Eden Prairie Nondegradation Assessment

D R A F T

Wenck

Prepared for

The City of Eden Prairie
June 2007

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Prepared for:

THE CITY OF EDEN PRAIRIE

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Executive Summary

This study is completed in response to the Nondegradation Assessment requirement of the Minnesota Pollution Control Agency as part of the City's National Pollutant Discharge Elimination System (NPDES) Phase II permit. The purpose of this study is to assess changes in stormwater runoff volume, total suspended solids (TSS) and total phosphorus (TP) loading in the City of Eden Prairie since 1988, and to predict how land change expected to occur between now and 2020 would impact those parameters. This analysis is to be used to identify Best Management Practices to be undertaken to return to 1988 or better conditions.

A key component of this analysis is an assessment of the change in impervious surface due to land use change. The percent impervious area varies considerably thorugout the City, with some subwatersheds less than 10 percent impervious and other approaching 50 percent.

Year	**1990**	**2000**	**2020**
Percent of upland area in Eden Prairie that is impervious	21%	29%	32%

This analysis estimated the pollutant loads and stormwater volumes for three key years – 1990 (a proxy for 1988), 2000, and 2020. Much of the land use change in Eden Prairie since 1988 occurred under regulation to protect water quality. Additionally, the City currently undertakes Best Management Practices (BMPs) to improve water quality. The pollutant load and volume reductions associated with those BMPs were estimated to determine the net impact to stormwater volume and TSS/TP load since 1988 and predicted to occur between now and 2020.

Parameter	**Total Load 1990**	**Total Load 2020**	**Total Increase 1990-2020**	**Removal by BMP**			**Net Removal (-) or Net Increase (+)**
				Develop-ment Rules	**Manhole Sump Cleanout**	**Street Sweeping**	
Total Suspended Solids	2,456,658 lbs/yr	3,687,643 lbs/yr	1,230,985 lbs/yr	1,972,599 lbs/yr	108,365 lbs/yr	151,971 lbs/yr	-1,001,950 lbs/yr
Total Phosphorus	9,134 lbs/yr	13,509 lbs/yr	4,375 lbs/yr	6,198 lbs/yr	269 lbs/yr	352 lbs/yr	-2,444 lbs/yr
Runoff Volume	10,343 acre-feet /year	14,828 acre-feet /year	4,485 acre-feet /year	None estimated	None estimated	None estimated	+4,485 acre-feet/ year

For the period 1990-2020, this study estimates the City will remove about 1 million *more* pounds of TSS than created since 1988, and 2,400 pounds *more* TP than created. For these two parameters, the City meets the MPCA requirement of no net increase in TSS and TP over 1988 conditions. However, land use change will generate 4,485 acre-feet of new runoff volume.

To address this increase in stormwater volume, the City has identified several new BMPs that will over time either reduce stormwater volume or minimize the adverse effects of additional stormwater volume. Managing stormwater volume has the additional benefit of reducing TSS and TP loading by reducing the amount of runoff picking up and transporting pollutants to downstream waters. These BMPs include:

- A new requirement on development and redevelopment to abstract (remove from runoff by infiltration, evapotranspiration, capture and reuse, etc.) a portion of annual runoff volume;
- Reducing additional stormwater runoff volume through evapotranspiration by developing and implementing an aggressive reforestation program;
- Retrofitting volume management BMPs where opportunities arise, such as on City street reconstruction projects; and
- Mitigating volume impacts by stream restoration, erosion control projects, and shoreline restoration.

1.0 INTRODUCTION

1.1 Introduction

This study is completed in response to the Nondegradation Assessment requirement of the Minnesota Pollution Control Agency as part of the City's National Pollutant Discharge Elimination System (NPDES) Phase II permit. The purpose of this study is to assess changes in stormwater runoff volume, total suspended solids (TSS) and total phosphorus (TP) loading in the City of Eden Prairie since 1988, and to predict how land change expected to occur between now and 2020 would impact those parameters. This analysis is to be used to identify Best Management Practices (BMPs) to be undertaken to return to 1988 or better conditions.

A nondegradation assessment consists of three key steps:

1. An assessment of change in land use and imperviousness in the city from 1988 to present and out to 2020 conditions.
2. An associated pollutant load change with the land use change for total phosphorus, total suspended solids, and water volume.
3. Identification of current of necessary BMPs to return to 1988 conditions or better.

This study is organized as follows:

1. A description of the City, land use change since 1988, and change expected to occur between now and 2020.
2. A description of the method used to calculate imperviousness and the results.
3. A description of the various input parameters used to model pollutant loading and stormwater runoff volumes.
4. A review of the existing BMPs designed to reduce pollutant loading, including a history of watershed and city rules and ordinances regulating development and redevelopment; the maintenance of sump manholes that collect material washed into the storm sewer system from the landscape; and the street sweeping program.
5. A detailed presentation of the results of water quality and quantity modeling reported by subwatershed in the city. These results estimate the amount of new TSS and TP loading and stormwater runoff volumes resulting from land use change in the City.
6. An analysis of the amount of pollutant loading removed by the BMPs described above.
7. The net impact of those BMPs in reducing the increased TSS and TP load and new stormwater volume.
8. Identification of new BMPs the City could undertake to return to 1988 conditions or better, or mitigate the impacts of increases.
9. Proposed modifications to the City's Storm Water Pollution Prevention Plan to plan to implement those BMPs.

2.0 LAND USE AND P8 MODELING

2.1 P8 Model Construction and Organization

Modeling for much of the City has already been completed through the preparation of Use Attainability Assessments (UAAs) for many of the lake watersheds in Eden Prairie by either the Nine Mile Creek Watershed District or the Riley-Purgatory-Bluff Creek Watershed District (Table 2.1). Staring Lake is due for completion in 2007 and covers a significant portion of the Purgatory Creek watershed in Eden Prairie. The UAAs include both watershed load modeling and in-lake response modeling. The UAAs are used to identify potential improvement projects and estimate the costs to restore the waterbody to meet selected water quality goals.

Table 2.1. Current status of UAA analyses in the City of Eden Prairie.

Watershed	Water Body	Status
Riley-Purgatory-Bluff Creek	Duck Lake	Completed
	Round Lake	Completed
	Mitchell Lake	Completed
	Rice Marsh Lake	Completed
	Lake Riley	Completed
	Red Rock Lake	Draft
	Staring Lake	Due Fall 2006
Nine Mile Creek	Birch Island Lake	Completed
	Bryant Lake	Completed
	Lake Smetana	Completed
	Anderson Lakes	Completed
Lower Minnesota	Rice Lake	Not Completed
	Grass Lake	Not Completed

The UAAs include a P8 model developed for each of the lake watersheds. P8 - Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds - is a public domain (http://wwwalker.net/p8/), industry standard model developed to assess pollutant loading in urban watersheds. P8 was developed using National Urban Runoff Program (NURP) data and provides loading estimates based on data collected as a part of the NURP program. P8 was designed to assess the effectiveness of BMP implementation in reducing runoff loads from impervious surfaces and provides a tool for evaluating other nonstructural practices such as street sweeping. These models represent the best tools available for predicting watershed loads under current conditions.

The models provided by the watershed districts were the basis for the City's assessment. For the assessment, the P8 model subwatersheds were maintained as well as the device configurations. However, imperviousness and the pervious curve numbers were updated based on evaluations of land use, LANDSAT data, and aerial photo interpretation. Selection of these input variables is described later in this report. It is important to note the modeling is not focused on absolute values, rather the purpose is to assess relative change among the time periods. The modeling does need to be close to real world values to assess the impact of current activities on loading. The modeling was developed for this purpose and is not intended to be a calibrated loading model.

The analysis was conducted according to the receiving water including twelve lakes (Figure 2.1). Although the analysis focused on changes in loading to the lakes, the subwatershed detail was maintained in the model for future evaluation of projects on water quality.

2.2 Land Use Assessment

Land use data was collected from the Metropolitan Council and the City of Eden Prairie. However, each of the key time periods and data sets had different land use categories. These data were combined into a representative group of categories (Table 2.2 Figures 2.2, 2.3 and 2.4). 1990 data was selected as a surrogate for 1988 because land use data was readily available for 1990 and not 1988. Little change occurred in the City between 1988 and 1990. In the 1990 land use coverage, agriculture and vacant lands were not uniquely identified. Since the conversion of agricultural land to developed land has significant implications, we assumed the agricultural land in 2000 was also agriculture in 1990 and converted the land use accordingly. The Metropolitan Council's coverage also included a mixed-use category that was dissected using Eden Prairie's data into the appropriate category such as commercial or single family residential. The resultant coverages are the best estimate of land use for the three critical time periods including 1990, 2000 (present) and 2020.

Table 2.2. Aggregated land use categories for the City of Eden Prairie

Land Use	1990 Land Use	2000 Land Use	2020 Planned Land Use
Vacant	Vacant/Agricultural	Undeveloped (Includes Ag and Vacant)[3]	Vacant, Open Space
Agricultural	2000 Agricultural[1]	Agricultural	Agricultural, 2000 Agricultural[1]
Single Family Residential	Single Family Residential, Farmstead	Farmstead, Seasonal/Vacation, Single Family Detached, Manufactured Housing Park	Single Family Residential
Multi-Family Residential	Multi-Family Residential	Single Family Attached, Multi-Family	Multi-Family Residential
Commercial	Commercial	Retail and Other Commercial, Office, Mixed Use	Commercial
Industrial	Industrial	Industrial	Industrial
Public/Semi Public	Public/Semi Public	Institutional[5]	Institutional[5]
Parks and Recreation	Parks and Recreation	Golf Course and Parks and Recreation	Parks and Recreation
Airport	Airport	Airport	Airport
Vacant	Vacant/Agricultural	Undeveloped (Includes Ag and Vacant)	Vacant, Open Space
Open Water	Open Water	Open Water	Open Water
Roadway	Major Highway	Major Highway, Roadway	Major Highway, Roadway
Railway	None	Railway	Railway

[1] For 1990 and 2020 land use, the 2000 agriculture class updated the existing land use.
[2] The mixed use category was defined as SFR, MFR, COM, or IND in 2000 and 2020 coverage were changed to the Eden Prairie Classifications.
[3] For the 2000 land use, the vacant classification was updated based on the City of Eden Prairie's current Land Use to either SFR, MFR, COM, IND, P&R, PSP, AG
[4] Compared the Met Council's 2000 and 2020 land use with the City of Eden Prairie's current and future land use. Changed the Met Council's classification to the Eden Prairie's land use based on aerial photography verification.
[5] Institutional uses are schools, churches, and government buildings.

Figure 2.1

Figure 2.2

Figure 2.3

Figure 2.4

These data were compiled for the City of Eden Prairie (Table 2.3). The 2020 land use coverage assumes build-out conditions and that no vacant land will remain in the City. A significant increase in single and multifamily residential and commercial land use with a loss of both vacant and agricultural areas is expected.

Table 2.3. Land use acreages in the City of Eden Prairie for the three key time periods.

Land Use Categories	1990 Land use (acres)	2000 Land Use (acres)	2020 Land Use (acres)
Agricultural	536	537	344
Airports	517	657	797
Commercial	803	1,082	1,275
EP Wetlands	3,352	3,353	3,353
Industrial	912	1,438	1,463
Major Highways	439	694	1,051
Multi-Family Residential	725	1,058	1,146
Park and Recreation	1,840	2,609	2,297
Public/Semi Public	458	616	1,039
Railway	N/A	70	69
Single-Family Residential	4,466	7,586	7,595
Vacant	6,378	730	0
Water	2,081	2,080	2,080
TOTAL	**22,508**	**22,509**	**22,509**

N/A = Not available

2.3 Imperviousness Assessment

To estimate the imperviousness in the City, assumed percent imperviousness by land use from the watershed district supplied models and LANDSAT imagery were assessed (Table 2.4; Figure 2.5). The LANDSAT impervious fraction is an area-weighted average of imperviousness for all pixels or partial pixels falling in each land use classification. The values were in relative agreement except for commercial and industrial areas. Aerial photos were analyzed to determine the imperviousness of these two land uses. The selected values for the modeling were chosen based on aerial photo interpretation or based on an evaluation of LANDSAT estimated imperviousness as well as knowledge of the area and to provide a conservative approach.

Table 2.4. Impervious fractions by land use from the UAAs, LANDSAT analysis, and those fractions used in this study.

Land Use	LANDSAT Impervious Fractions	UAA Impervious Fractions	Selected Impervious Fractions
Agriculture	0.04	0.03	0.05
Airports	0.30	0.30	0.30
Commercial[1]	0.50	0.85	0.67
Industrial[1]	0.47	0.75	0.50
Multi-Family Residential	0.41	0.65	0.60
Parks and Recreation Areas	0.10	0.02	0.10
Public Semi Public	0.32	0.50	0.32
Railway	0.13	N/A	0.20
Roadway	0.34	0.50	0.50
Single Family Residential	0.21	0.30	0.25
Vacant	0.08	0.03	0.05

[1]Verified through aerial photo analysis.
N/A = Not available

Figure 2.5

The aerial photo assessment of impervious areas covered a total of 376 commercial acres as well as 628 industrial acres (Table 2.5). Impervious and pervious areas were digitized to estimate the area of impervious surfaces in these land use categories. Although they represent a very small area, parking lot islands were considered impervious because of soil compaction in these areas. Commercial areas were determined to be approximately 67% impervious while industrial areas were determined to be 46% impervious.

Table 2.5. Digitized impervious and pervious acres for commercial and industrial areas in Eden Prairie.

Category	Commercial		Industrial	
	Acres	Percent	Acres	Percent
Pervious	123	33%	341	54%
Impervious	253	67%	287	46%
TOTAL	**376**	**100%**	**628**	**100%**

Upland areas (areas excluding lake and wetland surface areas) in the City went from 21% impervious in 1990 to a projected imperviousness of 32% in 2020 (Table 2.6). The Lake Smetana and NW Anderson Lake watersheds demonstrated the greatest impervious fractions with 50% and 44% impervious areas respectively. Additionally, the northeast corner of the City which flows to Nine Mile Creek was projected to be more than 50% impervious.

Table 2.6. Total change in upland imperviousness in the City of Eden Prairie.

Watershed ID	Watershed Area (acres)[1]	Percent Impervious[1]		
		1990	2000	2020
Birch Island	201	17	24	25
Bryant Lake	1,443	24	30	34
Duck Lake	117	23	24	25
Lower Riley Creek	1,176	8	20	25
Lake Riley	580	7	21	31
Lower MN	2,090	13	17	21
Outflow Watersheds	359	39	50	52
Lake Mitchell	661	15	31	31
Purgatory	2,873	23	31	33
Red Rock Lake	1,044	15	27	29
Rice Marsh Lake	140	6	21	29
Round Lake	398	24	25	25
Lake Smetana	834	36	47	50
Staring Lake	4,582	25	34	36
NW Anderson Lake	218	28	39	44
SE Anderson Lake	7	14	29	29
SW Anderson Lake	285	20	19	19
TOTAL	**17,008**	**21**	**29**	**32**

[1]Does not include wetland and lake surface areas.

2.4 Pervious Curve Numbers

The second key piece of information for the P8 model is a curve number for the pervious areas in the model. The SCS curve number reflects an area-weighted-average of the pervious areas considering soil types, land use and hydrologic groups. It was assumed that all pervious areas, or grassed areas, were in fair hydrologic condition. Table 2.7 lists the values used in the P8 modeling as a function of land use, hydrologic condition, and soil group.

Table 2.7. Curve numbers by land use and soil type.

Land Use	Hydrologic Soil Group (Grassed Areas in Fair Condition)									
	A	**B**	**C**	**D**	**A/D**	**B/D**	**B/C**	**A/B**	**A/C**	**Unclassified**
Agricultural	49	69	79	84	66.5	76.5	74	59	64	70.25
Airport	68	79	86	89	78.5	84	82.5	73.5	77	80.5
Roadway	49	69	79	84	66.5	76.5	74	59	64	70.25
Single Family Residential	39	61	74	80	59.5	70.5	67.5	50	56.5	63.5
Park and Recreation	39	61	74	80	59.5	70.5	67.5	50	56.5	63.5
Commercial	49	69	79	84	66.5	76.5	74	59	64	70.25
Major Highways	49	69	79	84	66.5	76.5	74	59	64	70.25
Multi-Family Residential	39	61	74	80	59.5	70.5	67.5	50	56.5	63.5
Vacant	39	61	74	80	59.5	70.5	67.5	50	56.5	63.5
Industrial	68	79	86	89	78.5	84	82.5	73.5	77	80.5
Railway	68	79	86	89	78.5	84	82.5	73.5	77	80.5
Public/Semi Public	39	61	74	80	59.5	70.5	67.5	50	56.5	63.5

2.5 Other P8 Inputs

Other model input is the particle, precipitation and temperature file. The particle file used was the P8 default NURP50 particle file. Both the precipitation and temperature files used were obtained from UAA models. All models were run for the same 10 year period (1990 to 2000) with 5 passes through the precipitation file.

2.6 Model Validation and Assumptions

Modeling was conducted for all loading in the City, including loading from other NPDES Phase II permit holders. Other permit holders include Mn/DOT, Hennepin County and Flying Cloud Airport. These loadings were included in this assessment.

The modeling approach presented here is a conservative approach to assess nondegradation. The P8 model was developed for urban watersheds. However, one of the critical aspects of this modeling is the change in loading that occurs as land is converted from open or agriculture to developed land. To test the P8 model's handling of open space, a test watershed (100 acres) was run for an average precipitation year (Table 2.8). Curve numbers in the model for open space and agriculture typically ranged from 60 to 70. Because of the low runoff (<1.4 inches), the loading rates for open land with these curve numbers is very low. This may be artificially lowering the runoff from these areas, especially if the current land use is agriculture. However, to maintain a conservative approach, these numbers were maintained in the model.

Table 2.8. Runoff and loading by curve number from a test watershed in P8.

CN	Runoff (in)	TSS load (lbs./ac/yr)	TSS (ppm)	TP load (lbs./ac/yr)	TP (ppm)
50	0.3	0.7	12	0.01	0.127
55	0.5	2	17	0.01	0.138
60	0.7	4	22	0.02	0.150
65	1.0	7	29	0.04	0.167
70	1.4	13	40	0.06	0.193
75	1.9	24	55	0.10	0.226
80	2.7	44	71	0.16	0.263
85	4.0	82	89	0.28	0.305
90	6.3	163	114	0.52	0.363
95	11.0	366	148	1.09	0.440
Impervious (NURP 50)	26.1	649	110	2.09	0.354
Impervious (NURP 90)	26.1	1947	330	4.43	0.750

To validate the model, model results were compared to stream data collected as a part of the Watershed Outlet Monitoring Program (WOMP; Table 2.9). For the WOMP data, a close to average year precipitation was selected to evaluate. Data are presented as flow weighted means or on a unit area basis. This makes the data comparable even though the model was only run for the City of Eden Prairie portion of the watersheds. The model typically over-predicted runoff and loading for the Purgatory Creek watershed. Although the model does not account for receiving water processes, it represents a conservative estimate of loading from the land.

Table 2.9. Monitored and predicted volume and water quality for Purgatory Creek.

Watershed	Year	Runoff (in)	Flow Weighted TSS (mg/L)	TSS load (lbs/ac/yr)	Flow Weighted TP (μg/L)	TP load (lbs/ac/yr)
Purgatory Creek	2004[1]	7	23	38	160	0.26
	Modeled[2]	10	93	217	314	0.73

[1]Data calculated from WOMP station for entire watershed
[2]Data calculated for City of Eden Prairie portion of watershed using NURP50 file.

3.0 CURRENT WATER QUALITY TREATMENT CAPACITY

Understanding the BMPs and water quality treatment devices in the watershed is vital in assessing load changes in the City between 1988 and present. Additionally, assessing whether the current practices are sufficient for protecting water quality into the future can help guide City activities to assure compliance with nondegradation.

3.1 Applicable Rules, Codes and Ordinances

Applicable watershed district rules and City codes and ordinances that address water quality were reviewed to determine the current treatment capacity in the City resulting from regulation.

3.1.1 Eden Prairie Codes and Ordinances

Wetlands (2000, modified 2003). Provides for management of wetlands and wetland impacts by management classification as determined by a functions and values assessment. Ordinance specifies allowable hydrologic change in wetlands, and buffer and setback standards by classification. Land-altering activities affecting wetlands must also provide a Stormwater Pollution Prevention Plan incorporating Best Management Practices.

Shoreland Management (2004). Establishes structure, septic system, and drain field setbacks, and minimum lot sizes; regulates grading and filling activities and alteration of natural vegetation in the shoreland management area; and regulates onsite sewerage systems in the shoreland area.

Land Alteration, Stormwater Management, and Tree Replacement (2006). Generally governs land alterations impacting 100 cy or more of earth. Requires erosion control, slope stabilization, tree preservation and replacement, and post-construction maintenance of stormwater management facilities.

3.1.2 Riley-Purgatory Creek-Bluff Creek Watershed District

The District's regulatory program was formally established in 1996. Projects to alter or disturb land surfaces in excess of one acre, fill within the 100-year floodplain, or fill within a wetland are required to meet NURP design requirements and include skimming of floatable materials. No specific rate or volume control is required. According to Bob Obermeyer, engineer for the District, standards have been in place since 1977 for projects altering more than one acre. The early emphasis was simply on erosion control, but in the early 80s started looking for sedimentation control and treatment. The design criteria used was to provide sufficient surface settling area to remove a 0.1 mm particle based on a 10-year, 1.65" in 30 minutes storm event (Obermeyer, pers. corresp. 6/8/06, 7/12/06).

3.1.3 Nine Mile Creek Watershed District

The District's regulatory program was formally established in 1996. Projects to alter or disturb in excess of 100 cubic yards of material, fill within the 100-year floodplain, or fill within a wetland are required to submit an erosion and stormwater management plan. On-site detention for rate control is required to maintain predevelopment rates of runoff for the 100-year storm event. No volume control is required. Water quality ponds must meet NURP design requirements and include skimming of floatable materials. According to Bob Obermeyer, engineer for the District, standards have been in place since 1977 for projects altering more than 100 cubic yards of material. The early emphasis was simply on erosion control, but in the early 80s started looking for sedimentation control and treatment. The design criteria used was to provide sufficient surface settling area to remove a 0.1mm particle based on a 10-year, 1.65" in 30 minutes storm event (Obermeyer, pers. corresp. 6/8/06, 7/12/06).

3.1.4 Lower Minnesota Watershed District

The District's regulatory program was formally established in 1999. A Runoff Management Plan (RMP) is required for residential projects in excess of 5 acres or nonresidential projects in excess of one acre, or projects meeting other criteria. Runoff from the site after development must not exceed the peak runoff from the site predevelopment for the 20-percent chance (5-year) and 1-percent chance (100-year) storm event. The two LMWD lakes in Eden Prairie, Grass Lake and Rice Lake, are Level IV lakes, requiring runoff treatment prior to discharge to NURP standards except that dead storage must be provided for a 2-inch event rather than a 2.5-inch event.

3.2 Treatment Device Quantification

The City of Eden Prairie's pond and wetland database was reviewed to assess the ability to quantify the treatment capacity in the City. The most important data includes pond dead storage or bottom and surface areas. Flood pool storage is also useful but not critical. Currently, these data are not available in the City's database. For the Nine Mile Creek Watershed, the data are available in the P8 model supplied by the District. The data are also provided in the other UAA models, however it is unclear if all of the ponds are included, most significantly the development or lot level ponds. Consequently, the treatment capacity was estimated based on the year the lot was developed and the District or City rules in place at the time.

3.3 Year Built For Developments

The first step in identifying the rules under which development occurred, is to determine the date when a lot was developed. Hennepin County maintains a GIS layer that includes the development year for a particular tax lot (Figure 3.1). The City was then broken into areas based on the period in which different watershed rules were in place. Realizing that some development can still occur without review (less than 5 acres), each subwatershed was evaluated

Figure 3.1

to estimate the area of development that occurred under the watershed district rules (Table 3.1). This was accomplished by evaluating the dates the lots were built in relation to neighboring lots. If several lots were built together, the area was assumed to develop under the rules.

Table 3.1. Estimated areas that developed under watershed district rules by subwatershed.

Watershed ID	Estimated Number Of New Lots	Estimated No. Built Under Rules	Fraction Built Under Rules
Birch Island	36	21	0.58
Bryant Lake	282	226	0.80
Duck Lake	22	14	0.64
Lower Riley Creek	Estimated	Estimated	0.90
Lake Riley	364	356	0.98
Lower MN	237	224	0.95
EP Outlfow Watersheds	13	12	0.92
Lake Mitchell	Estimated	Estimated	0.85
Purgatory	Estimated	Estimated	0.85
Red Rock Lake	Estimated	Estimated	0.90
Rice Marsh Lake	207	196	0.95
Round Lake	105	43	0.41
Lake Smetana	58	54	0.93
Staring Lake	Estimated	Estimated	0.75
NW Anderson Lake	65	57	0.88
SE Anderson Lake	0	0	0.00

3.4 Application of Rules

Watershed rules were in place in the early 1980s, however the key rules are those in place after 1988. From 1988 to 1992, developments were required to design stormwater ponds to provide dead storage based on the 10-year 30-minute event (1.65 inches; Tables 3.2 and 3.3). In 1993, the rules changed and required the pond to have the dead storage of a 2.5 inch 24 hour event. This design is considered a National Urban Runoff Program (NURP) standard and is assumed to provide a 50 to 60% total phosphorus reduction and a 70 to 80% total suspended solids reduction.

Table 3.2. Nine Mile, Riley-Purgatory Bluff Watershed District rules.

Year Built	TP % Reduction	TSS % Reduction	Volume % Reduction	Notes
Pre 1988	0	0	0	Some WQ reduction starting in early to mid 80s
1988-1992	50-60% (1)	70-80% (1)	0	Provide dead storage for the 10-year 30 min event (1.65 inches)
1993-2007	50-60% (2)	70-80% (2)	0	Rules – NURP. Provide dead storage for the 2.5 inch, 24-hr event

[1]Assumed based on the rule
[2]Assumed based on NURP standards

Table 3.3. Lower Minnesota River Watershed District rules

Year Built	TP % Reduction	TSS % Reduction	Volume % Reduction	Notes
Pre 1988	0	0	0	Some WQ reduction starting in early to mid 80s
1988-1992	50-60% (1)	70-80% (1)	0	Provide dead storage for the 10-year 30 min event (1.65 inches)
1993-2007	50-60% (2)	70-80% (2)	0	Rules – NURP. Provide dead storage for the 2.5 inch, 24-hr event

[1]Assumed based on the rule
[2]Assumed based on NURP standards

3.5 Sump Manholes

The City of Eden Prairie maintains over 600 sump manholes in the City. These manholes are cleaned with a vacuum truck on a periodic basis, with cleaning generally occurring annually. The City maintains records of raw material removed from the manholes (Table 3.4). Between 0.8 and 1.6 million pounds of raw material is removed annually from the manholes with an average removal of 1.3 million pounds.

Table 3.4. Volume and estimated mass of material removed from sump manholes in the City of Eden Prairie.

Year	Cubic Yards Pumped	Pounds Material Removed
1999	410	1,148,000
2000	545	1,526,000
2001	292	817,600
2002	571	1,598,800
2003	526	1,472,800
2004	477	1,335,600
2005	443	1,240,400
Average	466	1,305,600

3.6 Street Sweeping

The City of Eden Prairie has a street sweeping program and maintains detailed records of material removed from streets. The City removed between 2.2 and 4 million pounds of raw material annually between 2003 and 2006 with an average removal of 2.9 million pounds (Table 3.5).

Table 3.5. Measured mass of material removed from street sweeping in the City of Eden Prairie.

Year	Tons Swept	Pounds Material Removed
2003	2,028	4,056,000
2004	1,100	2,200,000
2005	1,100	2,200,000
2006	1,700	3,400,000
Average	1,482	2,964,000

4.0 MODEL RESULTS

4.1 Organization

Model results were organized on a receiving water basis with the City's twelve lakes as the focus (Figure 2.1). Model results are presented in for these subwatersheds. Those subwatersheds that drain out of the City or drain to creeks that ultimately drain out of the City without entering a lake were grouped together. The details of the P8 models supplied by the watershed districts were maintained and are provided in the Technical Appendices.

4.2 Load Changes

Changes to impervious area, volume, TSS, and TP for the City of Eden Prairie between 1990 and 2020 are presented in Table 4.1. Between 1990 and 2020 the City is expected to add a little less than 2,000 impervious acres resulting in an increased discharge of almost 4,500 acre-feet of water. The increased discharge was predicted to include an additional 1.2 million pounds of TSS and 4,300 pounds of total phosphorus.

Table 4.1. Raw increases in imperviousness, volume, TSS, and TP for the City of Eden Prairie from 1990 to 2020.

Watershed ID	Area (acres)	Impervious Area (acres)			Flow (ac. ft. per year)			TSS (lbs per year)			TP (lbs per year)		
		1990	2000	2020	1990	2000	2020	1990	2000	2020	1990	2000	2020
Birch Island	201	34	49	51	107	141	146	23,663	32,796	34,199	84	114	118
Bryant Lake	1,443	344	436	497	1,131	1,340	1,469	235,926	293,101	328,716	849	1,038	1,155
Duck Lake	177	41	43	44	111	117	120	27,133	28,674	29,567	93	98	101
Lower Riley Creek	1,176	95	235	291	320	642	778	68,633	156,731	193,222	245	535	656
Lake Riley	580	39	119	177	161	342	473	31,528	81,775	118,124	116	281	400
Lower MN	2,090	273	360	443	826	1,030	1,220	186,882	241,147	293,660	654	834	1,007
Outflow Watersheds	359	141	181	188	379	477	491	95,868	123,125	126,939	323	413	425
Lake Mitchell	661	102	203	207	358	579	586	81,676	141,917	143,664	413	701	710
Purgatory	2,873	663	882	941	1,763	2,270	2,406	440,095	578,401	615,695	1,491	1,947	2,070
Red Rock Lake	1,044	154	279	303	485	770	826	117,673	195,904	211,351	583	956	1,030
Rice Marsh Lake	140	8	29	40	42	89	115	6,334	20,226	27,467	28	71	94
Round Lake	398	95	99	98	271	285	280	63,258	67,007	65,736	317	335	328
Lake Smetana	834	301	393	413	873	1,090	1,134	216,437	277,434	289,462	1,066	1,355	1,412
Staring Lake	4,582	1,165	1,573	1,663	3,141	4,107	4,333	773,190	1,038,725	1,100,526	2,631	3,505	3,708
NW Anderson Lake	218	62	86	97	185	238	261	44,544	59,241	65,560	121	159	175
SE Anderson Lake	7	1	2	2	3	7	7	721	1,671	1,628	2	4	4
SW Anderson Lake	285	57	55	55	186	183	183	43,097	42,278	42,128	118	116	116
TOTAL	**17,068**	**3,575**	**5,024**	**5,510**	**10,343**	**13,708**	**14,828**	**2,456,658**	**3,380,154**	**3,687,643**	**9,134**	**12,461**	**13,509**

4.3 Current BMP Treatment

The three primary BMPs in the City are: load reductions through the application of development rules; street sweeping and sump manhole maintenance. These BMPs were evaluated to estimate the pollutant removal and volume reduction each were currently providing and could be expected to provide in the future. The reductions were summed to estimate the total amount of pollutant removal or volume reduction, and applied to the load increase resulting from land use change to determine the net change in pollutant load and stormwater volume between 1990 and 2020.

4.3.1 Development Rules

To evaluate the impact of application of development rules, each parcel in the city was assigned a treatment level depending on when it was built and the treatment rules that were in place at that time. For each subwatershed, raw and treated TSS and TP loads were calculated for each subwatershed based on land use in 1990, 2000, and 2020.

The reduction attributed to development rules was calculated as follows. Say a parcel that was vacant in 1990 generated a 30 pound per year TSS load. After development, it generated a raw load of 100 pounds per year TSS. Treatment rules were applied to the raw post-development load: 100 pounds * 80 percent removal = 80 pounds removed per year. This parcel generated a raw load increase of 70 pounds per year, but treatment resulted in 80 pounds per year TSS removal. Thus development can result in a net decrease in TSS and TP load.

Treatment rules have been in place since 1988, so development after 1988 could be assumed to be treated to NURP standards (80 percent removal TSS, 60 percent removal TP). However, as discussed in Section 3.3 above, some development may not have required treatment under the rules. The estimated removal due to development rules was calculated as the raw load increase times the 80 percent NURP removal rate, times the estimated fraction of development built under the rules shown in Table 3.1

Table 4.2. Predicted TSS and TP load increases between 1990 and 2020 and estimated removal due to development rules.

Watershed ID	Total TSS Increase 1990 - 2020 (lbs/yr)	Development Rules TSS Removal (lbs/yr)	Total TP Increase 1990 - 2020 (lbs/yr)	Development Rules TP Removal (lbs/yr)
Birch Island	10,536	15,684	34	64
Bryant Lake	92,790	153,323	305	447
Duck Lake	2,434	4,047	8	37
Lower Riley Creek	124,589	188,663	411	476
Lake Riley	86,596	115,654	284	290
Lower MN	106,778	170,689	353	440
Outflow Watersheds	31,071	49,541	102	124
Lake Mitchell	61,989	114,427	296	399
Purgatory	175,600	306,098	579	742
Red Rock Lake	93,678	169,595	447	574
Rice Marsh Lake	21,133	28,467	66	72

Watershed ID	Total TSS Increase 1990 - 2020 (lbs/yr)	Development Rules TSS Removal (lbs/yr)	Total TP Increase 1990 - 2020 (lbs/yr)	Development Rules TP Removal (lbs/yr)
Round Lake	2,478	4,700	12	18
Lake Smetana	73,025	121,030	346	410
Staring Lake	327,336	493,086	1,077	2,027
NW Anderson Lake	21,016	35,228	55	75
SE Anderson Lake	907	1,448	2	3
SW Anderson Lake	-970	921	-3	2
TOTAL	**1,230,985**	**1,972,599**	**4,375**	**6,198**

4.3.2 Sump Manholes

The City of Eden Prairie maintains over 600 sump manholes. Much of the volume of material that accumulates in the sump is trash and organic material such as leaves, and sand and sediment particles that are too heavy to become suspended in stormwater as TSS. To estimate the fraction of material removed from sumps that would likely have become a part of the TSS load, three samples of material were collected from sump manholes and analyzed for particle size. Approximately 8.3 percent of the material grains fell into the P8 TSS particle size class distribution (see Table 4.3). It was assumed then that 8.3 percent of the average annual volume of material removed from sump manholes was material that likely would have contributed to the downstream TSS load. To calculate the estimated annual TP removal from sump manholes, the P8 fraction of TP associated with TSS (3,850 mg/kg) was applied to the 5.1 percent that fell into the particle size distribution P0% to P50%. A literature value of 300 mg/kg was applied to the 3.2 percent that fell into the P80% class. The annual average removal of TSS and TP were applied to each subwatershed according to the number of sump manholes in that subwatershed (Table 4.4).

Table 4.3. Particle size breakdown by NURP particle size class for three samples taken from sump manholes in Eden Prairie.

NURP Particle Class	% of Sample			Particle Class Average %
	Sample 1	Sample 2	Sample 3	
P0%	0.0	0.0	0.0	0.00
P10%	1.1	1.1	6.0	2.73
P30%	0.1	0.0	1.6	0.57
P50%	0.5	0.5	4.3	1.77
P80%	1.0	1.1	7.6	3.23
Total	2.7	2.7	19.5	8.30

Table 4.4. Number of sump manholes and estimated TSS and TP removed annually by subwatershed.

Watershed	Number of Sump Manholes in Watershed	TSS Removal From Sump Manholes (pounds)	TP Removal From Sump Manholes (pounds)
Birch Island	7	1,180	3
Bryant Lake	52	8,764	22
Duck Lake	4	674	2
Lower Riley Creek	56	9,438	23
Lake Riley	31	5,224	13

Watershed	Number of Sump Manholes in Watershed	TSS Removal From Sump Manholes (pounds)	TP Removal From Sump Manholes (pounds)
Lower MN	29	4,887	12
EP Outflow Watersheds	3	506	1
Lake Mitchell	33	5,561	14
Purgatory	112	18,875	47
Red Rock Lake	58	9,775	24
Rice Marsh Lake	14	2,359	6
Round Lake	23	3,876	10
Lake Smetana	18	3,034	8
Staring Lake	198	33,369	83
NW Anderson Lake	3	506	1
SE Anderson Lake	0	0	0
SW Anderson Lake	2	337	1
TOTAL	**643**	**108,365**	**269**

4.3.3 Street Sweeping

The City of Eden Prairie has a street sweeping program and maintains detailed records of material removed from streets. As described above in section 4.3.2, three samples of street sweepings were analyzed and an actual particle size distribution developed. Based on that analysis, it is estimated that about 5.5 percent of the volume of street sweepings was of a particle size that fell into the P8 TSS particle size class distribution (see Table 4.5). That percent was applied to the average annual volume of street sweepings removed to obtain an estimate of TSS removal from sweeping, and as above, P8 and literature TP fractions were applied to estimate the volume of TP removed. The annual average removal of TSS and TP was allocated among the watersheds based on the impervious acres in that subwatershed, assuming that the subwatersheds with more impervious acres had more road surface that were swept (Table 4.6).

Table 4.5. Particle size breakdown by NURP particle size class for three samples taken from street sweepings in Eden Prairie.

NURP Particle Class	% of Sample			Particle Class Average %
	Sample 1	Sample 2	Sample 3	
P0%	0.0	0.0	0.0	0.00
P10%	1.6	1.6	1.1	1.43
P30%	0.5	0.5	0.0	0.33
P50%	2.2	1.7	0.8	1.57
P80%	2.7	2.7	1.1	2.17
Total	2.7	6.5	3.0	5.50

Table 4.6. TSS and TP removal as a result of street sweeping in the City of Eden Prairie.

Watershed ID	Impervious Watershed Area (acres)	TSS Removal (pounds)	TP Removal (pounds)
Birch Island	40	1,407	3
Bryant Lake	464	13,708	32
Duck Lake	42	1,214	3
Lower Riley Creek	290	8,026	19
Lake Riley	153	4,882	11
Lower MN	494	12,218	28
Outflow Watersheds	205	5,185	12

Watershed ID	Impervious Watershed Area (acres)	TSS Removal (pounds)	TP Removal (pounds)
Lake Mitchell	175	5,709	13
Purgatory	850	25,954	60
Red Rock Lake	277	8,357	19
Rice Marsh Lake	38	1,103	3
Round Lake	76	2,703	6
Lake Smetana	438	11,391	26
Staring Lake	1,573	45,867	106
NW Anderson Lake	79	2,675	6
SE Anderson Lake	2	55	0
SW Anderson Lake	37	1,517	4
TOTAL	**5,233**	**151,971**	**352**

4.3.4 Volume

Estimated volume increases for the major subwatersheds in the City are presented in Table 4.7. Although there is potential for a net loss from evaporation from constructed ponds, no BMPs or loss have been quantified for this study.

Table 4.7. Predicted volume increases in the City of Eden Prairie between 1990 and 2020.

Watershed ID	Watershed Area (acres)	Total Flow Increase 1990 - 2020 (ac.-ft. / yr)
Birch Island	201	39
Bryant Lake	1,443	338
Duck Lake	177	9
Lower Riley Creek	1,176	458
Lake Riley	580	312
Lower MN	2,090	394
Outflow Watersheds	359	112
Lake Mitchell	661	228
Purgatory	2,873	643
Red Rock Lake	1,044	340
Rice Marsh Lake	140	73
Round Lake	398	9
Lake Smetana	834	260
Staring Lake	4,582	1,192
NW Anderson Lake	218	77
SE Anderson Lake	7	4
SW Anderson Lake	285	-4
TOTAL	**17,068**	**4,485**

4.3.5 TSS Loading

The total predicted increase in TSS loading from 1990 to 2020 was compared to removals by active BMPs in the City to assess compliance with nondegradation. For all of the subwatersheds, annual TSS removals exceeded the estimated increase between 1990 and 2020 (Table 4.8).

Table 4.8. Predicted TSS load increases between 1990 and 2020 in comparison to BMP removals.

Watershed ID	Total TSS Increase 1990 - 2020 (lbs/yr)	TSS Removal			Net Removal (-) or Net Increase (+) (lbs)
		Development Rules (lbs)	MH Sump Clean-out (lbs)	Street Cleaning (lbs)	
Birch Island	10,536	15,684	1,180	1,407	-7,734
Bryant Lake	92,790	153,323	8,764	13,708	-83,004
Duck Lake	2,434	4,047	674	1,214	-3,500
Lower Riley Creek	124,589	188,663	9,438	8,026	-81,537
Lake Riley	86,596	115,654	5,224	4,882	-39,164
Lower MN	106,778	170,689	4,887	12,218	-81,017
Outflow Watersheds	31,071	49,541	506	5,185	-24,161
Lake Mitchell	61,989	114,427	5,561	5,709	-63,709
Purgatory	175,600	306,098	18,875	25,954	-175,327
Red Rock Lake	93,678	169,595	9,775	8,357	-94,049
Rice Marsh Lake	21,133	28,467	2,359	1,103	-10,797
Round Lake	2,478	4,700	3,876	2,703	-8,801
Lake Smetana	73,025	121,030	3,034	11,391	-62,429
Staring Lake	327,336	493,086	33,369	45,867	-244,986
NW Anderson Lake	21,016	35,228	506	2,675	-17,393
SE Anderson Lake	907	1,448	0	55	-596
SW Anderson Lake	-970	921	337	1,517	-3,745
TOTAL	**1,230,985**	**1,972,599**	**108,365**	**151,971**	**-1,001,950**

4.3.6 TP Loading

The total predicted increase in TP loading fro 1990 to 2020 was compared to removals by active BMPs in the City to assess compliance with nondegradation. For all of the subwatersheds, annual TP removals exceeded the estimated increase between 1990 and 2020 (Table 4.9).

Table 4.9. Predicted TP load increases between 1990 and 2020 in comparison to BMP removals.

Watershed ID	Total TP Increase 1990 - 2020 (lbs/yr)	TP Removal			Net Removal (-) or Net Increase (+) (lbs)
		Development Rules (lbs)	MH Sump Clean-out (lbs)	Street Cleaning (lbs)	
Birch Island	34	64	3	3	-36
Bryant Lake	305	447	22	32	-195
Duck Lake	8	37	2	3	-34
Lower Riley Creek	411	476	23	19	-107
Lake Riley	284	290	13	11	-30
Lower MN	353	440	12	28	-127
Outflow Watersheds	102	124	1	12	-35
Lake Mitchell	296	399	14	13	-130
Purgatory	579	742	47	60	-270
Red Rock Lake	447	574	24	19	-171
Rice Marsh Lake	66	72	6	3	-14
Round Lake	12	18	10	6	-22
Lake Smetana	346	410	8	26	-97
Staring Lake	1,077	2,027	83	106	-1,139
NW Anderson Lake	55	75	1	6	-28

Watershed ID	Total TP Increase 1990 - 2020 (lbs/yr)	TP Removal			Net Removal (-) or Net Increase (+) (lbs)
		Development Rules (lbs)	MH Sump Clean-out (lbs)	Street Cleaning (lbs)	
SE Anderson Lake	2	3	0	0	-1
SW Anderson Lake	-3	2	1	4	-9
TOTAL	**4,375**	**6,198**	**269**	**352**	**-2,444**

4.4 Model Sensitivity

Because the model is not calibrated and is only used for comparison purposes, it is useful to test the sensitivity of model to selected inputs, especially as we compare model results to real-world measured removals.

The first parameter that may affect the results of the model is the selection of the particle file. The current modeling is based on the NURP50 file, which represents the median concentrations from the NURP studies. To assess the potential effects of underestimating runoff concentrations, the Bryant Lake subwatershed was analyzed using both the median runoff concentrations (NURP50) and 90th percentile runoff concentrations (NURP90).

Results of the 50th and 90th percentile runs are presented in Table 4.10 and Table 4.11. Even if the actual concentrations were more similar to 90th percentile concentrations for both TSS and TP, the City of Eden Prairie would be meeting the nondegradation requirement.

Table 4.10. Bryant Lake subwatershed TSS loading and removals for the 50th and 90th percentiles of the NURP studies [update me].

Watershed ID	Total TSS Increase 1990 - 2020 (lbs/yr.)	TSS Removal			Net Removal (-) or Net Increase (+) (lbs)
		Development Rules (lbs)	MH Sump Clean-out (lbs)	Street Cleaning (lbs)	
Bryant Lake NURP 50	92,790	95,869	8,764	13,708	-25,551
Bryant Lake NURP 90	278,369	312,353	8,764	13,708	-56,456

Table 4.11. Bryant Lake subwatershed TP loading and removals for the 50th and 90th percentiles of the NURP studies.

Watershed ID	Total TP Increase 1990 - 2020 (lbs/yr)	TP Removal			Net Removal (-) or Net Increase (+) (lbs)
		Development Rules (lbs)	MH Sump Clean-out (lbs)	Street Cleaning (lbs)	
Bryant Lake NURP 50	306	273	22	32	-21
Bryant Lake NURP 90	647	608	22	32	-15

5.0 SUMMARY AND PROPOSED BMPS

The City of Eden Prairie, in conjunction with the Riley-Purgatory-Bluff Creek and Nine Mile Creek Watershed Districts, has been actively managing water quality for the past twenty years. These activities have included developing and enforcing rules to minimize water quality impacts from development; building and maintaining sump manholes throughout the city to collect sediment; and actively sweeping city streets to remove as much material as possible from the impervious surfaces. These activities have been very effective in the mitigation of increased TSS and TP loads from the watershed.

The increase in impervious surface between 1990 and 2000 has resulted in increased stormwater runoff volume, and that volume is expected to continue to increase with further development. Volume is difficult to remove from the watershed, and it is unlikely that the City will be able to attain 1988 volume conditions. However, the effects of increased runoff volume can be minimized or mitigated through stream bank and shoreline stabilization programs, infiltration, and rate control. Consequently, the best approach to addressing volume is through aggressive abstraction and mitigation and opportunistic volume control.

5.1 TOTAL SUSPENDED SOLIDS

The combination of development rules, manhole cleanout, and street sweeping has proved effective in reducing the volume of total suspended solids to a level well below that estimated to have been contributed in 1988. Most of that removal is a result of application of development rules and other regulations, but almost one-quarter is achieved through the aggressive street maintenance program. Each subwatershed meets the Nondegradation Total Suspended Solids requirement by removing more TSS through regulation and BMPs than the new load generated since 1988 (see Table 4.8). It should be noted that if any future TMDLs for any water resource to which Eden Prairie discharges requires additional TSS load reduction, then the City may be required to remove additional TSS or TP load beyond simply meeting the Nondegradation TSS and TP requirement.

5.1.1 Regulatory Program

Development rules will continue to require land-altering activities to provide at least NURP-level removal (80%) of Total Suspended Solids prior to discharge.

5.1.2 Manhole Sump Cleanout

This maintenance program removes not only smaller particles that contribute to Total Suspended Solids, but also larger particles of inorganic and organic material that can contribute to downstream clarity and water quality issues as well as obstruct pipes, create sediment deltas at outlets, and aggrade in streams and impair biotic functions. The sumps also collect trash and debris and prevent it from being discharged into downstream waters.

To maintain removal efficiencies, this cleanout task has to be conducted regularly. It is a costly activity, requiring significant labor, expensive vacuum equipment, and proper disposal of the removed material from the almost 650 sump manholes in the city. However, as described above, this activity has benefits well beyond assisting in meeting Nondegradation TSS removal requirements. The City will continue to operate and maintain the sump manholes in place throughout the storm sewer system.

5.1.3 Street Sweeping

This maintenance program removes not only smaller particles that contribute to Total Suspended Solids, but also larger particles of inorganic and organic material that can contribute to downstream clarity and water quality issues as well as obstruct pipes, create sediment deltas at outlets, and aggrade in streams and impair biotic functions. Street sweeping also improves traffic safety and general aesthetics by removing unsafe or unsightly materials from the streets.

The City currently annually contracts for street sweeping once per year –in the spring to remove sand and salt residue from winter de-icing plus any spring leaves and seeds and old organic material. Other street sweeping is performed throughout the year as necessary. The City recently purchased a second street sweeper to perform additional sweeping as staff is available.

Recent research in Wisconsin (Bannerman 2007) indicates that the incremental water quality benefit of increased street sweeping is small unless the frequency of sweeping is very aggressive. Street sweeping practices will be refined to improve the water quality and overall benefit of street sweeping:

1. Spring street sweeping will be performed as early as possible to remove material from the street before the spring rains.
2. Increased street sweeping frequency may be of benefit in sensitive locations, where there is noticeable aggradation in streams or below outfalls or where a UAA or TMDL indicates that efforts should be maximized to remove pollutant loading. The City will evaluate the potential benefits of a more aggressive schedule of street sweeping in sensitive areas.

5.1.4 Other Activities

The volume management activities described in section 5.3 below such as increased infiltration, biofiltration, and runoff volume controls may further reduce TSS and TP loading by pre-treating or reducing the amount of runoff volume conveying TSS and TP to waters.

5.2 TOTAL PHOSPHORUS

As with TSS, the combination of development rules, manhole cleanout, and street sweeping has proved effective in reducing the volume of total phosphorus to a level below that estimated to have been contributed in 1988. Most of that removal is a result of application of development rules, but almost 20 percent is achieved through the aggressive street maintenance program. Each subwatershed meets the Nondegradation Total Phosphorus requirement by removing more TP through regulation and BMPs than the new load generated since 1988 (see Table 4.9). It should be noted that if any future TMDLs for any water resource to which land in Eden Prairie drains requires additional TP or TSS load reduction, then the City may be required to remove additional TP or TSS load beyond simply meeting the Nondegradation TP and TSS requirement.

5.2.1 Regulatory Program

Development rules will continue to require land-altering activities to provide at least NURP-level removal (60%) of Total Phosphorus prior to discharge.

5.2.2 Manhole Sump Cleanout.

Phosphorus removal from this activity is calculated as a fraction of the TSS load, representing phosphorus that is either adsorbed to sediment particles or is part of an organic particle that is so small that it is suspended and considered part of the TSS load. This method of calculation ignores the larger organic particles (leaves both whole and shredded, seeds, grass clippings, etc.) that would not become part of the TSS load, but would be captured in the sump. Therefore, the method of calculation probably underestimates the amount of phosphorus reduction that can be achieved through settlement and removal in these sumps. These larger phosphorus sources also negatively impact downstream water quality.

To maintain the expected removal efficiencies, this cleanout task has to be conducted regularly. It is a costly activity, requiring significant labor, expensive vacuum equipment, and proper disposal of the removed material from the almost 650 sump manholes in the city. However, as described above, the phosphorus reduction achieved by this activity is probably greater than this analysis would indicate. The City will continue to operate and maintain the sump manholes in place throughout the storm sewer system.

5.2.3 Street Sweeping

As with the sump manholes above, this maintenance program removes not only smaller particles that are a fraction of the TSS load, but also larger particles of organic material that can contribute to downstream clarity and water quality issues. Street sweeping also improves traffic safety and general aesthetics by removing unsafe or unsightly materials from the streets, and reduces the amount of material on the street that can clog catch basin covers and limit street drainage.
The City currently annually contracts for street sweeping once per year –in the spring to remove sand and salt residue from winter de-icing plus any spring leaves and seeds and old organic material. Other street sweeping is performed throughout the year as necessary. The City recently purchased a second street sweeper to perform additional sweeping as staff is available.

Recent research in Wisconsin (Bannerman 2007) indicates that the incremental water quality benefit of increased street sweeping is small unless the frequency of sweeping is very aggressive. Street sweeping practices will be refined to improve the water quality and overall benefit of street sweeping:

1. Spring street sweeping will be performed as early as possible to remove material from the street before the spring rains.
2. Increased street sweeping frequency may be of benefit in sensitive locations, where there is noticeable aggradation in streams or below outfalls or where a UAA or TMDL indicates that efforts should be maximized to remove pollutant loading. The City will evaluate the potential benefits of a more aggressive schedule of street sweeping in sensitive areas.

5.2.4 Other Activities

The volume management activities described in section 5.3 below such as increased infiltration, biofiltration, and runoff volume controls may further reduce TP and TSS loading by pre-treating or reducing the amount of runoff volume conveying TP and TSS to waters.

5.3 VOLUME

This report estimates that stormwater volume in the city will increase by about 40 percent between 1990 and 2020, with most of that volume increase occurring between 1990 and 2000. Each subwatershed with the exception of SE and SW Anderson Lakes, Round Lake, and Duck Lake, significantly exceed the Nondegradation Volume Management requirement.

Where new volume is expected to be generated as a result of future development or redevelopment, the regulatory program can be a means to achieve some level of volume management. Best Management Practices in already-developed areas will likely be confined to small volume management practices retrofitted where opportunities arise, and mitigation of water quality-related impacts of volume such as streambank stabilization. The City's water resources and environmental education programs can also provide information to residential and other property owners on small-scale volume management practices for individual properties.

5.3.1 Regulatory Program

Abstraction/Infiltration. Neither the City nor the three watershed districts with land in the city require the infiltration or abstraction of stormwater runoff, although that concept is being discussed as a potential rule change. Abstraction is the removal of stormwater from runoff, and can include BMPs such as infiltration, evapotranspiration, pervious pavement, and capture and reuse. Most of the annual volume of stormwater runoff is generated by small rain events, so abstraction and infiltration of small events can significantly reduce the amount of annual runoff volume.

Precipitation-frequency curves derived from precipitation records at the Minneapolis-St. Paul International Airport can be used to estimate the percent of total annual volume that could be captured through infiltration. About 85 percent of annual stormwater volume is generated from the first one inch of rainfall – storm events of up to one inch, plus the first inch of events greater than one inch. A rule requiring abstraction of the first one inch of rainfall could theoretically reduce new runoff volume by 85 percent. About 80 percent of annual volume is generated from the first three-quarters inch and 65 percent from the first one-half inch of rainfall.

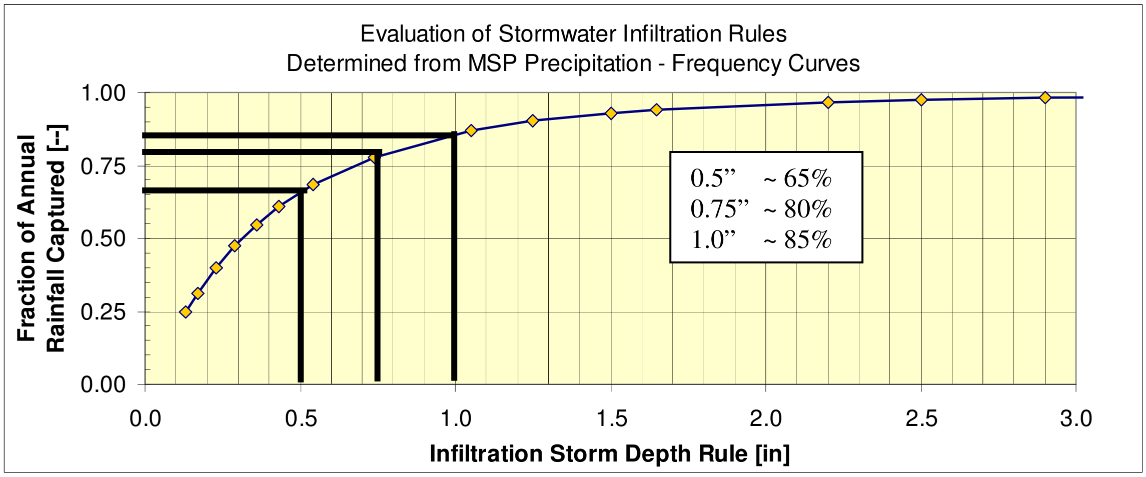

Figure 5.1. Annual stormwater volume that could be captured through abstraction/infiltration. (Wenck Associates, Inc. derived from MPCA Minnesota Stormwater Manual Appendix B.)

A secondary but important benefit of abstraction is that volume is no longer being contributed to runoff, and is not picking up and transporting pollutants to downstream waters. Research conducted by Prof. Robert Pitt (Pitt 1998) in the City of Milwaukee suggests that 25 percent of the annual total phosphorus load is conveyed in the first one-half inch of rainfall, and 15 percent of the annual TSS load. For the first inch of rainfall, that load is 65 percent of annual TP and 50 percent of annual TSS. In the Twin Cities, 90 percent of all rainfall events are one inch or less.

The most common form of abstraction is infiltration. A growing number of watershed management organizations are enacting infiltration rules, with one-half inch infiltration from new impervious surface common. The Ramsey-Washington County Watershed District and Capitol Region Watershed Districts recently enacted a one inch from new impervious surface rule, and the Minnehaha Creek Watershed District is considering one inch as well. The Nine Mile Creek Watershed District is discussing abstraction/infiltration of 0.75 inches, and anticipates considering a rule change in 2008. Following that action the City will adopt an abstraction/infiltration requirement that is consistent with the district requirement.

Adopting an abstraction requirement will reduce the new volume of runoff from developing and redeveloping areas. Eden Prairie soils are generally of soil hydrologic group B, with A soils on the bluffs area. These soils readily infiltrate. There are pockets of less permeable C and D soils, with most of the D soils in the northeast quadrant of the city around Bryant Lake. Most development and redevelopment should be able to successfully incorporate infiltration, although the area around Bryant Lake may require soil amendment to achieve any significant infiltration.

An abstraction requirement for new development will only address new volume predicted to occur between its promulgation and 2020 – about 1,120 acre-feet. However, in the very long-term, as existing development redevelops, the new volume generated between 1990 and 2000 and prior will slowly be mitigated as redevelopment and reconstruction occurs.

A requirement that required abstraction of three-quarters of an inch could reduce new annual volume by about 80 percent. The projected new stormwater volume between 2000 and 2020 is 1,120 acre-feet. If 80 percent, or 900 acre-feet was abstracted/infiltrated by rule, then the net new stormwater volume during that period would be approximately 220 acre-feet.

Soil Management Plan requirement. An assumption in calculating stormwater volume to be captured from an abstraction requirement is that the part of the site that is pervious and infiltrating stormwater pre-construction will be as pervious and infiltrate at least as much stormwater volume post-construction. In reality, construction activities such as mass grading, road and utility construction, and structure construction lead to soil compaction and loss of permeability.

To maximize the effectiveness of an infiltration requirement, the City will consider revising its Land Alteration Permit requiring development and redevelopment to submit a Soil Management Plan that details how the developer plans to 1) minimize soil compaction from construction activities, and 2) restore site permeability through actions such as post-construction soil ripping or soil amendment.

Encourage Low Impact Development (LID). Low Impact Development encourages developers to consider stormwater impacts of new development early in the planning process. The City's zoning code includes provisions for Planned Unit Developments that may vary from strict application of zoning requirements to make it easier to tailor a development to the terrain and minimize stormwater impacts such as new volume. The City should review its zoning code and Planned Unit Development process to consider means such as zoning or development incentives to encourage developers to creatively apply LID principles to minimize new stormwater volumes and pollutant loading.

5.3.2 Education Program

The City has in place an education and outreach program to provide information to various audiences on a wide variety of stormwater management and water quality issues. This program will target both residential property owners and commercial property owners on ways to incorporate small infiltration practices on their property. Small-scale practices such as rain gardens, conversion of turf to native vegetation, pond and wetland buffers, installation of rain barrels and cisterns, and use of pervious pavement and pavers, can add up to significant water quality and stormwater reductions when broadly applied. The City will also develop targeted information for developers on incorporating Low Impact Development principles and water quality and volume management into development and redevelopment.

5.3.3 Structural Improvements

Structural BMPs to manage storm water volume will be constructed as stand-alone projects or incorporated into other projects such as street reconstruction as opportunities arise. These BMPs store and infiltrate or evapotranspirate stormwater at the street, block, or neighborhood scale. The cost per acre-foot for these types of BMPs can be significant as stand-alone projects, but may be more cost-effective when combined with other improvements such as a neighborhood street reconstruction project. These types of BMPs also will have the benefit of further reducing pollutant loading.

Where it is difficult or too costly to significantly reduce new stormwater volume, downstream water resources will be protected from adverse effects through restoration and stabilization projects.

Infiltration basins. An infiltration basin is a shallow, vegetated basin designed to hold and infiltrate stormwater. Some evapotranspiration also occurs. Infiltration basins can have a significant ongoing maintenance cost. Over time sediment discharged into the basins accumulates and reduces the infiltration capacity. This sediment must be removed periodically and permeability restored through soil ripping, soil amendment, etc.

Constructed wetlands. Constructed wetlands can decrease stormwater volume through evapotranspiration from wetland vegetation as well as evaporation from open water stored in the wetland.

Underground infiltration. New technologies are available to construct infiltration devices under large paved areas such as parking lots or streets. These use bottomless underground chambers constructed on permeable bedding material to store and infiltrate runoff. There is an ongoing annual cost to remove and dispose of accumulated material from the device.

Streambank stabilization. The new volume of storm water generated through land use change is conveyed through the system of lakes, wetlands, and small channels into the major streams that drain the City: Riley Creek, Purgatory Creek, Nine Mile Creek, and to a lesser extent, Bluff Creek. This additional volume increases peak flow rates and elevations in the streams, and has the potential to destabilize and erode streambanks. The increased peak flows and streambank erosion also may stress biological communities in the streams.

These adverse impacts can be mitigated by strengthening streambanks and restoring areas of existing erosion, as well as considering structural amendments to the stream channel such as rock vanes. Habitat lost to past impacts can be mitigated with this restoration by revegetating streambanks, adding step pools, and enhancing substrate.

The City and the watershed districts have performed general inventories of the major streams to identify areas of existing erosion. The City should work in partnership with the watershed districts to undertake a program of stream restoration. These projects would range from simple spot repairs of streambanks to potential total restoration of the stream. These projects should combine both stabilization and habitat enhancement. The cost of stream and shoreline restoration can vary depending on the extent of existing erosion, access to the site, and whether easements would be required. In some cases both streambank and in-stream restoration may be required to restore stability and enhance habitat that has been degraded by sedimentation.

5.3.4 Nonstructural Improvements

Reforestation. Urban trees are an integral part of the storm water management system. Trees intercept rain and snow fall, storing event volume for later evaporation. Trees also use surface storage for transpiration, removing additional stormwater volume from the stormwater system. Trees have other benefits as well. Trees increase property values, provide habitat, take in CO2 and release oxygen, enhance neighborhood aesthetics, and decrease home heating and cooling costs. The City recognizes this value by requiring, by ordinance, replacement of trees lost to construction or land alteration.

Numerous studies have been conducted estimating the volume of rainfall that trees intercept (for example, Xiong et al 2000, McPherson 2005) This annual volume is dependant on the type and species of tree, and whether the tree is isolated, such as an urban street tree, or part of a forest canopy. For example, evergreen trees can intercept and store more stormwater than deciduous trees because their narrow leaves provide a greater leaf surface area. The volume also depends on the intensity of the storm, with less intense events resulting in more interception. On average, however, literature suggests that an isolated deciduous tree can intercept approximately 25 percent of the annual volume of rainfall that falls upon it. Combined with the daily water use for transpiration (Wullschleger 1998), it is estimated that a single deciduous tree can evapotranspirate 2,000 - 3,000 gallons of stormwater per year. A coniferous tree can evapotranspirate an even greater amount.

It is estimated that about 10,900 trees could evapotranspirate about 100 acre-feet of stormwater volume. The City will develop a reforestation program to reduce the amount of rainfall that runs off the landscape. With approximately 10,500 single family detached units and another 4,000 single family attached units, a goal of planting at least one tree per single family unit could as the trees mature provide about 150 acre-feet of stormwater volume management. Additional reforestation in commercial and industrial areas, parks, schools, and other public and open spaces will provide additional volume management benefits.

6.0 SWPPP MODIFICATIONS

The following are the proposed modifications to the City of Eden Prairie SWPPP to address the findings of this analysis.

6.1 TOTAL SUSPENDED SOLIDS

The City currently meets the Total Suspended Solids requirement. Modifications to the SWPPP are confined to some refinement of the BMPs for those activities that reduce TSS.

6.1.1 Regulatory Program

Development rules will continue to require land-altering activities to provide at least NURP-level removal (80%) of Total Suspended Solids prior to discharge. BMP 4a-1 Construction Site Runoff Control and BMP 5b-1 Post-Construction Site Runoff Control will be revised to provide for amendment of local controls and the local water management plan to specify this as a minimum level of pollutant removal performance.

6.1.2 Manhole Sump Cleanout

To maintain removal efficiencies, this cleanout task has to be conducted regularly. BMP 6b-2 Annual Inspections and BMP 6b-5 Inspection Followup describe the actions the City will take to inspect these sump manholes and perform necessary maintenance. No modifications are necessary to the SWPPP to adequately document these actions, however, SWPPP narrative will highlight that these facilities are an important component of the pollutant removal system.

6.1.3 Street Sweeping

1. BMP 6a-2 Street Sweeping will be revised to provide that spring street sweeping be performed as early as possible to remove material from the street before the spring rains.
2. Increased street sweeping frequency may be of benefit in sensitive locations, where there is noticeable aggradation in streams or below outfalls or where a UAA or TMDL indicates that efforts should be maximized to remove pollutant loading. BMP 6a-2 Street Sweeping will be revised to add an evaluation of the potential benefits of a more aggressive schedule of street sweeping in sensitive areas, including the generation of a map of those sensitive areas.

6.1.4 Other Activities

The volume management activities described in section 5.3 above such as increased infiltration, biofiltration, and runoff volume controls may further reduce TSS loading by pre-treating or reducing the amount of runoff volume conveying TSS to waters. BMP 5a-1 Post Construction

Structural and Nonstructural BMPs will be amended to incorporate these practices into city construction projects.

6.2 TOTAL PHOSPHORUS

The City currently meets the Total Phosphorus requirement. Modifications to the SWPPP are confined to some refinement of the BMPs for those activities that reduce TP.

6.2.1 Regulatory Program

Development rules will continue to require land-altering activities to provide at least NURP-level removal (60%) of Total Phosphorus prior to discharge. BMP 4a-1 Construction Site Runoff Control and BMP 5b-1 Post-Construction Site Runoff Control will be revised to provide for amendment of local controls and the local water management plan to specify this as a minimum level of pollutant removal performance.

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6.2.4 Other Activities

The volume management activities described in section 5.3 above such as increased infiltration, biofiltration, and runoff volume controls may further reduce TP loading by pre-treating or reducing the amount of runoff volume conveying TP to waters. BMP 5a-1 Post Construction Structural and Nonstructural BMPs will be amended to incorporate these practices into city construction projects.

6.3 VOLUME

The City will work cooperatively with the three watershed districts with land in the city to coordinate regulatory volume management BMPs with watershed district rules.

6.3.1 Regulatory Program

Abstraction requirement. BMP 4a-1 Construction Site Runoff Control and by reference BMP 5b-1 Post-Construction Site Runoff Control will be revised to provide for review and amendment of local controls and the local water management plan to evaluate and implement an abstraction/infiltration requirement for new development and redevelopment that is consistent with watershed district requirements.

Soil Management Plan requirement. BMP 4a-1 Construction Site Runoff Control and by reference BMP 5b-1 Post-Construction Site Runoff Control will be revised to provide for review and amendment of local controls and the local water management plan to evaluate and implement a soil management plan requirement for new development and redevelopment.

Evaluate regulatory means to encourage Better Site Design (LID). A new BMP in Minimum Measure 5 will be added provide for a review of City Ordinances and procedures to identify means such as zoning or development incentives to encourage developers to creatively apply LID principles to minimize new stormwater volumes and pollutant loading.

6.3.2 Education Program

The City undertakes an education and outreach program to providing education to various audiences on a wide variety of stormwater management and water quality issues. These are described in various BMPs implementing Minimum Measure 1: Public Education and Outreach. These BMPs adequately generally describe the education and outreach program. Specific topics to be covered in these activities vary from year to year. The annual list of topics will include information on small practices for water quality and volume management such as rain gardens, conversion of turf to native vegetation, installation of rain barrels and cisterns, and use of pervious pavement and pavers. Topics will also include developer education regarding stormwater management.

6.3.3 Structural Improvements

Structural Projects. Structural BMPs will be constructed as stand-alone projects or incorporated into other projects such as street reconstruction as opportunities arise. The highest need is for the reduction of new stormwater volume generated since 1988. Most structural volume-management improvements are not cost-effective as stand-alone projects, but may be more cost-effective if they can be incorporated into other projects such as street reconstruction. BMP 5a-1 Structural and Nonstructural BMPs will be revised to incorporate pollutant loading and volume management BMPs on city projects.

Mitigation Projects. Where it is difficult to significantly reduce new stormwater volume, downstream water resources can be protected from adverse effects through restoration and stabilization projects. BMP 5a-1 Structural and Nonstructural BMPs will be revised to incorporate development of a stream and shoreline restoration program to mitigate past erosion, enhance habitat, and prevent future erosion. This program will include city or watershed district projects, and a grant program to provide assistance to property owners in completing such projects.

6.3.4 Nonstructural Improvements

Reforestation. A new BMP in Minimum Measure 5 will be added to develop and initiate a City Reforestation program.

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