRAM function metrics of outlet condition (mnram qu. 13)/vegetative quality (99): L=low function, M=medium function, H=high function

Severe – L/L, M/L
Moderate – L/M, M/M
Marginal – L/H, H/L
Fully functioning (no degradation) – M/H, H/M, H/H

The scale was developed to better quantify the 1) WCA definition of ‘a wetland that provides minimal wetland function and value due to human activities such as drainage, diversion of watershed, filling, excavating, pollutant runoff, and vegetative or adjacent upland manipulation’ and 2) ‘partial drainage’. Each wetland plant community type in a wetland complex shall be determined separately.

**Upland buffer –**natural vegetation area contiguous with wetland that separates the resource from urban and agricultural areas to lessen the impact that activities in those areas can have on the wetland. Upland buffer can be used for wetland mitigation credit around an existing or mitigation wetland, if the average width is at minimum 25-50 feet and no less than 25 feet in any area, and it is contiguous with the wetland edge.

**Upland habitat area –** existing natural non-wetland habitat contiguous with an existing, restored, or created wetland. The area can be considered for habitat function mitigation credit if it is shown to be critical for special concern, threatened, or endangered species; or is at least 300 feet contiguous with the wetland edge and 300 feet or more beyond the wetland edge for this same distance.

**Wetland Preservation** C**orridor** (WPC) **–** high priority resources in the RMP watershed

# APPENDIX TO THE
# LINO LAKES
# RESOURCE MANAGEMENT PLAN

June, 2008

Prepared For:

RICE CREEK WATERSHED DISTRICT
and
CITY OF LINO LAKES

Prepared By:

Emmons & Olivier Resources, Inc.
651 Hale Avenue North.
Oakdale, Minnesota 55128

Appendix A: Existing Conditions Watershed Modeling Report

Appendix B: Full Build Out Watershed Modeling Report

Appendix C: Resource Management Plan Modeling Report

Appendix D: Centerville Lake Outlet Memo

# Appendix A:
# Existing Conditions Watershed Modeling Report

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# XP-SWMM Model Development/Methodology

## Model Purpose and Introduction

The XP-SWMM model for Lino Lakes was developed to provide hydrologic and hydraulic information for the following RMP purposes:

- To provide long-term volumes in support of the chain of lakes TMDL water quality analysis
- To provide an analysis of the current city infrastructure and identify areas of concern; and
- To provide the City with the stormwater infrastructure information needed to meet the Local Surface Water Management Plan requirements.

XP-SWMM was chosen as the modeling software for three primary reasons:

- It allows the modeler to use the Green-Ampt method resulting in improved runoff estimation under continuous simulation and small event modeling. While the SCS method is the most widely used method of generating runoff, it has the tendency to inaccurately predict runoff volumes for a number of reasons [e.g. intended for large rainfall events and not for smaller, water quality events; intended for event-based modeling and not for continuous simulations; failure to adjust initial abstraction to account for losses in a particular system; and sensitivity to selection and methodology of use (e.g. impervious compositing) of curve numbers]. In order to more accurately predict the volumes of runoff generated in the City of Lino Lakes for a variety of modeling scenarios, the Green-Ampt method was selected as the hydrologic model. By accounting for soil-moisture storage and infiltration, this method more accurately predicts the peaks and volumes of runoff generated for smaller storm events as well as for continuous simulations.
- It utilizes full dynamic wave equations which improve calculations in hydraulic mode. This is particularly important to accurately account for the backwater effects that are prevalent throughout much of the city due to flat topography.
- It provides a flexible interface that allows the input of continuous rainfall and flow inputs. The ability to input modeled and monitored hydrographs from upstream drainage areas allowed the model to utilize the best available data for each inflow without expanding the detailed XP-SWMM model upstream of the city.

The Lino Lakes model is capable of completing multi-year continuous simulation for the years 1999-2003 or event simulation depending on the needs of the user. Most ponds, water bodies, and wetlands within Lino Lakes have been explicitly modeled as a live storage volume with an outlet allowing a high resolution of results and analysis. This document describes the input parameters and assumptions that went into development of the Lino Lakes model, the calibration process and the model results.

## Model Development

This section describes the development of the existing conditions XP-SWMM model by following the steps or process used to develop each portion of the model. First, the overall modeling methodology and use of GIS/XPSWMM interface is discussed. Then the model input parameters for the hydrologic and hydraulic portions of the model are described.

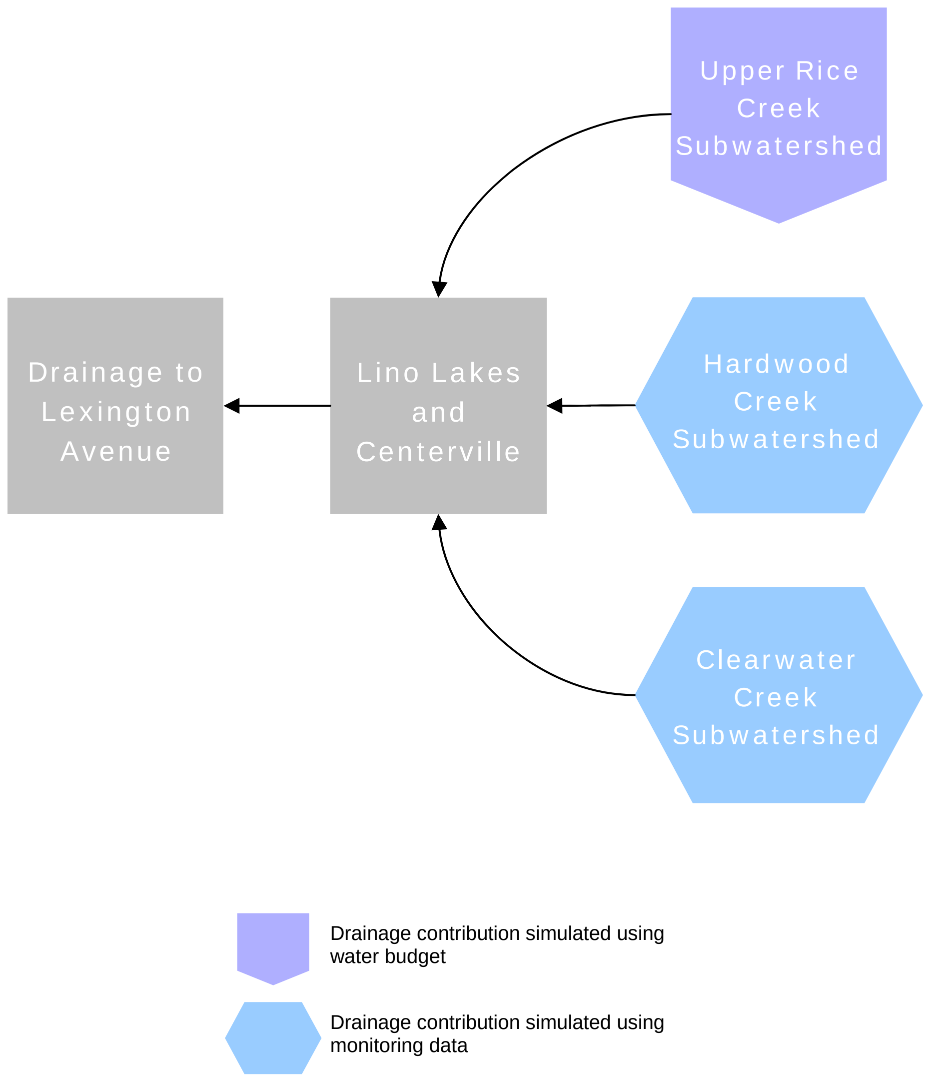
### *Modeling Methodology*

As stated previously, XP-SWMM was chosen as the modeling software for three primary reasons:

- It allows the modeler to use the Green-Ampt method resulting in improved runoff estimation under continuous simulation and small event modeling.
- It utilizes full dynamic wave equations which improve calculations in hydraulic mode.
- It provides a flexible interface that allows the input of continuous rainfall and flow inputs.

The geographic extents of the XP-SWMM model include all areas within the Lino Lakes city limits and some areas directly tributary to the city but outside the political boundaries. Areas tributary to the city were defined using either monitored flow data, water budget data, or input from the RCWD's district-wide HydroCAD model. Figure A1 shows a schematic of the LL RMP model.

**Figure A1. Lino Lakes Modeling Extents, Inflows and Outflows**




For continuous simulation, the model may be used for any period between 1999-2003. This is the temporal extent of the water budget that provides the inflows from Upper Hardwood Creek under continuous simulation. If monitoring data is collected in future, the water budget and the model's simulation period could be expanded to other years.

The model can be used for the simulation of any synthetic rainfall/runoff event up to the 100-year 24-hour event. Larger events are possible but have not been tested. If larger events are desired the model should be reviewed before using results.

### *Use of GIS/XP-SWMM Interface*

A GIS/XP-SWMM interface was used to create and simplify the generation of data and the data input process. The interface expedited the data input of the following variables:

- Subwatershed area;
- Impervious percentage;
- Slope;
- Width;
- Stage/storage;
- Weighted average capillary suction;
- Weighted initial soil moisture deficit; and
- Weighted average saturated hydraulic conductivity.

### *Hydrologic Input Parameters*

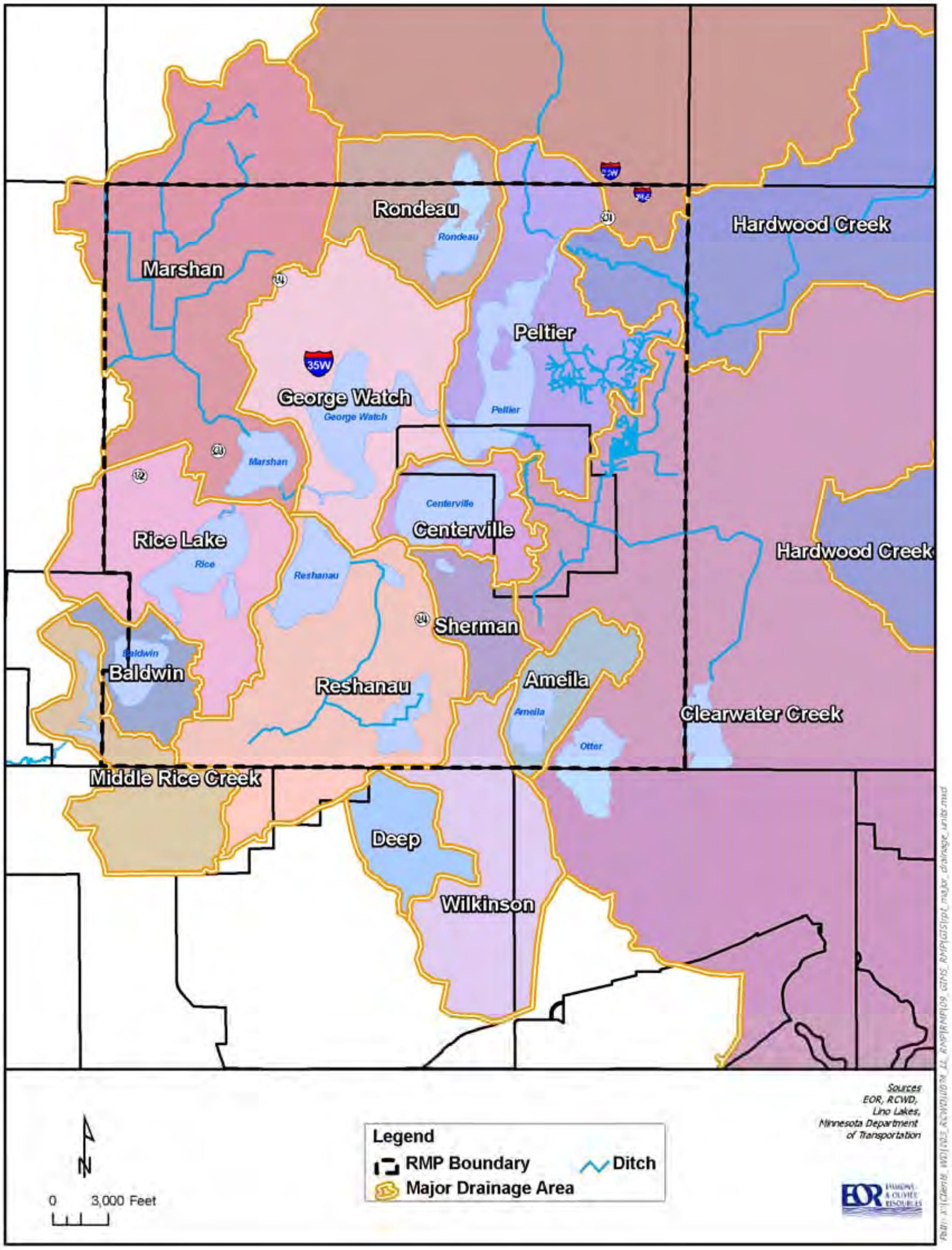
All of the hydrologic input parameters used to create the XP-SWMM runoff portion of the model are described in this section. This part of the model is responsible for generating runoff rates and volumes in the form of a runoff hydrograph for each subwatershed, given runoff parameters and rainfall inputs. The results from this portion of the model are then read by the hydraulics portion of the model (see following section, Hydraulic Input Parameters). All input parameters are available upon request from the RCWD.

**1. Subwatershed/Catchment Boundaries**

Delineation of subwatershed and catchment boundaries for the model was performed using the finest resolution topographic contours available. For this project we use the term *catchment* to mean the smallest scale hydrologic delineation completed, and the term *subwatershed* to refer to the major drainage systems within the city. Subwatersheds are named by either the creek or lake that they are tributary to (example: Catchments that are tributary to Marshan Lake, including the 10-22-32 ditch system, are all part of the Marshan subwatershed). For areas within the district, the 2-foot contours provided by the district were used. Previously defined hydrologic boundaries were reviewed and incorporated where feasible as they provided a logical starting point and also provided consistency with other modeling efforts conducted by the district.

The final subwatershed boundaries used for the XP-SWMM model include 387 catchments with an average size of approximately 40 acres (excluding large lake direct drainage subwatersheds). Defining the catchments at this resolution allows all culverts 18” or greater to be explicitly modeled. Figure A2 shows the subwatersheds within the city, the catchments are not shown due to the scale of the maps.

**Figure A2. Lino Lakes Subwatershed Boundaries and Flow Directions**




## 2. Rainfall

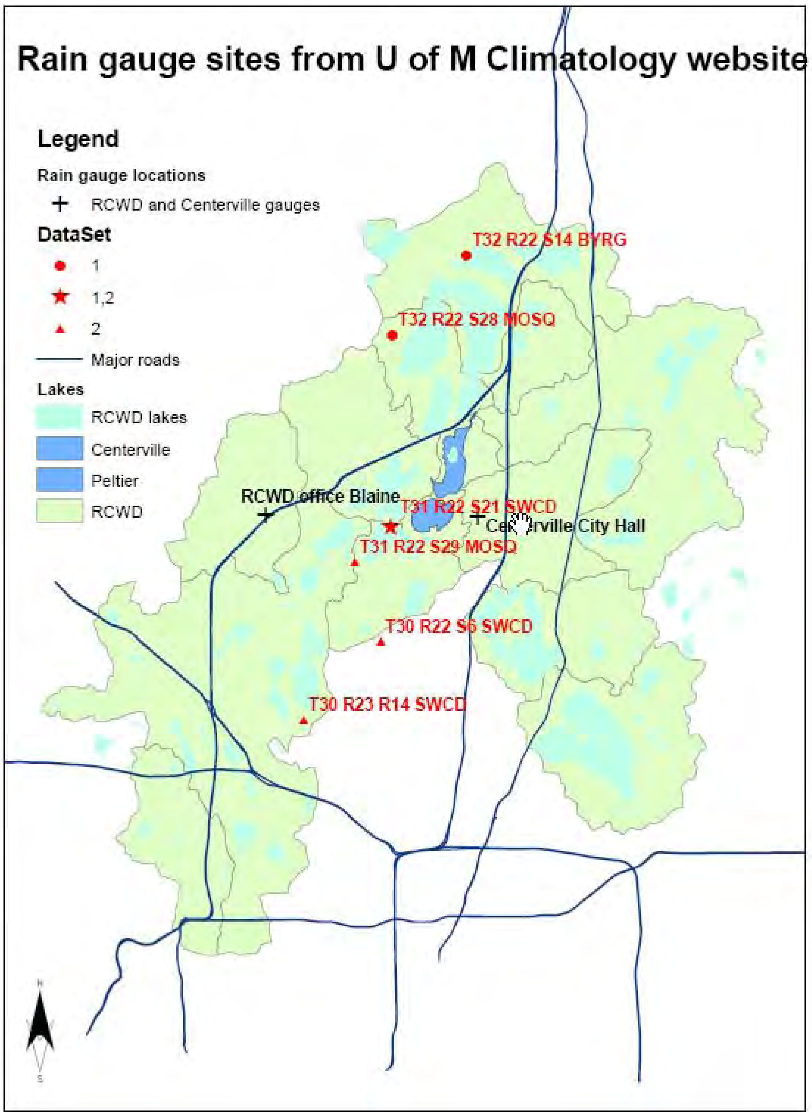
Precipitation data was obtained from the Climatology Working Group (http://climate.umn.edu/) database. With this database, the target location is set using section, township, and range, and the allowable maximum number of missing data points per month. The various sites are then searched so that the closest data set with less than the allowable number of missing data points can be identified.

For the precipitation data, two separate data sets were obtained (see Figure A3), using the following search criteria:

Set 1: Target T31 R22 S28 (located in Upper Rice Creek Watershed); 3 missing days allowed per month

Set 2: Target T31 R22 S21 (located near Peltier Lake); 3 missing days allowed per month

**Figure A3. Rain Gauge Sites from U of M Climatology Web-Site**




To compile the precipitation data set for the model, the following guidelines were followed:

- On days for which precipitation data were recorded in both data sets, the two values were averaged.
- On days for which there were data for only one of the sites, that value was used.
- If data were missing from both data sets, a value of zero was used.

The daily totals were then distributed based on a SCS 24-hour distribution at hourly intervals. The distributed rainfall data was then converted to a Rainfall Interface File using the XP-SWMM rainfall utility. Using this rainfall utility allows the rainfall to be referenced to a specific date and time instead of based on the starting time of the simulation. This makes the model more flexible and is especially beneficial when simulating times with different starting dates.

### 3. Evaporation

Monthly evaporation rates (free surface water evaporation, inches) were obtained for the area of interest from the Hydrology Guide for Minnesota. These monthly rates are provided in the following table.

**Table A1. Mean Free Water Surface Evaporation used for the Lino Lakes Water Budget**

| Month | Free Water Surface Evaporation (inches) |
|---|---|
| January | 0.32 |
| February | 0.35 |
| March | 1.40 |
| April | 3.20 |
| May | 4.90 |
| June | 5.60 |
| July | 6.40 |
| August | 5.40 |
| September | 3.50 |
| October | 2.50 |
| November | 1.05 |
| December | 0.38 |

Source: Hydrology Guide for Minnesota.

### 4. Width and Slope

The width and slope parameters are used to simulate the flow delivery in XP-SWMM (when using infiltration hydrology) by defining a theoretical subwatershed width and slope. The width and slope of the subwatershed affect both the time of concentration and the volume of runoff occurring. For this methodology the drainage area is idealized as a rectangular subwatershed. As the width of the watershed increases the length of the flow path is assumed to decrease. This decreases the travel time of the runoff from the subwatershed and increases the volume of runoff contributed. Similarly the slope controls the rate that the water flows across this idealized subwatershed, steeper slopes translate to faster runoff delivery and an increase in runoff volume.

An initial estimate of the width of each subwatershed was computed as the area of the subwatershed divided by the length of the longest flow path. The estimated subwatershed slope was calculated as the change in elevation divided by the length of the longest flow path. Spatial Analyst was used to generate a Digital Elevation Model (DEM) raster surface based on 2-foot topography provided by the RCWD. Using ArcHydro, the DEM was first reconditioned into a hydrologically corrected surface suitable for subwatershed scale analysis. A flow direction grid was then created which was itself used to generate the longest flow path lines for each subwatershed. The width and slope parameters were further analyzed through the ACD 10-22-32 parameter sensitivity analysis (see calibration). The result was to divide both values (width and slope) in all of the watersheds by two, essentially indicating that the flatter portions of the flow path control the runoff timing and volume.

### 5. Depressional Storage

The Green-Ampt methodology uses depressional storage to dictate the amount of rainfall required before runoff can occur. This value is somewhat analogous to initial abstraction used by the CN methodology. In XP-SWMM, depressional storage is defined for both pervious and impervious areas within each subwatershed. This value has great importance under small events and becomes less important for larger storms.

The Anoka County Ditch (ACD) 10-22-32 calibration process (see calibration section) indicated that a good initial estimate for the pervious depressional storage in the upper watershed would be approximately 0.10 inches applied over the subwatershed area. Initial estimates for the impervious depressional storage that have produced reasonable results thus far are 0.01 inches over the impervious area. Exceptions to this methodology are further explained under the "Storage" section, which is found under *Hydraulics Input Parameters*.

### 6. Satellite-based Estimation of Impervious Surface Area (%ISA)

A crucial input parameter for surface water runoff modeling is an estimate of the percent impervious surface area (%ISA) covering the land. GIS-based methods used to estimate this value include manually digitizing impervious features, estimation based on parcel land use category, and analysis of relevant land cover data such as the Minnesota Land Cover Classification System (MLCCS).

Research carried out at the University of Minnesota Remote Sensing and Geospatial Analysis Laboratory (RSGL)[1] has lent credence to a new method for estimating %ISA based on multi-spectral imagery acquired from space and air-borne remote sensing platforms. EOR has translated this research into a practical and commercially viable method for estimating %ISA; this method was used to define input parameters for the surface water runoff modeling component of the Rice Creek Watershed District Lino Lake Resource Management Plan (LL RMP).

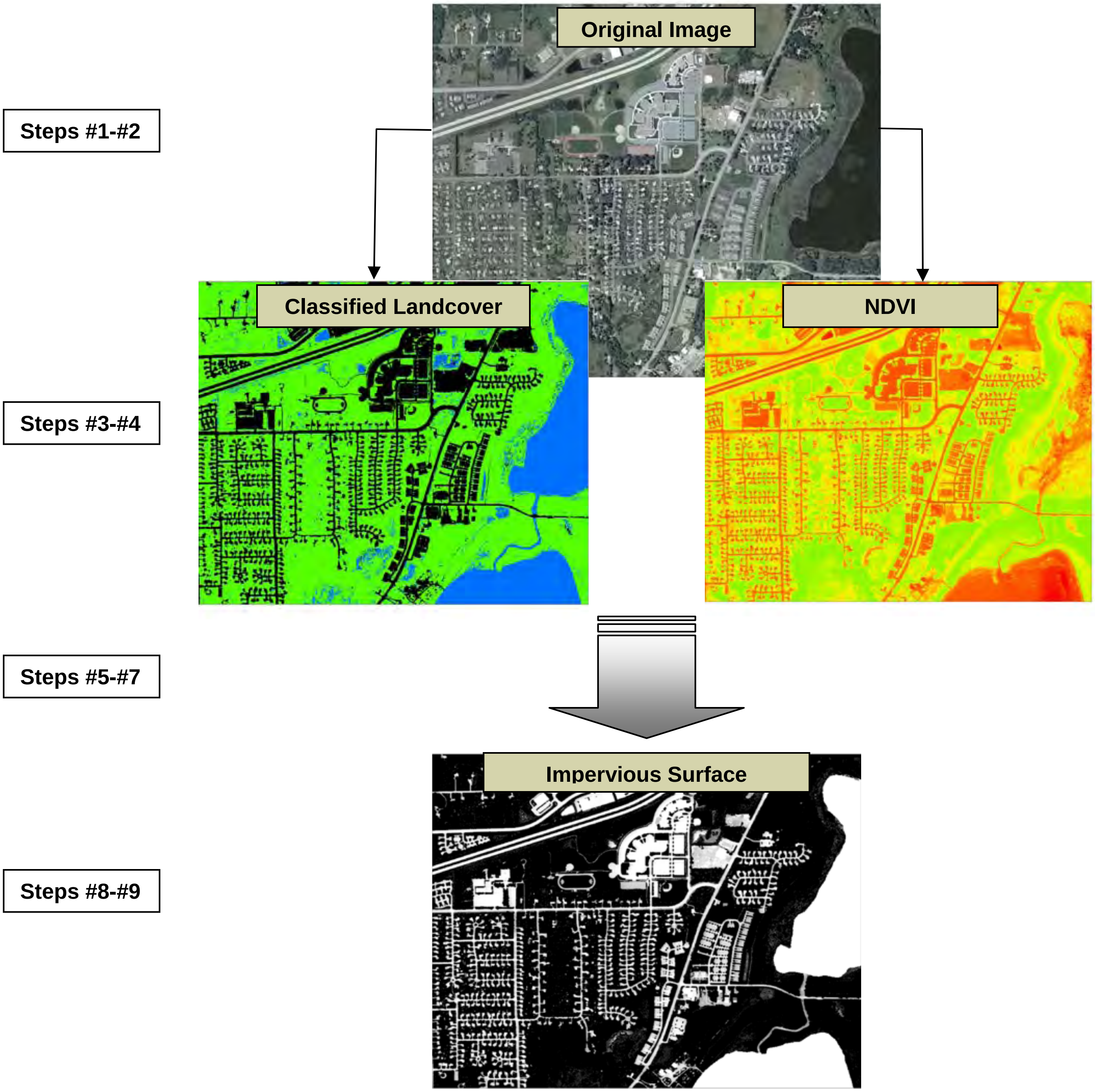
The steps for estimating %ISA based on remotely sensed imagery are described in the following list and graphically in Figure A4:

1. Evaluate study area and acquire appropriate imagery (may require multiple images).
2. Rectify and geo-reference the imagery (if necessary).
3. Classify imagery into four-high level classes of urban, vegetation, water, shadow.
4. Generate an appropriate vegetation index for each image.
5. Create a set of ground samples representing degrees of imperviousness.

[1] Sawaya, K., Bauer, M. et al., *Extending satellite remote sensing to local scales: land and water resource monitoring using high-resolution imagery*, Remote Sensing of Environment, v.88 (2003), p. 144-156

6. Run regression based on impervious samples and average vegetation index.
7. Apply regression to vegetation index and rescale values to 0-100% impervious.
8. Mask out non-urban areas and merge imagery (*if necessary)*.
9. Manual review/update areas for seasonal or “date-difference” effects.
10. Generate zonal statistics for each subwatershed.

**Figure A4. Deriving Impervious Surface Estimates (see text for definition of steps)**



In order to determine reasonable estimates of %ISA for large-scale watersheds with these methods, it is critical to use imagery of sufficiently high resolution acquired during leaf-on conditions (sometime between early-summer and late fall). There are currently two commercial satellite platforms which produce such imagery. The Quickbird platform (owned/operated by DigitalGlobe) produces multi-spectral imagery with a ground resolution of 2.4 meters; the IKONOS platform (owned/operated by GeoEye) produces multi-spectral imagery with a ground resolution of 4 meters. Both platforms produce 11-bit imagery with four separate bands representing the electromagnetic spectrum range covering the blue, green, red, and near infra-red wavelengths.

EOR reviewed imagery available from both Quickbird and IKONOS. Based on season and availability two Quickbird images were purchased providing full coverage of the LL RMP study area[2]. The first image, capturing the southern 60% of the study area was acquired in July, 2006. The second image capturing the remaining 40% was acquired in October, 2003. Although two years had passed between 2003 and 2005 (the year for which surface water runoff conditions were being modeled) an earlier comparison to the Metropolitan Council 2005 air photos revealed that minimal development/land cover change had occurred in this area during that period. Similarly, the 2006 Quickbird image was deemed acceptable for modeling prior year conditions since much of the area covered by this image had been fully developed prior to 2005.

After rectifying/geo-referencing each image to an RMSE of 1.2 meters, a set of 60 randomly selected samples representing each of five land cover classes were taken from each image and used as input to the maximum likelihood image classification method. The five land cover classes defined were: Water, Urban, Vegetation, Urban Shadow, and Vegetation Shadow. The shadow classes were important since urban areas may otherwise be "hidden" by heavy canopy. Likewise, shadows from man-made structures that obscure urban surfaces such as parking lots must be differentiated from those shadows that obscure vegetated areas.

As is often the case with pixel-based image classification the effects of "spectral confusion" can sometimes lead to misclassifications, particularly between bare soil and concrete and water with dark shadows. However, since these errors tend to occur in scattered, disconnected pixels, the overall classification tends not to be severely impacted. Once both images have been classified they are mosaiced to create one land cover image covering the entire study area.

The regression steps which follow are based on the assumption that a direct (inverse) linear relationship exists between the %ISA in a given area and the amount of vegetation present. While various methods are available for deriving vegetation metrics from multi-spectral imagery, by far the most common is the Normalized Difference Vegetation Index, or NDVI. The NDVI transformation is calculated as:

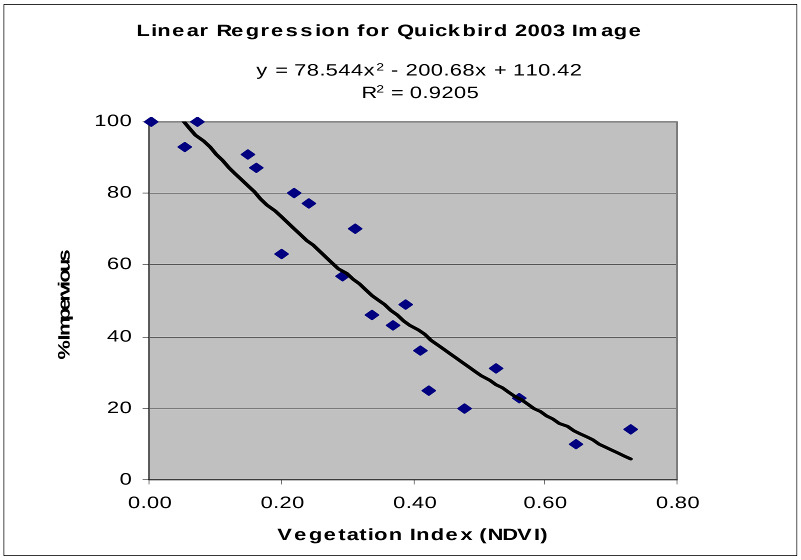
$$NDVI = \frac{NIR - RED}{NIR + RED}$$

[2] EOR initially reviewed 2005 color infrared photography available from the Metropolitan Council; this imagery was acquired during leaf-off conditions as was therefore not suitable for the methods used here.

RED and NIR are spectral values from an image representing the red and near-infrared bands. The NDVI itself is a value ranging from -1.0 and +1.0; if the reflected light in near-infrared wavelengths is significantly more than in visible wavelengths, is likely that vegetation is dense[3].

To investigate the relationship between NDVI and %ISA 20 randomly distributed samples were taken from each image, with two samples in each 10% range of imperviousness (0-10%, 10-20%, 20-30%, etc.). The areas sampled included partial and complete impervious coverage in/around urban lots, commercial/industrial lots, parking areas and roads. For each area sampled, the average NDVI was also extracted. With two sets of values, a bi-variate linear regression was calculated for each image, with %ISA as the independent variable and average NDVI as the dependent variable. Figure A5 illustrates the regression results for the October, 2003 image.

**Figure A5. NDVI and %ISA Regression Analysis**




An r-squared value of 0.92 indicates a very strong relationship between average NDVI and percent impervious. The resulting regression equation (a separate regression must be created for each image) was applied to the NDVI image in order to derive a new image representing percent imperviousness. All resulting values were finally rescaled between 0 – 100 in order to represent a continuous range of 0% to 100% impervious for each 2.4 meter pixel.

Although an image now exists which represents this inverse relationship it is important to recall that this transformation was applied to all pixels in the image, not only those representing urban surfaces. The classified land cover image created earlier is now utilized to effectively "mask out" all non-urban areas and reassign those areas as having zero imperviousness. In a similar fashion, water bodies such as lakes and ponds considered to be 100% impervious in surface runoff models must also be reassigned. A set of lake and pond polygons was used to define another mask; in this case the masked areas were reassigned to 100%.

Before generating the final per-subwatershed %ISA values, two additional (manual) steps were carried out. The first was to correct spectral confusion between bare soil and concrete, typically

[3] http://earthobservatory.nasa.gov/Library/MeasuringVegetation/measuring_vegetation_2.html

open, bare soil fields and graded construction sites. The northern portion of the LL RMP area has several large sod farms which, during the late spring and summer months, are fully vegetated. However, when the Quickbird image for this area was acquired in October, 2003 the fields were bare soil. These areas were also masked out in a similar fashion as described earlier.

The final adjustment made to the %ISA image was done to compensate for changes between 2005 (the modeled year) and 2006 (the year one of the images was acquired). Although much of the area covered by the 2006 image had already been largely developed prior to the modeled year a manual review showed several small previously vegetated areas that had since been graded for construction. The resulting bare soil on the site had been incorrectly classified as impervious (due again to spectral confusion between urban surfaces and bare soil). While these small areas would not have a significant effect on analysis at a smaller geographic scale, they would have significant impacts on localized subwatershed analysis. These areas were again masked out.

The final image produced represents an estimate of the average level of imperviousness present in each 5.76 square meters (~62 square feet) patch of ground. In order to summarize average percent impervious for each subwatershed, a GIS zonal operation was performed on the image using a previously created subwatershed polygon shapefile.

Table A2 shows a comparison between estimates derived from manual digitizing, MLCCS land cover, and the methods presented here. It is clear from this comparison that these methods produce consistently better results than the MLCCS-derived as compared to manual digitization. In the case of Subwatershed MAR-097, the large difference between the manually digitized and satellite-derived values can be explain by the effects of spectral confusion described earlier (this table does not reflect the final manual corrections).

**Table A2. ISA Estimation Method Comparison for 6 Lino Lakes RMP Subwatersheds**

| Subwatershed | Manually Digitized | Satellite Estimate | MLCCS Derived |
|---|---|---|---|
| MAR-092 | 8.00% | 10.77% | 28.00% |
| MAR-076 | 27.00% | 26.63% | 20.10% |
| MAR-097 | 2.00% | 17.04% | 9.00% |
| MAR-035 | 37.00% | 39.13% | 24.00% |
| MAR-031 | 15.00% | 13.73% | 13.00% |
| MAR-017 | 55.00% | 55.73% | 60.00% |

## 7. Infiltration

Infiltration was modeled using the Green-Ampt continuous soil infiltration methodology in XP-SWMM. The Green-Ampt methodology (equation shown below) was chosen primarily for its ability to track and update soil moisture conditions at each time step; providing increased accuracy of runoff volumes during a continuous rainfall simulation and small single events as well as during bigger flood events.

Green-Ampt Infiltration Equation:

$f = K[1+ (\phi - \theta_i)) S_f]/F$ where: $f$= Infiltration Rate(L/T)
K= Saturated Hydraulic Conductivity (L/T)
$\phi$= Soil Porosity ($L^3/L^3$)
$\theta_i$= Initial Water Content ($L^3/L^3$)
$S_f$= Capillary Suction at the Wetting Front (L)
F= Cumulative Infiltration (L)

Application of the Green-Ampt equation within XP-SWMM required definition of three basic parameters:

- Initial soil moisture deficit—This parameter is an estimate of the antecedent soil moisture conditions, which affect the initial soil infiltration rate. Following the first storm event during a continuous simulation, soil recovery computations automatically update the soil moisture content.

- Soil capillary suction—This parameter influences the movement of a wetting front through the soil profile. Estimation of this value influences the initial soil infiltration rate (during the early stage of a storm event), but looses impact over time.

- Saturated hydraulic conductivity—This parameter estimates the rate of water movement through a saturated soil profile. The saturated hydraulic conductivity is a function multiple soil properties and is highly influenced by vegetative cover. This is the most significant of the three parameters needed and ultimately drives the maintained infiltration rate.

The three infiltration parameter values were calculated as a weighted average unique to each subwatershed through GIS spatial analysis.

Of the three infiltration parameters required, the saturated hydraulic conductivity represents the most variable component of the Green-Ampt equation. An extensive effort was made to refine the assignment of this parameter based on the information available through the MLCCS mapping effort for the modeling of the Minnehaha Creek Watershed District. This methodology underwent extensive review and received approval from the TAC members (including United States Army Corps of Engineers (USACE); Federal Emergency Management Agency (FEMA); Metropolitan Council; Minnesota Department of Natural Resources (MDNR); Minnesota Department of Transportation (MnDOT); Minnesota Pollution Control Agency (MPCA); local city, county and watershed staff and representatives; and other water resource engineer consultants).

This parameter was analyzed during model calibration based on results from the continuous simulation and ACD 10-22-32 calibration. The values accepted as part of the Minnehaha Creek modeling effort were used for the Lino Lakes model and did not need further refinement as they calibrated well to the monitoring data.

### *Hydraulic Input Parameters*

This section describes the input parameters used in the hydraulics portion of the XP-SWMM model. This portion of the model contains the hydraulic features present within Lino Lakes and also the other information used to calculate inflows from outside the city. The hydraulic model functions by reading the output from the hydrologic model (see previous section, *Hydrologic Input Parameters*) and uses the parameters described in this section to calculate flow rates and water elevations in open channels, hydraulic structures, ponds, lakes and wetlands. All input parameters are available upon request from the RCWD.

**1. Peltier Lake Water Levels**

Lake level readings for Peltier Lake were provided by the St. Paul Regional Water Service (formerly the Saint Paul Water Utility). The contact for this information was David Schuler, Chief Engineer. Originally, the St. Paul Regional Water Service indicated that they had weekly lake level readings for Peltier Lake. In actuality, readings were collected weekly, biweekly (every two weeks) and were occasionally collected once every three weeks.

Once received, data collected by the St. Paul Regional Water Service had to be modified in the following manner:

1. All small numbers (less than 2) should be negative and were so changed
2. Threw out any numbers greater than 7 (total points deleted from data set is 2)
3. If the numbers are small (less than 2) add 885.39 as the reference point
4. If the numbers are large (greater than 4) add 879.86 as the reference point
5. Deleted outliers (total points deleted from data set is 7)

Due to the length of time between data points (one to three weeks), EOR had to manually interpolate between lake level readings. This manual interpolation took rainfall events, snowmelt events, recorded flow in Hardwood and Clearwater Creeks and the lake outlet structure configuration into account.  For example, if there was a significant precipitation event between two recorded elevations taken a week apart, the interpolated lake levels would be modified to show a higher lake level after the storm event.  Conversely, if little to no precipitation occurred between water level measurements, linear interpolation was used.

### 2.  Centerville Lake Water Levels

Lake level data has not been recorded for Centerville Lake since 1996.  The Department of Natural Resources has annual readings for 1997, 1998 and 2002.  The St. Paul Regional Water Service does not collect lake level readings for Centerville Lake.  It was assumed that Peltier and Centerville Lakes operate as one system.

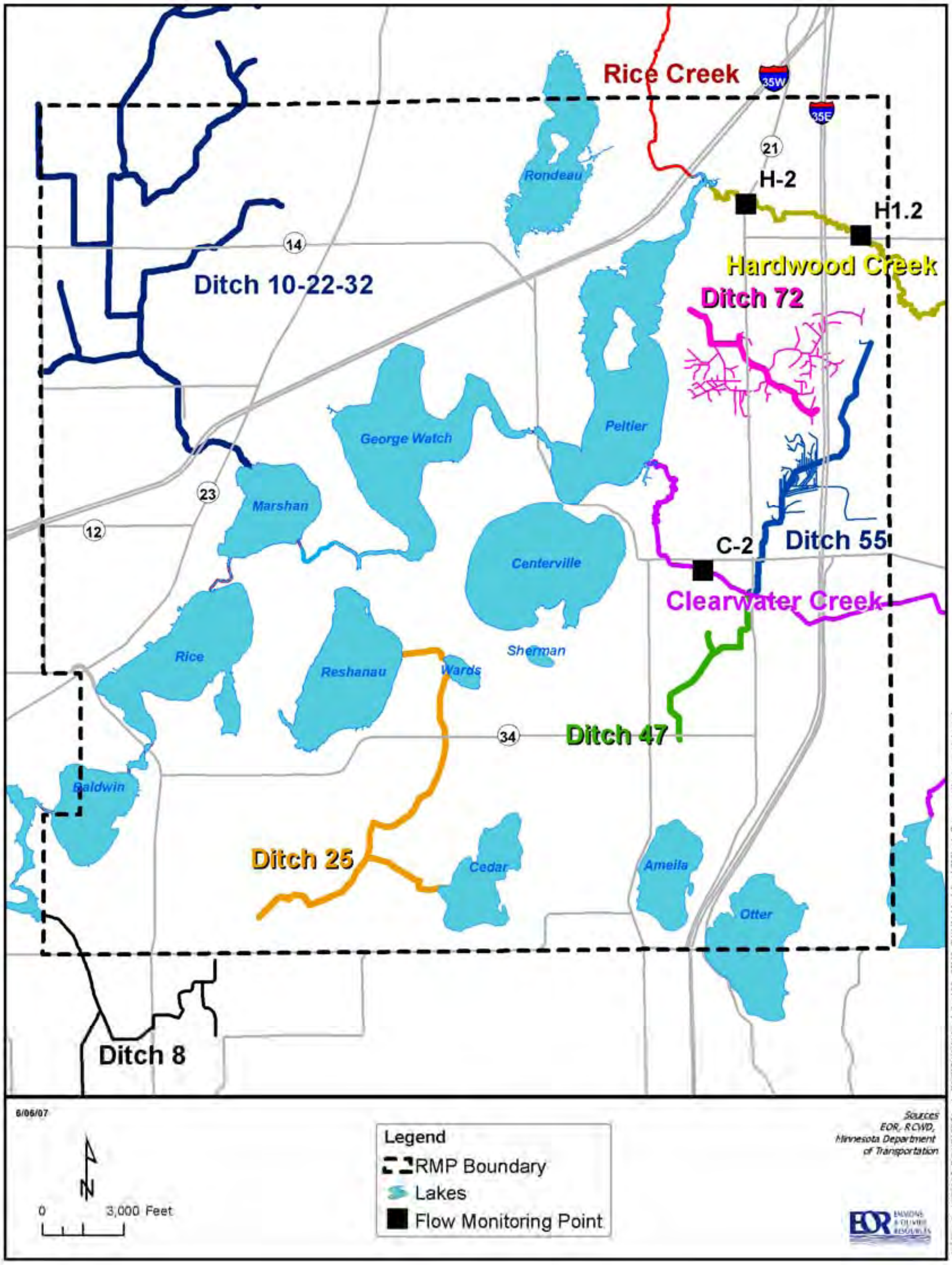
### 3.  Peltier Lake Discharge

A stage/discharge curve was developed using the outlet configuration provided in the *Peltier Lake Dam Operation and Maintenance Manual* prepared by the St. Paul Water Utility in June of 1998.  In calculating discharge (cfs) it was assumed that the discharge is not subject to tailwater effects.

### 4.  Hardwood Creek Flow Data (Stations H2 and H1.2)

Monitoring station H2 has stream flow data for 1999 – 2006 and monitoring station H1.2 has stream flow data for 2002 – 2006.  Due to a debris jam in Hardwood Creek (located west of County road 21) that happened in 2003 to 2004, the H2 data from 1999 – 2002 and the H1.2 data from 2003 – 2006 was used for the model.  Daily average flow data recorded in cubic feet per second (cfs) was used for the water budget, while 15-minute readings were used for the XP-SWMM model. Monitoring Locations are shown on Figure A6.

**Figure A6. Flow Monitoring Locations**




## 5. Clearwater Creek Flow Data *(Station C-2)*

This monitoring station has stream flow data for 1997 – 2006. Daily average flow data recorded in cubic feet per second (cfs) was used for the water budget (see next section, Upper Rice Creek Flow Data), while 15-minute readings were used for the XP-SWMM model.

### 6. Upper Rice Creek Flow Data (Water Budget)

A water balance or water budget, the accounting of inflows and outflows of water to and from a system, was developed (in excel) for the Peltier/Centerville Lakes system to make up for inconsistencies in the monitoring data. This water balance was primarily used to estimate continuous stream flow from the Upper Rice Creek watershed from 2001 to 2006 because monitoring data for Station R8.5 poorly represents stormwater runoff and streamflow from this area. The monitoring station, which is located at the Highway 35 culvert, records more of the backwaters of Peltier Lake than it does the stream flow from Upper Rice Creek. As a result, Upper Rice Creek streamflows developed using the water balance approach were used in the XP-SWMM model developed for the LL RMP.

### 7. Stage-Storage

Lakes, larger ponds, wetlands, and some channel segments are included explicitly in the model as a storage node in which the shape and amount of storage available are defined by a stage/storage rating curve.

The stage/storage rating curve was generated automatically using a custom GIS application. This application calculated the volume available for live storage (storage above the normal water level) at two-foot intervals for each of the water bodies.

The initial water surface elevation within modeled storage is defined as the storage invert plus the initial depth specified. For continuous simulation and design events it was assumed that initial water elevation or normal water elevation (NWL) was equal to the basin's outlet elevation. Initial surface water elevations of many storage nodes were altered to reflect actual conditions. Many of the stormwater ponds were constructed in soils with a high infiltration capacity. These stormwater ponds function from one to eight feet below the designed outlet elevation. For these stormwater ponds, as well as natural landlocked basins or wetlands, the NWL is located below the outlet and the outlet will only operate under larger storm events.

In a few cases, small wetlands or depressions not explicitly modeled are accounted for by adjustment of the impervious or pervious depression storage (applied in the hydrologic model layer). This method is used, for example, when a wetland in the upper portion of a defined subwatershed is too small to warrant definition as a separate subwatershed. The default depressional storage was increased relative to the size of the depression and the drainage area to the depression.

Stage-storage data for ponds came from two primary sources: (1) grading plans or the hydraulic model associated with those plans from RCWD permits; or (2) GIS-based calculation that uses two-foot contours to approximate the true stage-storage of the pond or wetland. The GIS approach was the primary approach used. The grading plans were only used if the development and ponding was in the process of construction and not yet reflected on the 2-foot contours.

The following list describes the GIS-based procedure used to calculate the stage-storage used in the XP-SWMM model.

- Merge contour datasets from Lino Lakes, Ramsey and Washington counties
- Create 1 meter raster grid based on 2-foot topography

- Extract minimum elevation per subwatershed using zonal statistics
- Round up to nearest integer to created lowest elevation level
- Add six fields and added 2 feet to each successive field starting at the minimum elevation field
- Run stage storage model within model builder (1_EOR_TOOLS\Basin HWL)
  - Created raster from subwatershed polygons using elevation field
  - Subtract elevation grid from subwatershed grid
  - Extract positive values for each stage storage level
- Intersect subwatersheds with water level polygons
- Update acreages and created .dbf

## 8. Structure Sizes and Elevations

All defined storage is also given a defined outlet. The outlets range from sophisticated multi-stage or multi-structure constructed outlets, to a simple overland swale or low spot in the landscape defining where water would travel if the pond overtops. In the case of channel storage, the outlet is either a channel cross section, or in some cases, a weir or bridge opening.

A wide range of infrastructure type is encountered within the City of Lino Lakes. Structures described and modeled explicitly include: culverts, weirs, swales, drop structures, stormsewer, and bridges. The approximate number of structures and cross-sections defined in the model is 1,000. Structure information was gathered from three primary sources: City of Lino Lakes storm water structure inventory, RCWD permit files, and recent survey information.

The definition of culverts, weirs, swales, drop structures and stormsewer in XP-SWMM is a standard and well-defined process. The next section, Conduit Factors and Roughness Values provides more information regarding the definition of culverts in XP-SWMM. However, bridges can be modeled a variety of ways in XP-SWMM. Many bridges were simulated by defining one or more cross sections to better represent the waterway openings. The use of natural cross sections allowed the definition of unique shapes and the assignment of multiple roughness coefficients. The "max depth" parameter was defined to represent the elevation of the low member of the bridge. The channel is treated as though it is capped at the max depth. When water depths exceed this elevation during a simulation, the channel is converted to pressurized pipe flow. An additional channel was defined describing the top of the bridge or the effective low point that serves as the emergency overflow.

## 9. Conduit Factors & Roughness Values for Culverts

The conduit factors identified in Table A3 were used to define the various structures found within the Lino Lakes boundary. The entrance loss coefficients were set to those values found in the table if information regarding the culvert condition was available. The primary source for the data was field survey and inspection. For structures without data available an entrance loss of 1.0 was used. Each structure was modeled using an exit loss of 0.5.

**Table A3. Manning's Coefficients and Culvert Losses**

| Culvert Type | Flared End Section? | Protruding Pipe? | Manning’s n-value | Entrance Loss |
|---|---|---|---|---|
| Reinforced Concrete Pipe | Yes | - | 0.013 | 0.5 |
| Reinforced Concrete Pipe | No | No | 0.013 | 1.0 |
| Reinforced Concrete Pipe | No | Yes | 0.013 | 1.5 |
| Reinforced Concrete Pipe | Stormsewer connection | | 0.013 | 0.5 |
| Corrugated Metal Pipe | Yes | - | 0.024 | 0.5 |
| Corrugated Metal Pipe | No | No | 0.024 | 1.0 |
| Corrugated Metal Pipe | No | Yes | 0.024 | 2.0 |
| Corrugated Metal Pipe | Bottom is corroded & rusted out | | 0.025 | 1.0 |
| Corrugated HDPE | Yes | - | 0.022 | 0.5 |
| Corrugated HDPE | No | No | 0.022 | 1.0 |
| Corrugated HDPE | No | Yes | 0.022 | 2.0 |
| Smooth HDPE or PVC | Yes | - | 0.011 | 0.5 |
| Smooth HDPE or PVC | No | No | 0.011 | 1.0 |
| Smooth HDPE or PVC | No | Yes | 0.011 | 2.0 |

NOTE: If no information was known about the outlet of the pipe, or if the condition was not clear, a default entrance loss of 1.0 was used for all pipes.

All crushed pipes were modeled based on their effective cross-sectional area. Sediment depth (labeled “plugged ½, 1/3, ¼, etc.”) was modeled by creating an arch pipe with the same effective flow area as the partially blocked pipe. The sediment depth feature in XP-SWMM does not function properly and using an arch simulates a circular culvert with sediment accumulation.

## 10. Groundwater Contributions

A groundwater assessment for Peltier and Centerville Lakes was performed for the TMDL as well as the XP-SWMM modeling effort to assess potential groundwater contributions to the system. In general terms, Peltier and Centerville Lake’s elevation relative to the local water table and the elevation of the area lakes, ability of local surficial geology to readily transmit water, and localized hydraulic gradients in the region classify Peltier and Centerville Lakes as groundwater flow through lakes. Due to a lack of groundwater monitoring data, it is not possible to quantify the amount of groundwater entering and discharging from the Peltier and Centerville (or from the Chain of Lakes as a whole) Lakes system. For modeling purposes, it was assumed that the overall groundwater contribution was negligible (all groundwater that flows into the lakes, flows out of the lakes as groundwater).

**11. Channel Routing**

The creeks and major ditches defined in the model were a combination of both natural cross sections and storage nodes. In general, steeper portions were modeled using cross sections and level areas were modeled using either cross sections or stage-storage. Additionally, county ditches and larger drainage paths contain a higher degree of detail than private ditches and small drainage features. Geometry was defined primarily by entering surveyed natural cross sections. In areas that a field survey was not completed an open channel was defined based on 2-foot contours provided by RCWD.

**12. Infiltration (rating curves out of storage areas)**

Hydraulic infiltration in the XP-SWMM model differs from hydrologic infiltration. Where hydrologic infiltration occurs in the upland during and after rainfall, hydraulic infiltration refers to the infiltration of water after it has runoff and reached a storage area, typically an infiltrating pond, wetland or other depression. Infiltration is a factor in many of the natural depressions (landlocked basins or wetlands) and stormwater ponds within Lino Lakes. The surface water infiltrates into the groundwater for the depressions and ponds that are located in sandy type soils and are located above the groundwater table. For modeling of these depressions, a volumetric infiltration rate (cfs) was applied. The rate was dependant on the hydrologic soil type located beneath the pond and the pond/depression surface area intersecting the soil type. Hydrologic soil group (HSG) A was assigned the minimum infiltration rate specified in the MPCA Stormwater Manual of 0.8 in/hr, while type B soils were assigned 0.3 in/hr. HSG C and D were not assigned an infiltration rate due to the relatively low rate of infiltration in these soils. Multiplying the area intersecting the A or B soils yielded a volumetric infiltration rate.

Some ponds and depressions did not intersect the high infiltration soils at the normal water level, but only when the water level reached an elevation above the NWL. For those conditions, infiltration was only applied to the depression when the water level in the depression reached the elevation where significant infiltration could occur, at lower elevations the infiltration was assumed to be zero.

## XP-SWMM Model Calibration

The existing conditions model calibration procedure took place in 2 phases:

Phase I - ACD 10-22-32 was calibrated first due to the timing of the RMP process; and

Phase I - The calibration of ACD 10-22-32 was extrapolated to the rest of the model and was further calibrated to lake elevations.

### *ACD 10-22-32*

Anoka County Ditch 10-22-32 is an agricultural ditch with a drainage area of over 4,000 acres. A level monitoring gauge was placed in the downstream invert of the Lake Drive culvert for five months (mid-July to mid-December) in 2004 and four months (three small increments) in 2006. No large rainfall events were captured in 2006, however one intermediate sized rainfall event was captured in 2004. On October 28-29, 2004, 1.70" of precipitation fell at the RCWD office in Blaine, while 2.50" fell at a RCWD precipitation gauge in Hugo. Because ACD 10-22-32 is located between these two rain gauges, the tipping bucket data from each of these two stations were combined to create the rainfall file for 10-22-32. The tipping buckets record the time that every 1/100$^{th}$ of an inch falls. To combine the rainfall records, each time one of the tipping buckets recorded rainfall, it was given a value of 0.5/100$^{th}$ of an inch. The rainfall records were combined, resulting in a calibration rainfall event indicating 2.10" of precipitation for the October 2004 rainfall event.

The 10-22-32 portion of the model was run using the hydrologic and hydraulic parameters as defined previously. The parameters analyzed as part of the calibration process were width, slope, depressional storage, and saturated hydraulic conductivity. Width and slope were generated as part of a custom GIS application as previously described.

A sensitivity analysis was performed for depressional storage; however, because of the small depth of precipitation recorded, it was difficult to extract useful conclusions from the sensitivity analysis. Width and slope were also analyzed, however, neither parameter proved sensitive to reasonable adjustments. The controlling parameter for the runoff volume generation was the impervious surface coverage. Impervious cover is always an important factor in runoff generation but governs the volume of runoff more in sandy soils with high infiltration rates than soils that already produce a great deal of runoff.

As discussed in the width and slope section, the result was to divide both values (width and slope) in all of the watersheds by two, essentially indicating that the flatter portions of the flow path control the runoff timing and volume.

### *Lino Lakes RMP Model*

In general terms, modification to the input parameters identified through the calibration process on ACD 10-22-32 were applied to the rest of the subwatersheds in the Lino Lakes model. Having modified the input parameters based on this preliminary calibration, the entire model was calibrated using lake level in Baldwin Lake. Given the results of this calibration, it was decided that the final outlet (model outfall) should be extended from Baldwin Lake to Lexington Avenue. This change resulted in a model that simulated monitoring data inside and downstream of Lino Lakes and meets the purposed of the overall project. The specific steps performed for the overall calibration (LL RMP model) are described in the following bullets.

#### 1. Data Availability and Calibration Location

The most complete and reliable calibration data available in the city consists primarily of weekly Baldwin Lake water elevations recorded by the DNR during the summer months (generally mid April through November) at the channel between Rice Lake and Baldwin Lake. The Baldwin Lake outlet is the controlling outlet of the Rice Creek Chain of Lakes making it an attractive location to calibrate to. The Baldwin Lake water elevations were selected to use as calibration.

#### 2. Data Selection Summary for Calibration

The timeframe for calibration was selected as the year 2001: 1/1/2001 -12/31/2001. The year of 2003: 4/12/2003-12/31/2003 was selected as the time period for verification of the model calibration. Completing a model verification run ensures that the model is applicable under a variety of different rainfall patterns and hydrologic conditions. These time periods were selected for a number of reasons both logistical and practical:

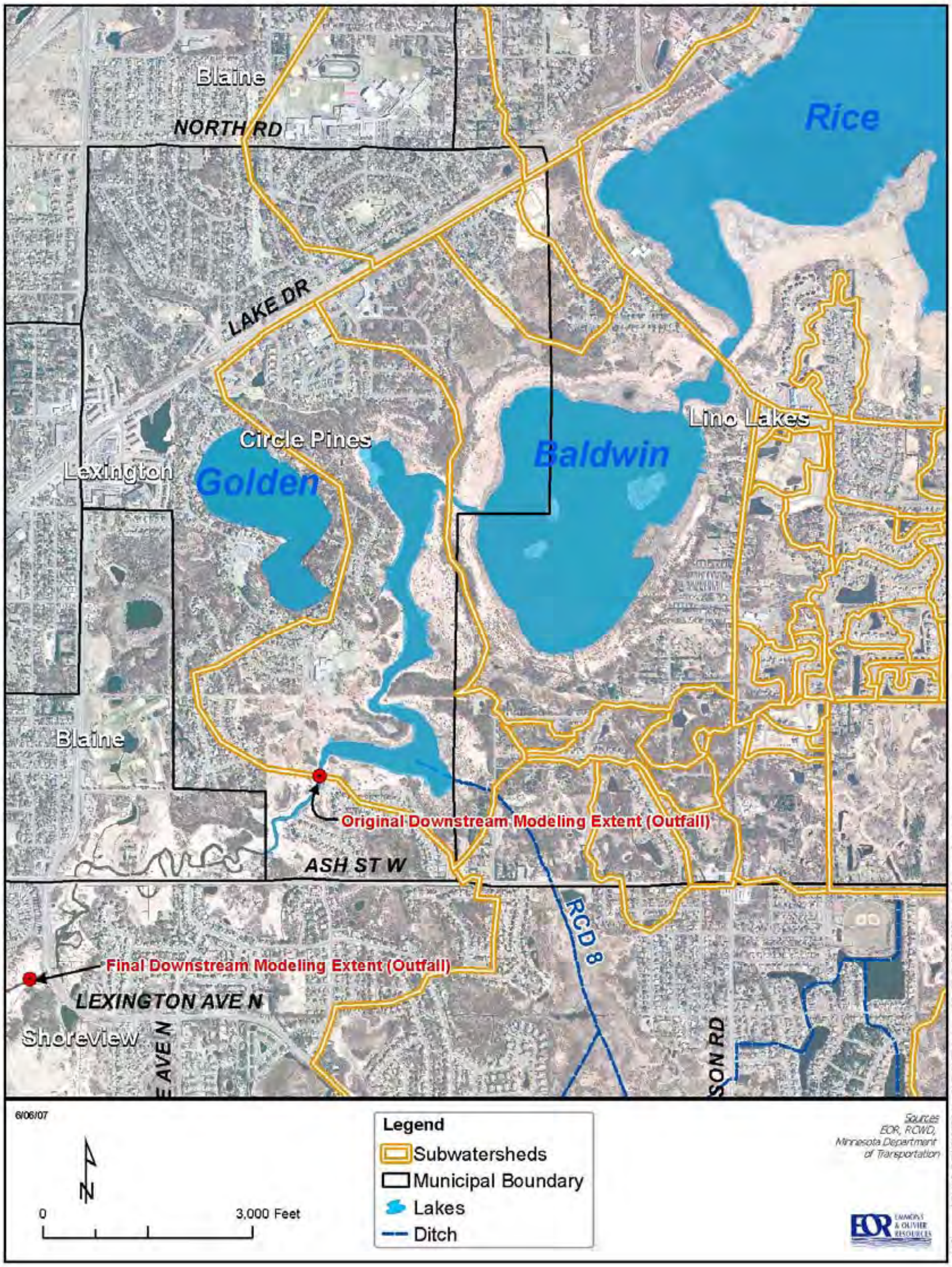
- Time period occurs during water budget period: it is necessary to select a time period between 1999-2003 to calculate the inflows from Upper Rice Creek (see bullet item #6 *Upper Rice Creek Flow Data* (water budget) under the *Hydraulic Input Parameters* section)
- Contains requested time period to be used in TMDL
- Regular and reliable lake level data available for this time period
- Range of rainfall and snowmelt events and conditions exist in this time period.

**3. Calibration Procedure**

The original run showed that the peak high water elevations in Baldwin Lake were not being met. A number of sensitivity runs adjusting runoff volume by increasing imperviousness by 20% and decreasing KSAT values by half showed that the lower lakes system was draining too quickly, particularly at higher elevations, and that the reason for this apparent water elevation shortfall was the backwater condition at the Baldwin Lake outlet.

The original calibration model used a fixed backwater condition at the outfall of the linear wetland complex just downstream of Baldwin Lake at the location where Middle Rice Creek exits the linear wetland. Backwater conditions at the Baldwin Lake Outlet are complicated due to the extremely flat grades and backflows coming primarily from Golden Lake and Ditch 8 (Figure A6). Additionally complicating the modeling of the outlet is the presence of large stands of cattails. Experience elsewhere in the district tells us that thick vegetation can significantly restrict flows if floating mats become lodged in the channel. To account for these conditions the Manning's coefficients were increased to 0.03 for the in-channel area, and 0.055 for the floodplain area. This change produced a more realistic water elevation match with the recorded Baldwin Lake elevations although the model still fell short of meeting the high water elevation peaks due to backwater inflows.

**Figure A7. Baldwin Lake Outlet Location, Golden Lake, and County Ditch #8**



At this point the decision was made that the backwater effects were too complicated to be simulated by adapting Manning's coefficients and outfall conditions. To account for this the model was extended from the outlet of Baldwin Lake to 1,000 feet downstream of Lexington Avenue. The RCWD-wide HydroCAD model was duplicated in XP-SWMM for drainage areas downstream of Baldwin Lake. After adding in this downstream portion the model produced results that were consistent with measured data. The calibrated 2001 and 2003 model runs are shown in Figures A8 and A9.

**Figure A8.  2001 Baldwin Lake Water Levels**

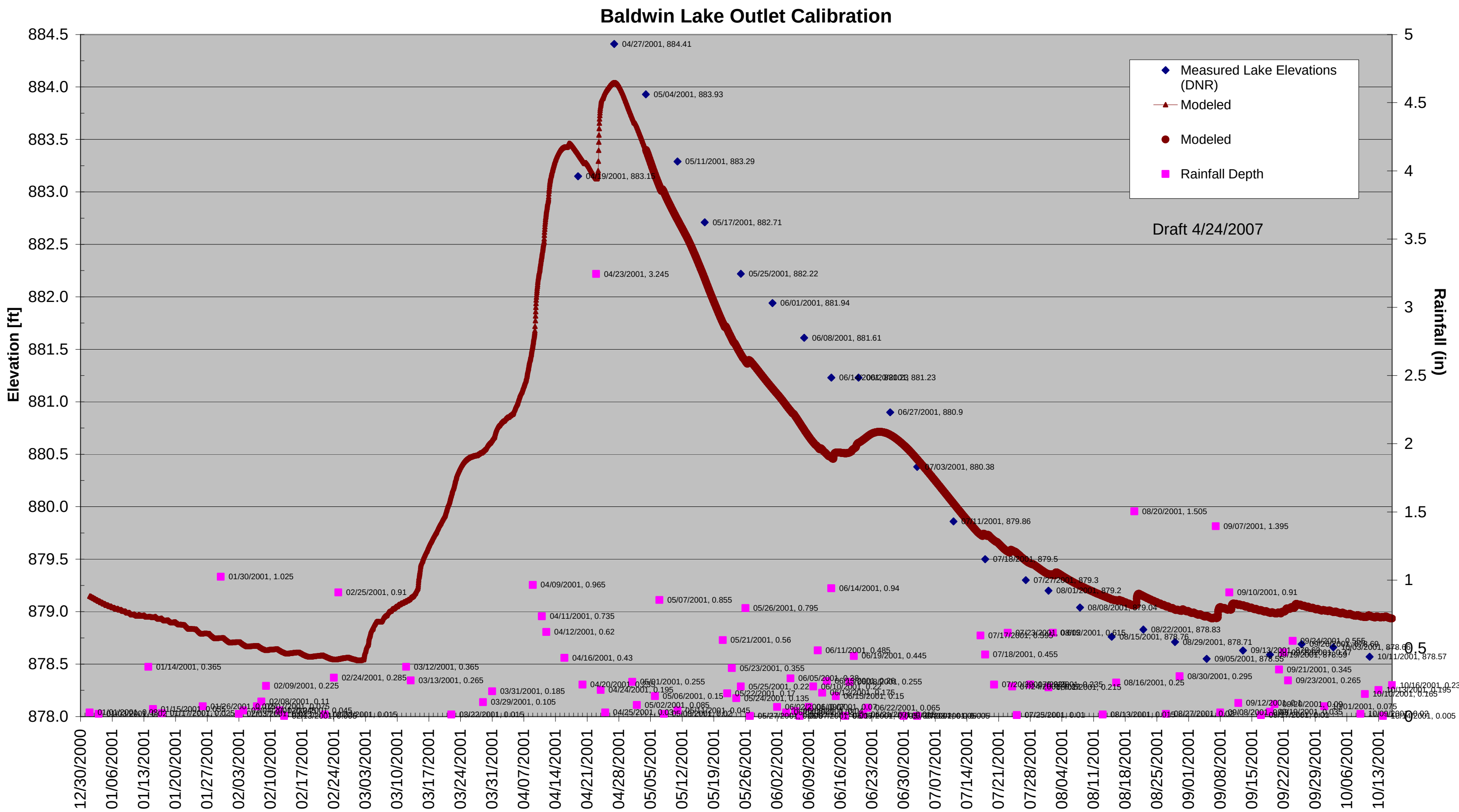
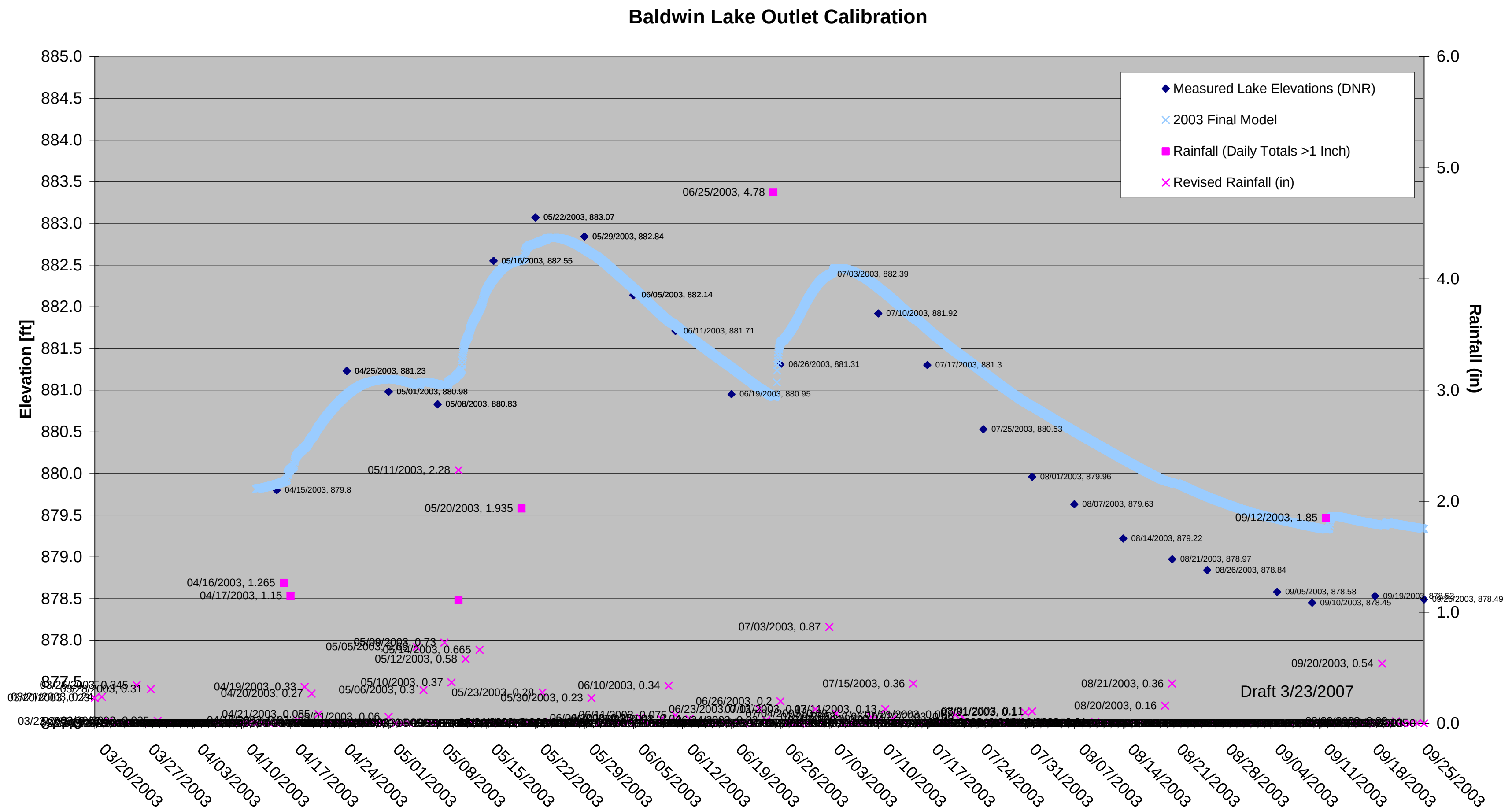


**Figure A9. 2003 Baldwin Lake Water Levels**



## Modeling Results

As discussed earlier in this report, the XP-SWMM model for Lino Lakes was developed to provide hydrologic and hydraulic information for the following RMP purposes:

- To provide long-term volumes in support of the chain of lakes TMDL water quality analysis;
- To provide an analysis of the current city infrastructure and identify areas of concern; and
- To provide the City with the stormwater infrastructure information needed to meet the Local Surface Water Management Plan requirements.

This section describes the modeling results and modeling deliverables developed to address each of these purposes.

### *Provide long-term volumes in support of the chain of lakes TMDL water quality analysis*

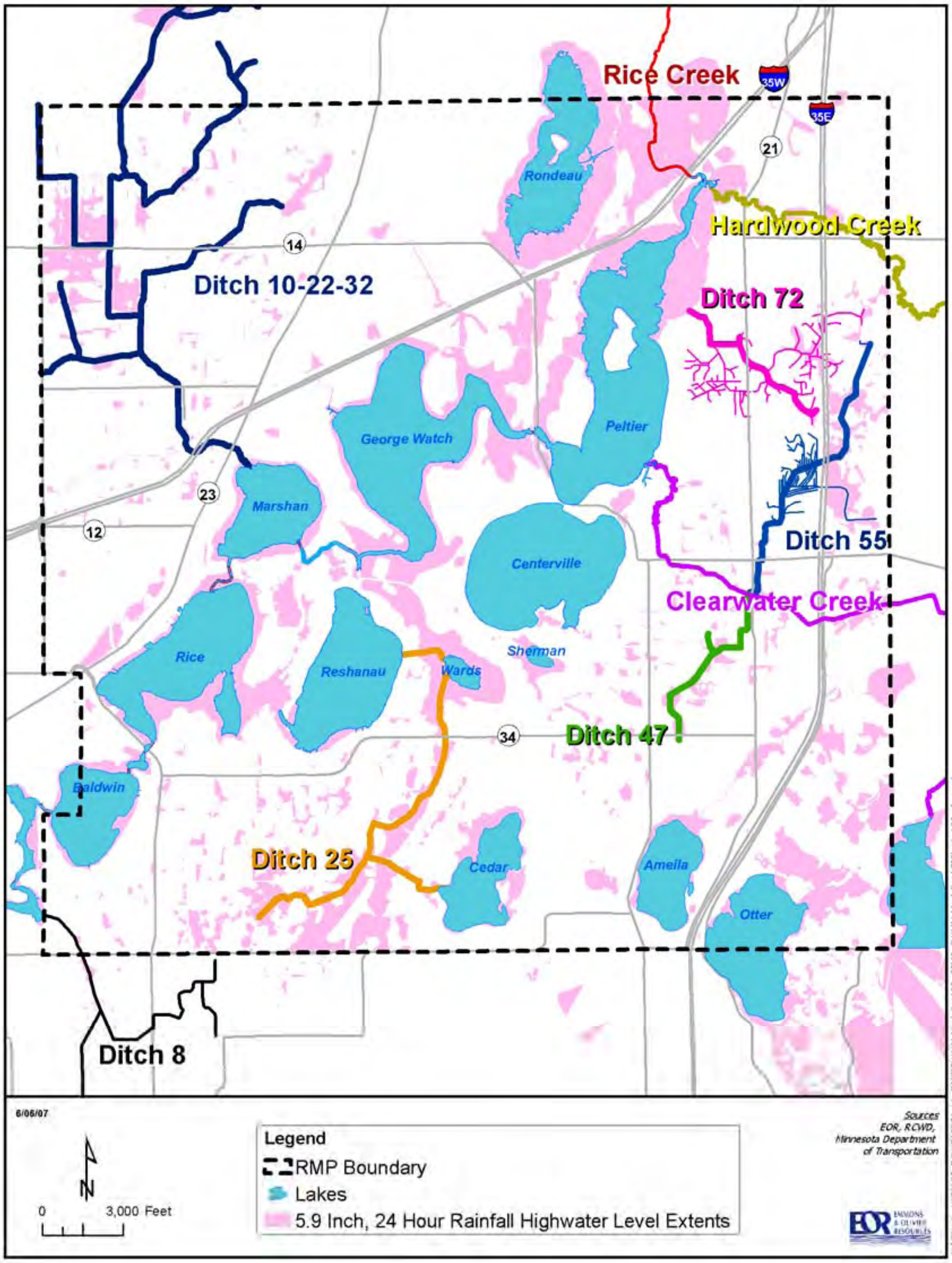
Continuous annual simulation models spanning complete calendar years were delivered to Wenck Associates for purposes of the TMDL. Specifically, the XP-SWMM results were used for calibrating a P8 model for Lino Lakes (Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds). P8 predicts watershed pollutant loads and pollutant removal efficiencies in ponds, infiltration basins, and swales, in an urban setting. Results from XP-SWMM used in the P8 model included the live storage elevations for water quality ponds and wetlands. In addition, since P8 often over predicts watershed runoff, annual volumes were calibrated to the XP-SWMM results. Using these two models, changes in land use and watershed practices were simulated to predict the effect of these changes on in-lake water quality.

### *Provide an analysis of the current city infrastructure and identify areas of concern*

Event-based models were used to identify points in the Lino Lakes conveyance system that may be susceptible to flooding. The 100-year 24-hour rainfall event (5.9 inches) was modeled to determine high water levels and identify areas where water was over-topping a road or came to within one foot of over-topping the road. This information was used to develop a Conveyance System Capacity map which was evaluated in the resource management planning process.

A 5.9-inch, 24-hour rainfall event high water elevation extents map is shown in Figure A10. Figures A10-A19 of the RMP report contain the maps that identify the previously mentioned constraint points.

**Figure A10. 5.9-inch, 24-hour Rainfall Event High Water Elevation Extents**



*Provide the City with the stormwater infrastructure information needed to meet the Local Surface Water Management Plan requirements*

During the RCWD's review of the City's Local Surface Water Management Plan (LSWMP) it was noted that the Minnesota Statute §103B.235 requirements for defining drainage areas, flow characteristics (rates, volumes, flow paths), and existing stormwater management facilities (e.g. storage) were not met. Since the District was in the process of developing XP-SWMM hydrologic and hydraulic models for two CWMP areas within the City, it was decided that the District would provide this information to the City upon its completion. It was also decided that the City would fund the District's expansion of the model to incorporate those areas within the City of Lino Lakes but outside the CWMP areas. Based upon this agreement, the RCWD approved the City of Lino Lake's LSWMP in November of 2005. This existing conditions XP-SWMM model fulfills the outstanding LSWMP requirements.

A final copy of the XP-SWMM model has been provided to the City of Lino Lakes along with an infrastructure database. This infrastructure database contains the physical information for cross-sections, culverts and storage ponds defined in the XP-SWMM Model.

For cross-section, the following information is provided in the database:
- Cross-section name
- XP-SWMM link name
- Shape
- Upstream invert
- Downstream invert
- Source of data

For culverts the following information is included in the database:
- XP-SWMM link name
- Culvert type
- Shape
- Diameter
- Upstream invert
- Downstream invert
- Source of data

For pond storage the following information is included in the database:
- Pond name
- Node name
- Upstream link in SWMM
- Downstream link in SWMM
- Starting water level
- Type
- Source

# Appendix B:
# Lino Lakes Full-Build-Out Modeling Report

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## List of Tables

# Lino Lakes Full-Build-Out Report

This report is an addendum to the Existing Conditions Watershed Modeling Report and contains information regarding the development of the full-build-out (FBO) model created for Lino Lakes. Since the FBO model builds upon the existing conditions model, the reader is referred to the existing conditions report for the most comprehensive discussion of the XP-SWMM model development effort. This report will describe the differences between the existing conditions model and FBO model and will discuss the results of the FBO model.

## Model Purpose and Introduction

The FBO XP-SWMM model for Lino Lakes was developed to provide hydrologic and hydraulic information for the following RMP purposes:

- To provide long-term volumes in support of the chain of lakes TMDL water quality analysis;
- To provide an analysis of the current city infrastructure under the FBO scenario and identify areas of concern; and
- To analyze RMP land use alternatives.

The City of Lino Lakes, which is in the process of updating its local comprehensive plan, has had the foresight to look beyond the minimum Metropolitan Council projection requirements to what it calls "ultimate development conditions" or "full-build-out conditions". Using the 2020 land-use map as a baseline, the City began developing a 2030 land-use map for local comprehensive planning purposes. However, the City realized the opportunity to take the 2030 land-use map one step further and has created a full-build-out land-use map. This land-use map, along with the current infrastructure data, was used to evaluate future land-use decisions and the functionality of the infrastructure as development occurs within Lino Lakes and the tributary municipalities.

## Model Development

The FBO model was developed by taking the existing conditions model and making the following changes: 1) creating the FBO model framework, 2) updating the hydrology, and 3) updating the hydraulics. These steps are discussed in this section of the FBO report. A discussion of the FBO model results is presented after the model development section.

### Creating the FBO Model Framework

The FBO model was developed using the existing conditions model and the existing catchment divides as the basis for creating the model structure. The individual steps taken to modify the existing conditions model and develop the FBO model are summarized below. Figure B1 illustrates this process by summarizing the same information (steps) in a flow chart.

Step 1 Determine whether or not a particular catchment will be subject to land-use changes under the FBO scenario. If there are no changes in land-use, the catchment remains the same as it was defined under existing conditions. If there is a land-use change, proceed to Step 2.

Step 2 For catchments that contain parcels that are not fully developed (i.e. parcels that are going to be developed under the future land use scenario) the catchment is split into two subcatchments: “fully developed” and “developing”. This delineation allows for a high level of definition in the model and allows the user to easily distinguish between runoff generated from the existing landscape and runoff generated from future development. All developing parcels within a particular catchment were considered as one subcatchment regardless of their position in the landscape or disconnection from other developing parcels within the catchment.

Step 3 For those subcatchments that are already fully developed under existing conditions, there will be a change in the hydrologic parameter “width” but there will be no change to the hydraulic parameters. These hydrologic and hydraulic changes are described in the following sections of this report.

Step 4 For those subcatchments that are developing under the future land0use scenario, there will be changes to both the hydrologic and hydraulic parameters. Again, these hydrologic and hydraulic changes are described in the following sections of this report.

Given this framework, the drainage areas in the FBO model follow the order, from largest to smallest:

1 – Subwatershed (equivalent to RMP Management Units)
2 – Catchment (hydrologic boundary based on existing drainage patterns)
3 – Subcatchments (split between “fully developed” areas and “developing” areas)

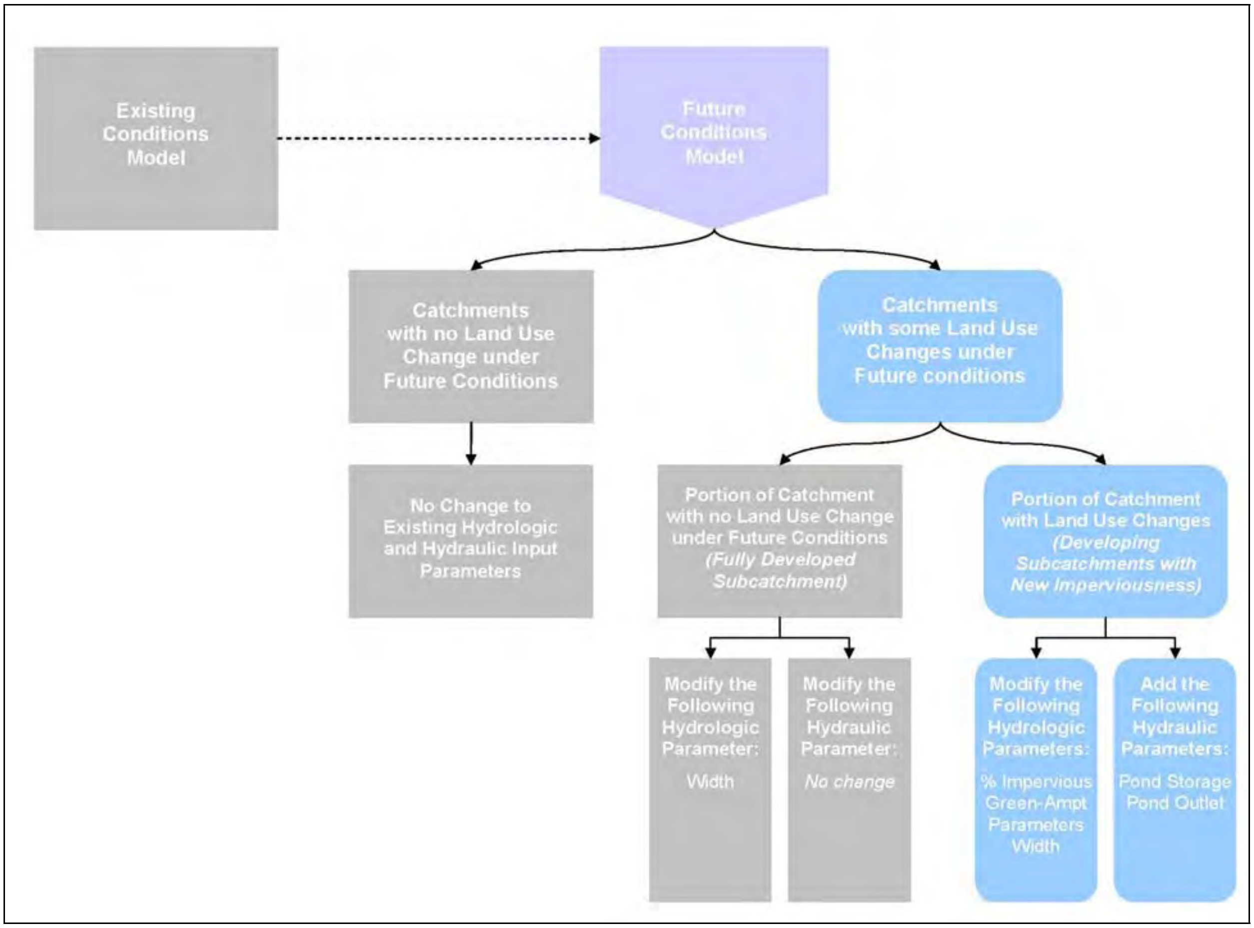


**Figure B1. Flow Chart Illustrating the Full-Build-Out Model Framework**

## Full-Build-Out Hydrologic Input Parameters

The FBO model was created by changing hydrologic input parameters based on the development anticipated to occur within the city. The primary hydrologic changes that occur as a result of development are: 1) increase in impervious surfaces, and 2) soil compaction and pervious landcover change. These changes were incorporated into the model by altering the impervious coverage and the Green-Ampt parameters. In addition, the splitting of catchments created the need to modify the width based on the new subcatchment areas. These modifications are described in more detail below.

### <u>Future Impervious Surfaces</u>

The key parameter necessary to develop a future conditions stormwater model is the future conditions impervious surface cover. Three different methods were used to account for future impervious coverage depending on the availability of data. Different land-use data exists for Lino Lakes, the tributary municipalities and the City of Centerville.

#### *Lino Lakes*

The City of Lino Lakes developed a detailed land-use map (Figure B2) that identifies the development level proposed under full-build-out conditions (all parcels in the city are developed to their ultimate level). For modeling purposes, this scenario was analyzed to show the effect that decades of development will have on existing culverts and natural resources; specifically wetlands, ponds, creeks, ditches, and lakes.

In order to complete the FBO analysis, the new impervious percentage for each developing subcatchment was calculated. The steps taken to determine the new impervious percentage are summarized as follows:

1) The City created a parcel level landuse map that classified each parcel as either “developed” or “to be developed”.

2) For parcels that are fully “developed” (grayed-out area of Figure B2), the existing impervious area for that parcel was used because that parcel is not expected to increase in impervious area under FBO conditions. “Developed” areas also include areas that are inherently undevelopable, such as lakes, parks, and wetlands. Those areas may not be fully “developed” in the typical sense of the word, but they are areas that will not increase in impervious area.

3) For the parcels that are expected to develop further and increase in impervious surface area, Table B1 was used to assign the impervious percentage of those parcels under FBO conditions. The following steps were taken to generate Table B1.

    A) Emmons & Olivier Resources attempted to correlate the Lino Lakes land use and zoning categories. For example, the “Low Density Residential” land use category includes the “R-1” (Single Family), “R-1X” (Single Family Executive), “R-EC” (Single Family Estate Conservation), and “R-2” (Two Family Residential) zoning categories.

    B) Most City zoning categories specified a maximum allowable impervious percentage within each zone. However, this percentage was not realistic because it ranged from 65% to 85% for all zones. The maximum impervious percentage for “Low Density Residential” land use was 65%. However, the average impervious percentage for existing “Low Density Residential” developments in the City of Lino Lakes was calculated to range from 25-35%.

    C) Because the maximum allowable impervious percentages in the zoning requirements were not realistic (a proposed low density development with 65% impervious would not be considered), new maximum impervious percentages for zoning categories were examined. After discussions with the City, the impervious percentages specified in Table 1 were considered to be acceptable maximum allowable values by the City. For stormwater modeling, in order to be conservative, all FBO development was assumed to be developed to the maximum allowable impervious percentage. These maximum impervious percentages will likely be incorporated into the City zoning requirements.

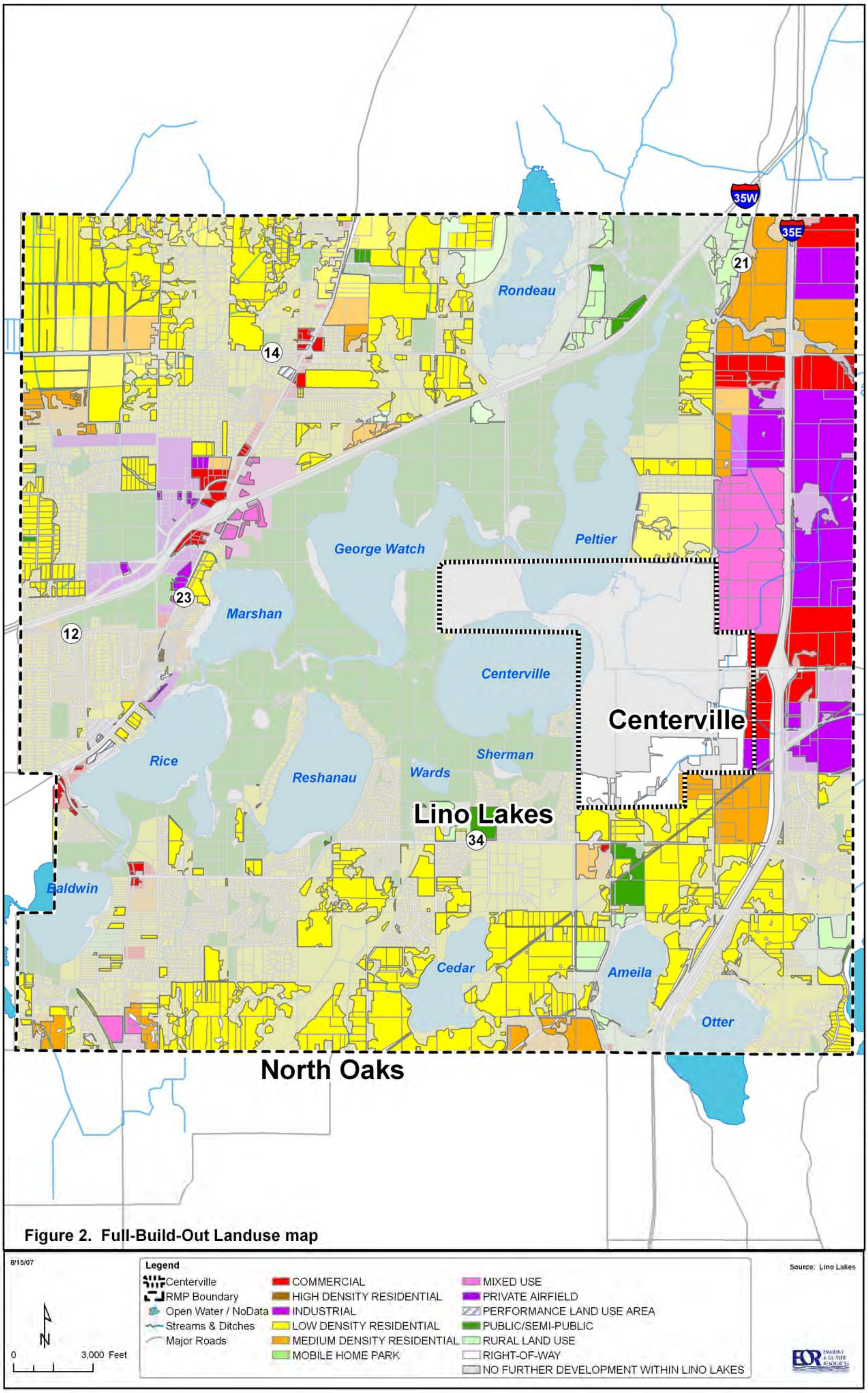


**Figure B2. Lino Lakes Full-Build-Out Landuse Map.**

**Table B1. Lino Lakes Maximum Impervious Percentage by Land Use Category.**

| Lino Lakes Land Use Category | Maximum Impervious Percentage (used in SWMM model) |
|---|---|
| Rural Land Use (RLU) | 10% |
| Low Density Residential (LDR) | 40% |
| Medium Density Residential (MDR) | 50% |
| High Density Residential (HDR) | 65% |
| Commercial (COM) | 75% |
| Industrial (IND) | 75% |
| Public Semi-Public (PUSP) | 65% |
| Right of Way (ROW) | 75% |
| Performance Land Use Area (PLUA) | 75% |
| Mixed Use (MU) | 75% |

***Tributary Municipalities***

The changes associated with development within Lino Lakes are not the only changes that will affect the existing infrastructure and natural resources in Lino Lakes. Development changes in municipalities tributary to the City of Lino Lakes will also impact these features. Much of the tributary area to Lino Lakes is located to the east of the City. These tributary municipalities include: City of Blaine, City of Columbus, City of Dellwood, City of Forest Lake, City of Grant, City of Hugo, City of Mahtomedi, May Township, City of North Oaks, City of Shoreview, City of White Bear Lake, White Bear Township, and City of Willernie. The majority of flow from these municipalities enters Lino Lakes via three primary waterways: Clearwater Creek, Hardwood Creek, and Upper Rice Creek.

To account for the flow from these municipalities, inflow hydrographs were added to the model at the locations where the three primary waterways enter the City. These hydrographs were generated using the HydroCAD model created as part of the 1997 RCWD calibration study. The HydroCAD model was modified to include the Metropolitan Council 2020 land use plan changes that are proposed to occur in these tributary municipalities due to development. This is the minimum required development plan by the Metropolitan Council at the time of the FBO model development and the most complete information that could be applied to the entire tributary area. All land use categories were assigned the standard impervious percentage based on the land use proposed for the year 2020. The HydroCAD model was then run for the desired storm events and hydrographs were generated at the target locations (the city boundary). These hydrographs were input into the FBO XP-SWMM model as user-defined hydrographs at the target locations.

***Centerville***

A hybrid of the two approaches described thus far was used for Centerville, a city encompassed entirely by Lino Lakes. Because of its proximity to Lino Lakes, Centerville was modeled with much more detail than the other tributary municipalities under existing conditions. A parcel by parcel map of "developed" and "to be developed" parcels was not provided by the City of Centerville, so the level of modeling detail possible within Lino Lakes was not achieved for Centerville. However, Centerville was discretely modeled as part of the SWMM analysis. The

Metropolitan Council 2020 land use plan was used to assign future impervious percentages for developable areas. Developable areas were selected using MLCCS data.

### Green-Ampt Parameters

Green-Ampt parameters for fully developed subcatchments were computed using the same area-weighted method applied to the existing conditions model. For developing subcatchments, the Green-Ampt parameters were generated by compositing the existing soils with a MLCCS land cover that contains either perennial grasses, or perennial grasses with sparse trees. Changing the developing Green-Ampt parameters accounts for the compaction of soils and modification in pervious land cover due to development, producing more runoff from the future condition pervious areas.

### Depressional Storage

The Green-Ampt methodology uses depressional storage to dictate the amount of rainfall required before runoff can occur. This value is somewhat analogous to initial abstraction used by the CN methodology. In XP-SWMM, depressional storage is defined for both pervious and impervious areas within each subwatershed. For the FBO model, the impervious area depressional storage was set to 0.34 inches to simulate the RCWD rule that requires infiltration practices for the first 0.34 inches of runoff (the median storm depth) from new impervious surfaces.

### Width

As explained previously, catchments that are expected to undergo an increase in impervious area under the FBO landuse scenario were divided into two separate subcatchments, one representing the already developed portion and the other representing the developing portion (see Figure B1) For the purposes of this model, it was assumed that both of these areas drain to the same outlet. The area of each portion was computed using GIS, based upon the “developed” and “to be developed” parcel map and the existing drainage boundaries.

To calculate the geometry of the new subcatchments, the assumption was made that the flow path and slope for the subcatchments would be maintained. This assumption implies two areas side by side in the landscape with the same length, slope, and outlet point. This assumption was made to simulate land-use changes under full-build-out conditions while creating a simpler, more user-friendly model.

While this assumption allows the use of the existing conditions catchment length, slope and outlet point, it requires that the width parameter be changed to account for changes in subcatchment area because the areas of the two subcatchments are different (smaller) than the existing conditions catchment area. Therefore, for each future conditions subcatchment, the width parameter is calculated as the subcatchment area divided by the longest flow path length, where the longest flow path length is that which was calculated for the existing conditions catchment.

## Hydraulic Input Parameters

Changes to the hydraulic input parameters for the FBO model were made in response to the development of parcels and the RCWD rate control (volume control rules met under previous section, Hydrologic Input Parameters) rules that these developing parcels will need to meet. Where development occurs that would trigger the existing RCWD rules, a pond was created and the outlet sized to simulate the rate control required for that development. Modifications to address ponding and rate control are discussed in more detail below. To account for small increases in impervious area within a subcatchment, a rate control threshold was created that allows for areas to slightly increase impervious area without the need for rate control.

### Pond Design

The proposed developments that are modeled under the FBO conditions will be required to meet the existing RCWD rules. Each development that occurs will be constructed with a stormwater pond, infiltration basin, or other stormwater feature that mitigates the increased flows due to new impervious area. However, it is not possible to model each development discretely because the exact method of mitigating stormwater and drainage area to each feature is not possible to predict. To account for future stormwater features, the runoff from developing areas was routed to a pond designed to approximate a pond that could be constructed in the future to meet existing RCWD rules. The stage storage for the new ponds was designed using a methodology developed for this project. This method was based on the new impervious area and is summarized as follows:

- The normal water level (NWL) of the pond was modeled as five percent of the new impervious surface.
- The storage area increased incrementally above the NWL by 10% every two feet.
- The maximum live storage modeled for the ponds was six feet.
- The pond outlets were sized so that the ponds bounce between three to five feet for the 100-yr design.

This design was checked at numerous locations and found to meet RCWD rate control rules without being unrealistically conservative. Dead storage in proposed ponds was not modeled.

### Rate Control Threshold

A rate control threshold based on increase in impervious coverage was used to limit the number of ponds that were modeled and to better match how development will likely occur. For example, if a residential lot is split into two lots the impervious percent will increase, however the small additional impervious area wouldn't require the construction of a rate control pond. The rate control threshold was set at an increase of impervious coverage greater than three percent of a catchment area or an increase in impervious area of greater than three acres across the existing catchment. Using this methodology, all catchments that show a meaningful increase in impervious percent or impervious area include peak rate control mitigation (ponding). Of the 379 existing catchments, 194 exceeded the threshold and required the construction of rate control ponds in the model.

## Modeling Results

As previously stated, the three main objectives of the FBO model are:

- To provide long-term volumes in support of the chain of lakes TMDL water quality analysis;

- To provide an analysis of the current city infrastructure under the FBO scenario and identify areas of concern; and
- To analyze RMP land use alternatives

To analyze how the existing conveyance system would perform under full-build-out conditions, a map (Figure B3) was created showing the roads that would experience inadequate freeboard or road overtopping, and the ponds that discharge from via emergency overflows for the 100-year event. Some of the areas identified on the FBO version of this map have been previously identified under existing conditions. For the resource management units where development has created or exacerbated a constraint in the system, the constraint is identified and the cause of the problem is discussed in Table B2 and the text of this section.

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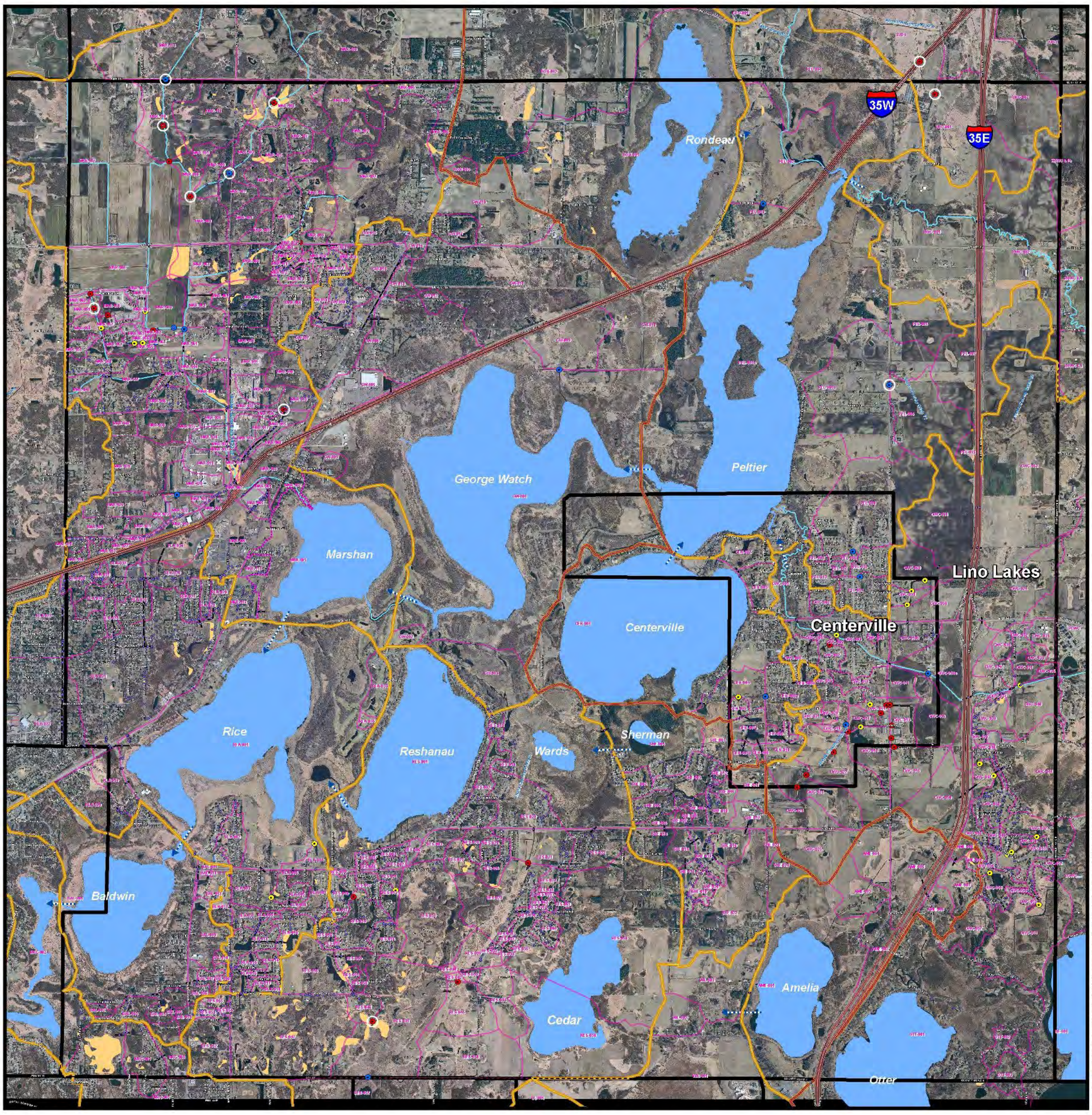


EMMONS & OLIVIER RESOURCES

## *Full Build Out*
## *Conveyance System Capacity*

Legend

- Sensitive Water Level Points
- Road Overtops
- Less Than 1' Freeboard on Road
- Pond Overtops Under 100-Year Flood Event
- Pipe
- Peltier/Centervile TMDL Boundary
- Resource Management Unit
- Catchments
- Subshed Outflow Point
- Direct Drainage Area
- Municipal Boundary
- Ditch/Creek
- Upland Resource Preservation Area

**Lino Lakes FBO Conveyance System Analysis**

| Location within City | Subwatershed | Primary Existing Landuse | Primary Full Build Out Landuse | Existing Structure | Notes |
|---|---|---|---|---|---|
| NE | URC-001 | Agriculture | MDR, Industrial, Commercial | 36" RCP | |
| NE | URC-001 | Agriculture | MDR, Industrial, Commercial | 36" RCP | 35W Culvert |
| E | PEL-006 | Agriculture | MDR, Industrial, Mixed Use | 14" Draintile | Part of Ditch 72 |
| S | RES-046 | Rural | LDR | 27" Arch | Inverse Slope |
| NW | MAR-018 | Rural | Mixed Use | 12" RCP | |
| NW | MAR-059 | Rural | MDR | 21" RCP | |
| NW | MAR-100 | Rural | LDR | 24" RCP | |
| NW | MAR-102 | Rural | LDR | 15" CMP | |
| NW | MAR-108 | Rural | LDR | 12" CMP | Sediment |
| NW | MAR-110 | Rural | LDR | 24" CMP | Sediment |
| NW | MAR-112 | Rural | LDR | 12" CMP | Sediment |

**Figure B3. Full Build Out Conveyance System Capacity Map**

**Table B2. Landuse-Based Drainage Analysis (also see Figure B3)**

| Resource Management Unit | Culvert ID | Catchment ID | Primary Existing Landuse | Primary Full Build Out Landuse | Existing Structure | Road | Culvert Invert (ft) | Road Elevation (ft) | Upstream HWL (ft) | Road Overtops | Less than 1' Freeboard on Road |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Rice Creek | URC-001c2 | URC-001 | Agriculture | MDR, IND, COM | 36" RCP | 20th Ave N | 888.1 | 899.0 | 899.2 | X | |
| Upper Rice Creek | URC-001c1 | URC-001 | Agriculture | MDR, IND, COM | 36" RCP | 35W | 886.4 | 896.0 | 896.3 | X | |
| Peltier (72) | PEL-006c | PEL-006 | Agriculture | MDR, IND, MU | 14" Draintile | 20th Ave N | 894.6 | 903.0 | 902.7 | | X |
| Reshanau (25) | RES-046a | RES-046 | Rural | LDR | 27" Arch | Field Road | 891.0 | 893.5 | 893.9 | X | |
| Marshan (10-22-32) | MAR-018c | MAR-018 | Rural | MU | 12" RCP | Lilac and Apollo | 902.2 | 908.0 | 908.4 | X | |
| Marshan (10-22-32) | MAR-059c | MAR-059 | Rural | MDR | 21" RCP | Field Road | 895.0 | 898.0 | 898.0 | X | |
| Marshan (10-22-32) | MAR-100c1 | MAR-100 | Rural | LDR | 24" RCP | Field Road | 892.6 | 896.7 | 897.1 | X | |
| Marshan (10-22-32) | MAR-102c2 | MAR-102 | Rural | LDR | 15" CMP | Driveway | 899.5 | 903.2 | 902.5 | | X |
| Marshan (10-22-32) | MAR-108c2 | MAR-108 | Rural | LDR | 12" CMP | Driveway | 902.4 | 903.8 | 903.8 | X | |
| Marshan (10-22-32) | MAR-110c1 | MAR-110 | Rural | LDR | 24" CMP | Field Road | 893.2 | 898.3 | 901.2 | X | |
| Marshan (10-22-32) | MAR-112c | MAR-112 | Rural | LDR | 12" CMP | Pine Street | 899.7 | 902.7 | 902.5 | | X |

## Upper Rice Creek Resource Management Unit

The landuse within the Upper Rice Creek Resource Management Unit will primarily change from agricultural uses to medium density residential, commercial, and industrial.

Culvert URC-001c2 conveys surface water from a private ditch in the northeast corner of Lino Lakes from the east side of 20$^{th}$ Ave N to the west toward 35W. The shift from the current agricultural use to medium density residential, industrial and commercial will cause 20$^{th}$ Ave N to overtop under the future conditions 5.9-inch 24-hour storm.

A second constraint in this resource management unit (RMU) occurs 1,100 feet downstream of 20$^{th}$ Ave N in the private ditch is URC-001c1. This is a 36" RCP that carries water from the south east to the northwest under 35W. This culvert is located outside of the city limits but should be accounted for during planning due to its important location at 35W. The shift from the current agricultural use to medium density residential, industrial and commercial will cause 35W to overtop under the future conditions 100-year 24-hour rainfall event (5.9-inches).

## Peltier Resource Management Unit

The landuse within the Peltier Resource Management Unit will primarily change from agricultural uses to mixed use, commercial, and low density residential.

The Peltier Resource Management Unit is primarily served by the existing agricultural drain tile system 72. This RMU will see some of the most intense development in the city consisting primarily of mixed use, industrial and commercial uses. This system will be undersized throughout when development occurs along the 35E corridor. The modeling shows that under FBO conditions, 20$^{th}$ Ave N will have inadequate freeboard.

## Reshanau Resource Management Unit

The landuse within the Reshanau Resource Management Unit will primarily change from agricultural uses to low density residential. Much of this RMU is already developed as low density residential.

The Reshanau Resource Management Unit consists primarily of Ditch 25 and its tributaries. Culvert RES-046 is located on the main branch of Ditch 25 in what is an undeveloped catchment. This existing culvert will be inadequate if the existing field road exists at or is rebuilt at the existing elevation after the drainage area has been developed to low density residential. Additionally the culvert is ¼ full of sediment and has an inverse slope. This culvert will most likely be replaced during development or road reconstruction.

## Marshan Resource Management Unit

The landuse within the Marshan Resource Management Unit will primarily change from agricultural uses to low and medium density residential. This RMU is already developed with a mix of landuses with the most intense development focused around the 35W/Lake Drive intersection.

The Marshan Resource Management Unit consists primarily of Ditch 10-22-32 and its tributaries. The culvert MAR-018c conveys water from an area currently under construction. This mixed use development will be reviewed by the RCWD to verify that the storm sewer system has sufficient capacity. The storm sewer likely has a 10-year design, so overtopping for the 100-year 24-hour event may be reasonable.

MAR-059c is a driveway culvert providing access to Sunset Road from the east. This driveway is planned to be abandoned as part of a development (Century Farms) that is already underway. Overtopping is not a concern because the driveway is not utilized and most of the historic drainage from Branch 11 has been re-routed into Branch 12.

MAR-100c1 is a culvert located on Branch 12, in the middle of the sod farm situated north of Main St. It is used to get tractors and equipment over the ditch. This culvert will likely be removed or reconfigured under the FBO scenario.

MAR-102c2 is a driveway culvert located on Branch 14, just west of 4$^{th}$ Ave, near a sod farm. This culvert should be removed or reconfigured under the FBO scenario.

MAR-108c2 is a field culvert on Branch 14, south of Pine St and east of 4$^{th}$ Ave that is undersized. It is a 12” CMP with some accumulated sediment. This culvert should be analyzed as part of the low density residential development that will occur upstream of this location. Removal or reconfiguration may be required.

MAR-110c1 is a 15” PVC field culvert located in Branch 12, north of Main St and south of Pine St. This culvert is undersized under existing conditions. However, as currently operating, it provides peak flow rate reduction and provides benefits to the downstream ditch. This culvert should be examined closely before permitting the low density residential development upstream of this location.

MAR-112c is located on Branch 12 and conveys flow under Pine St. This culvert is completely submerged and partially blocked by sediment. If overtopping of Pine St is a concern, this culvert should be redesigned.

# Appendix C:
# RMP Modeling Report

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# Lino Lakes Resource Management Plan Modeling Report

This report is an addendum to the Existing Conditions Watershed Modeling Report and the Full Build Out (FBO) Modeling Report and contains information regarding the development of the resource management plan (RMP) model created for Lino Lakes. Since the RMP model builds upon the existing conditions and FBO models, the reader is referred to those modeling reports for the most comprehensive discussion of the XP-SWMM model development effort. This report will describe the differences between the FBO and RMP models and will discuss the results of the RMP modeling.

## Model Purpose and Introduction

The RMP XP-SWMM model for Lino Lakes was developed to provide hydrologic and hydraulic information for the following RMP purposes:

- To provide an analysis of the current city infrastructure under the RMP scenario and identify areas of concern;
- To analyze the ability of RMP strategies to reduce volumes and loading to impaired waters;
- To analyze the ability of RMP strategies to meet wetland protection goals; and
- To analyze the ability of RMP strategies to improve ditch management.

The City of Lino Lakes, which is in the process of updating its local comprehensive plan, has had the foresight to look beyond the minimum Metropolitan Council projection requirements to what it calls "ultimate development conditions" or "full-build-out conditions". Using the 2020 land-use map as a baseline, the City began developing a 2030 land-use map for local comprehensive planning purposes. However, the City realized the opportunity to take the 2030 land-use map one step further and has created a full-build-out land-use map. The RMP landuse map is a derivative of the FBO landuse map with wetland buffers and open space corridors added. The RMP land-use map, along with the current infrastructure data, was used to evaluate future land-use decisions and the functionality of the infrastructure as development occurs within Lino Lakes and the tributary municipalities.

## Model Development

The RMP model was developed using the FBO conditions model and the FBO catchment divides as the basis for creating the model structure. The same model framework used in the FBO model was also used for the RMP model. Please refer to the FBO report for more information regarding the model framework.

The following changes were made to the FBO model to create the RMP model: 1) updating hydrology based on expanding wetland buffers for stormwater management, 2) updating hydraulics under the RMP scenario, and 3) applying proposed resource management unit (RMU) recommended projects. These steps are discussed in this section of the RMP report. A discussion of the RMP model results is presented after the model development section.

## RMP Hydrologic Input Parameters

The RMP model was created by using hydrologic input parameters based on additions of the wetland buffers and open space on the FBO landuse. The FBO landuse, with areas reserved for wetland buffers and open space is referred to as the RMP landuse. Figure C1 shows the current FBO landuse. The grayed-out areas on Figure C1 represent parcels or other areas that are not likely to develop further.

RMP scenario wetland buffers were then applied in the model by reclassifying portions of the "developing" land around wetlands to "undeveloping". See the FBO modeling report for further information regarding "developing" and "undeveloping" classifications. Figure C2 shows the landuse with additional areas grayed out, representing the additional wetland buffers modeled as "undeveloping" in this scenario. The additional wetland buffer areas represent a total of 1.4 square miles or approximately 3.9% of the total city area.

The primary hydrologic changes that occur as a result of changes in landuse are: 1) change in impervious surfaces, and 2) soil compaction and pervious land cover change. The same methodology used to account for these changes under FBO conditions was applied to the RMP model using the current FBO landuse. Further information regarding this methodology can be found in the FBO modeling report.

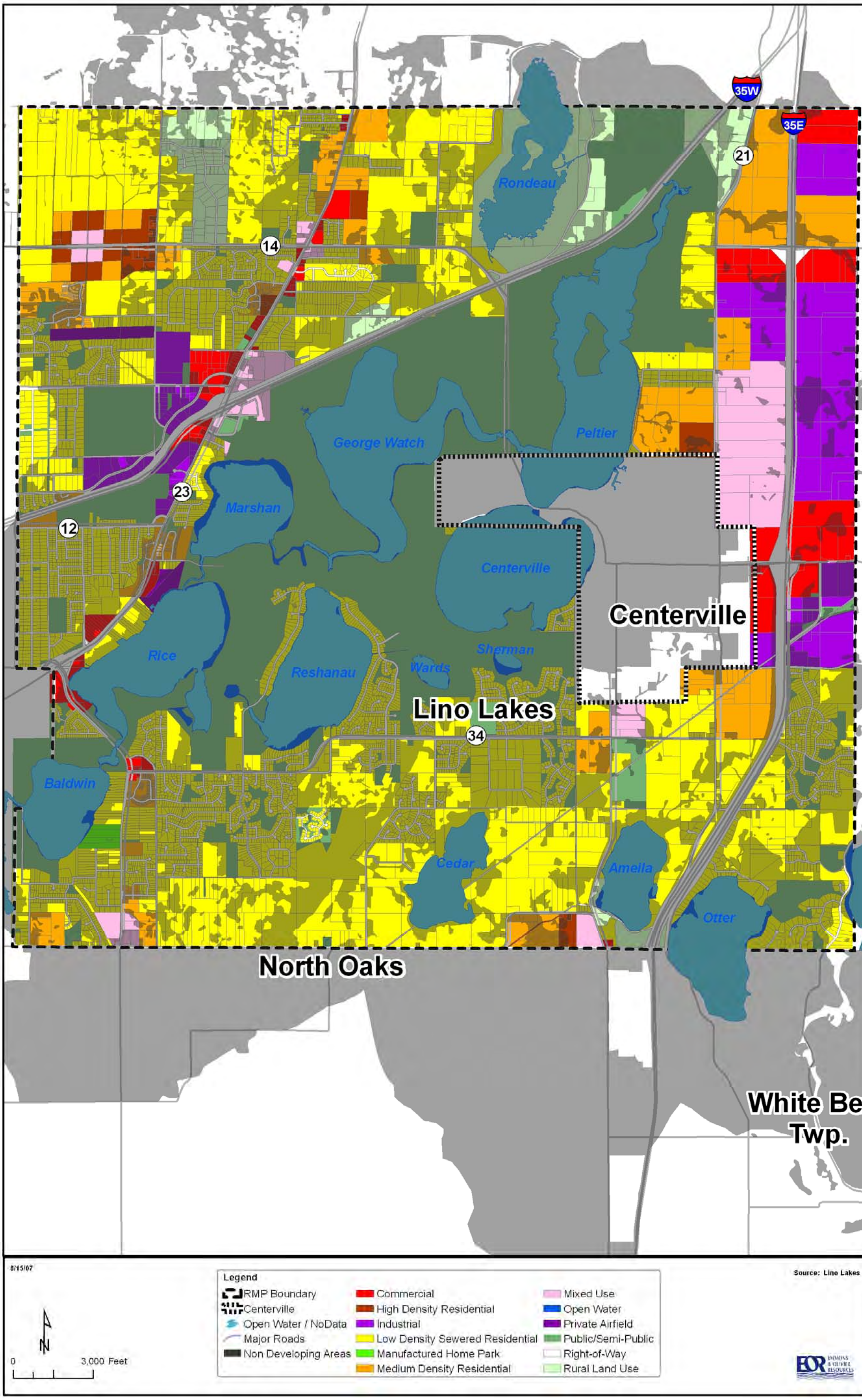


**Figure C1. Full Build Out Landuse and Non Developing Areas**

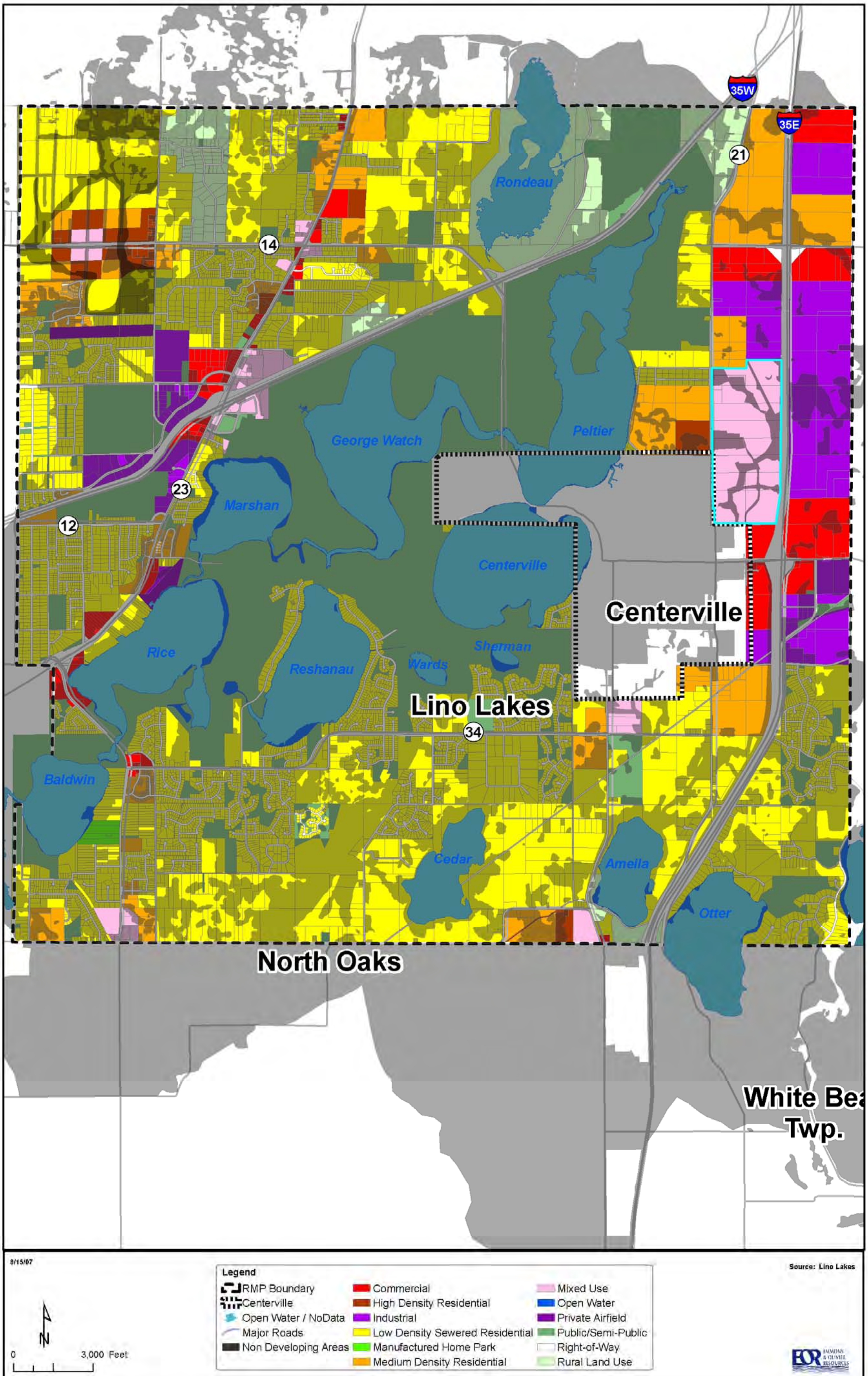


**Figure C2. RMP Landuse and Non Developing Areas**

### Hydraulic Input Parameters

Changes to the hydraulic input parameters for the RMP model were made using the same methodology as the FBO model. Where a change in development intensity occurs that would trigger the existing RCWD rules, a pond was created and the outlet sized to simulate the rate control required for that development. Modifications to address ponding and rate control are discussed in more detail in the FBO modeling report.

### Resource Management Unit Strategies

The results of the modeling were used to develop strategies to reduce flooding, protect wetlands, and improve water quality (see RMP). In two locations, concept plans for development already existed and were incorporated into the RMP model. These locations are the Robinson Sod Farm area in northwest Lino Lakes and the Hardwood Creek Development west of 35E near Centerville. Throughout the rest of the city, specific projects were not modeled and only the effects of implementing wetland buffers and RMP open space corridors was analyzed for stormwater benefits.

## Modeling Results

As previously stated, the four main objectives of the RMP model are:

- To provide an analysis of the current city infrastructure under the RMP scenario and identify areas of concern;
- To analyze the ability of RMP strategies to reduce volumes and loading to impaired waters;
- To analyze the ability of RMP strategies to meet wetland protection goals; and
- To analyze the ability of RMP strategies to improve ditch management.

### Infrastructure Analysis

To analyze how the existing city infrastructure would perform under RMP conditions, a map (Figure C3) was created showing the roads that would experience inadequate freeboard or road overtopping, and the ponds that discharge via emergency overflows for the 100-year event. Some of the areas identified on the RMP version of this map have been previously identified under existing conditions and/or FBO conditions. Locations that show decreased severity or elimination of infrastructure problems are circled in white. Applying RMP projects and landuse eliminates 11 of the 42 infrastructure constraints anticipated to exist under FBO conditions.

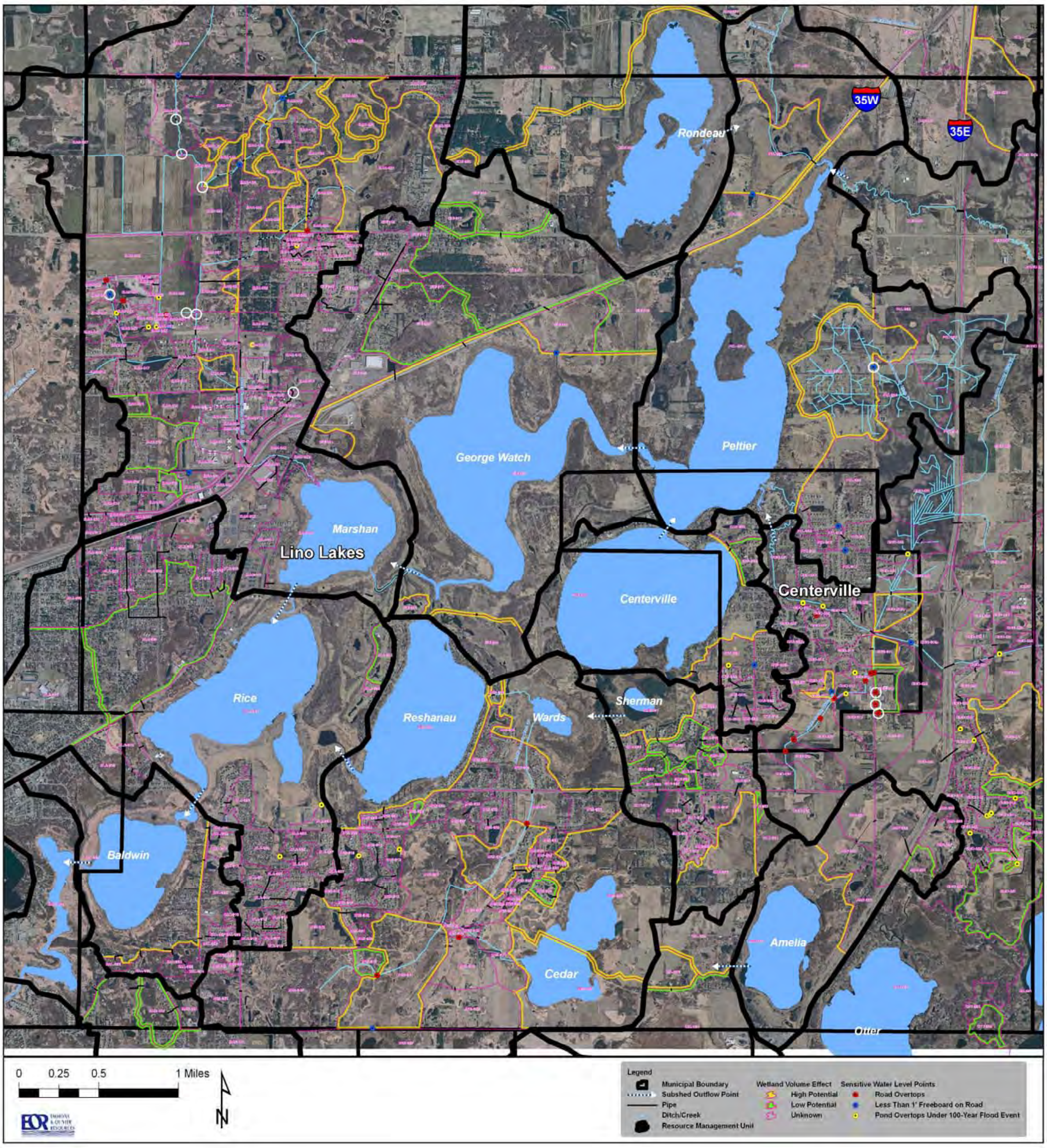


**Figure C3. Resource Management Plan Conveyance System Capacity Map**

## Volume Reduction

Reducing the total runoff volume generated from new development is an important first step in helping meet TMDL requirements. The proposed RMP reduces the amount of runoff generated during storms when compared to the FBO condition. This reduction in runoff volume equates to less impact to sensitive wetlands and reduced pollutant loads to impaired water bodies. Table C1 shows the city-wide volume reduction due to implementing the RMP. The percentages are the percent decrease of the total runoff volume due to the buffers.

**Table C1. RMP Volume Reduction (Compared to FBO)**

| Decrease in Runoff Volume (2.4" 24-hour rainfall) [AC-FT] | Decrease in Runoff Volume (2.8" 24-hour rainfall) [AC-FT] | Decrease in Runoff Volume (4.2" 24-hour rainfall) [AC-FT] | Decrease in Runoff Volume (5.9" 24-hour rainfall) [AC-FT] |
|---|---|---|---|
| 17.0 (4.5%) | 27.2 (0.9%) | 49.8 (0.9%) | 81.1 (0.9%) |

## Wetland Protection

Wetland protection goals have been defined for many of the wetland areas within Lino Lakes. Wetland protection in this section refers to protection of wetlands from excess stormwater bounce and duration. To analyze the effects that RMP buffers would have on wetlands, stage-hydrographs were created for each of the wetlands within Lino Lakes that was classified as highly susceptible. Please note that not all highly susceptible wetlands within the city were explicitly modeled and that many of the wetland with low potential for future impact are located within drainage areas that are currently fully developed. The results of the city-wide analysis are summarized in Table C2 and specific results relating to wetland bounce and duration are shown in Table C3.

**Table C2. Wetland Impact Summary**

| Catchments Containing Highly Susceptible Wetlands | Highly Susceptible Wetlands Modeled | Low Potential for Impact Under any Future Scenario | High Potential for Impact Under FBO Scenario | High Potential for Impact Under RMP Scenario |
|---|---|---|---|---|
| 127 | 69 | 24 | 45 | 30 |

## Ditch Management

Tables A4 through Table C9 summarize information by system for major county, judicial and private ditches. Each table contains 2 pages, the first is for the 1-year and 2-year rainfalls and the second covers the 10-year and 100-year rainfall. These tables include comparisons of high water elevations, peak flow rates and total volumes discharged at specific locations on the ditch alignment for 4 different 24-hour rainfalls. These tables were used in the RMP to find locations for stormwater attenuation, wetland restoration and to identify areas of concern. The results of the modeling indicate a positive reaction to the RMP buffers in the ditch systems.

## Additional Information

In addition to the summary tables presented this far, Table C10 contains the high water elevations for a variety of 24-hour rainfall events for all modeled nodes. The storms that have been modeled to acquire these elevations have been 24-hour rainfalls, these rainfall events do not necessarily correlate to a flood return frequency. For example, many of the flood elevations surrounding the chain of lakes are most likely controlled by a multiple-day snowmelt event. These high water elevations are included for reference and should not be construed to be flood elevations or to represent a flood of any specific return period. Additional modeling data not reported in this appendix is available upon request.

# Conclusions

The results of the modeling clearly show a benefit to stormwater infrastructure, sensitive wetlands, and ditch management within Lino Lakes if the RMP buffers are implemented. More information regarding the use of modeling results and the RMP can be found in the main portion of the RMP.

# Appendix D:
# Centerville Lake

# M E M O R A N D U M

**To:** Doug Thomas
District Administrator
Rice Creek Watershed District
**From:** Kent E. Brander, P.E.; Carl K. Almer

**Subject:** Centerville Lake Outlet **Date:** December 17, 2007

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The purpose of this memo is to summarize investigations and recommend a course of action concerning the connection between Centerville Lake and the Chain of Lakes. This work has been conducted as a separate work task under the Lino Lakes RMP.

**Introduction**

The structure between Peltier Lake and Centerville Lake was designed to serve as a hydraulic connection between the lakes, and there is an interest in breaking that connection. The purpose of breaking the connection would be to keep water from Peltier Lake out of Centerville Lake, because it is been concluded through prior investigations that the water from Peltier Lake has a higher Phosphorus concentration. However, the prospect of breaking the connection between the two lakes raises concerns regarding the water level in Centerville Lake. The concern stems from the fact that Peltier Lake is in line with the Chain of Lakes, and Centerville Lake is connected to the Chain of Lakes only by its connection with Peltier Lake. Therefore, if the connection between the two lakes is broken, Centerville Lake will not receive surface inflow from the Chain of Lakes system, and there is a concern that its own watershed and groundwater inflows may not provide enough water to sustain the lake at an adequate level. Also, without the ability to overflow to Peltier Lake, the water surface elevation in Centerville Lake may rise higher than it would with the connection in place, and could reach an undesirable level.

**Previous Investigations and Limitations**

Some efforts have been made to characterize the surface water and groundwater flow into and out of Centerville Lake. The lake was modeled as part of an overall surface-water model of the Chain of Lakes system, and it was also included in a groundwater study for Centerville and Peltier Lakes. While these previous studies do provide estimates of the amount of water flowing into Centerville Lake and confirm that Centerville Lake is connected to the groundwater system, they do not contain enough detail to say whether or not Centerville Lake could be self-sustaining without the connection to Peltier Lake. To make such an evaluation would require a more detailed surface water model, the installation and observation of monitoring wells in the vicinity of the lake, and a detailed water budget analysis. Even with these investigation components, there would be a significant level of uncertainty involved in such a prediction.

Still, it is considered highly likely that disconnecting the lakes would provide significant water quality benefits, and there is a good chance that lake levels would not be negatively impacted by the change.

**Review of Options**

There are two general courses of action that could be taken at this point with respect to the connection of Centerville Lake.

1. Perform a thorough analysis of the Centerville Lake surface water and groundwater systems as described above. If the analysis suggests that Centerville Lake would be able to sustain itself, modification of the structure could proceed. If the analysis indicates that Centerville Lake would not be able to sustain itself, the project could be cancelled or other options could be explored.
2. Structurally disconnect the lakes on a temporary or provisional/reversible basis, and carefully monitor the response of Centerville Lake in terms of water level. If the water level in Centerville Lake falls (or rises) to unacceptable levels, the connection with Peltier Lake could be reestablished, to return to present conditions.

As indicated above, the problem with Option 1 is that a thorough water budget analysis and numerical model would require a significant investment of time for both monitoring and modeling, and in the end, the level of confidence would still not be very high, given the high margin of error in available analysis methods. Therefore, even with the study completed, additional monitoring and a means of reversing or changing structural modifications would be recommended.

From a practical standpoint, Option 2 seems to be the preferred approach, in that no time is spent on additional analysis that in any case may not provide the level of confidence desired. Currently, there is a structure between the two lakes in which stoplogs can be placed in order to block the hydraulic connection. Based on visual inspection, the condition of the structure appears adequate to serve its original purpose. Original plans with details of the stoplogs are on file, and if necessary, new stoplogs that fit within the structure could be constructed. The cost for materials and installation for this approach would not be expected to exceed $3,000. The stoplogs could be placed in the structure to hydraulically disconnect the lakes, and monitoring of the effects on lake levels could begin at that point. Continuous monitoring (with existing District equipment) would be recommended for a period of time immediately following the installation of stoplogs, and after a certain amount of time passes without any significant issues arising, monitoring could be less frequent or focused more around significant precipitation or runoff events.

**Recommendations**

We recommend that stoplogs be placed within the structure connecting Peltier Lake and Centerville Lake in order to stop flow between the lakes. Structures and property lines around the perimeter of Centerville Lake should be mapped on a topographic map, and specific water surface elevations that would be considered unacceptably high and unacceptably low should be identified. The top elevation of the highest stoplog should be lower than the maximum acceptable water level in Centerville Lake. St. Paul Regional Water Services (SPWRS) has indicated that it does not anticipate having any objections to disconnecting the lakes in this manner; however, SPWRS retains authority over water levels in these lakes, and it would be necessary to obtain their approval of the final plan, as well as their input regarding changes to the structure and maximum and minimum allowable water levels.

The water surface elevation in Centerville Lake and the conditions within the stoplog chamber should be checked within 3 days immediately following installation of the stoplogs, to ensure that no unexpected severe consequences have resulted. Following this initial check, normal monitoring of water levels in the lake should continue under current programs with existing District equipment.

Following installation of the stoplogs, we recommend that water levels be monitored for a period of at least two years before considering construction of a new/permanent structure to control flow between the lakes. At that time, the results of the currently proposed effort could be evaluated and a cost/benefit analysis could be performed for any additional modifications.