INVER GROVE HEIGHTS
Northwest Area

Chapter 7

Stormwater Sizing Criteria

Northwest Area (NWA) Inver Grove Heights Stormwater Manual

Stormwater Sizing Criteria

Chapter 7

Key Topics: **stormwater sizing terminology, stormwater sizing criteria, recharge and infiltration standard, peak discharge standard, pretreatment standard, wetland bounce standard, redevelopment projects**

Contents

I. Introduction

This chapter outlines for stormwater professionals an approach for consistent sizing of stormwater management practices within the NWA that:

- **Perform Effectively**
  Manage enough runoff volume to address the problem it is intended to address.
- **Perform Efficiently**
  Manage just enough runoff volume to address the problem but not over-control it. More storage is not always better, and can greatly increase construction costs.
- **Be Simple to Administer**
  Be understandable, relatively easy to calculate with current hydrologic models, and workable over a range of development conditions and intensities. In addition, criteria should be clear and straightforward to avoid needless disputes between design engineers and plan reviewers when they are applied to development sites, while also eliminating any competitive disadvantages that are created when uniform regulations do not exist.
- **Promote Better Site Design**
  Be structured in a manner so that property owners have real incentives to reduce storage volumes (and costs) by applying better site design techniques (Chapter 4).

II. Overview of NWA Stormwater Sizing Framework

This section reviews the key stormwater sizing concepts and terminology used in the chapter and presents an overview of the framework for managing stormwater in the NWA.

Table 7.1 Review of Key Stormwater Sizing Terminology

Term	Definition:
Better Site Design	Better site design refers to the application of non-structural practices at new development sites to reduce site impervious cover, conserve natural areas, and use pervious areas to more effectively treat stormwater runoff. Also known as low impact development.
Design Storm	An engineering term for a single rainfall event with a defined intensity, duration and statistical recurrence interval ranging from 0.5 years up to 100 years. These single event storms are based on long-term rainfall data, and are used in hydrologic models to predict the peak discharges and runoff volumes associated with each type of storm. Unless otherwise indicated, all design storms in this chapter have a 24 hour duration and a Type 2 distribution.
Detention Time	Various definitions for detention time exist in hydraulic manuals and in help screens in computer models. For this Manual, a simple method of computing detention time is recommended. Detention time is equal to the length of time starting at basin full (for a specific design storm) and ending when either the basin is dry (filtration or infiltration) or the basin has attained normal water level (stormwater ponds or constructed wetlands).

Table 7.1 Review of Key Stormwater Sizing Terminology	
Term	**Definition:**
Hydrologic Soil Group	HSG is a USDA-NRCS designation given to different soil types to reflect their relative surface permeability and infiltrative capability. Group A soils have low runoff potential and high infiltration rates; Group B soils have moderate infiltration rates; Group C soils have low infiltration rates; and Group D soils have high runoff potential with very low infiltration rates and consist chiefly of clay soils (TR-55, 1986). See Chapter 8 for further discussion and classification of soils within the NWA.
Landlocked Basin	A basin that does not discharge under back-to-back 100-year, 24-hour rainfall events.
Pre-Development Conditions	The term pre-development can be interpreted many different ways. The City of Inver Grove Heights uses land cover conditions immediately preceding the current development project as the pre-development condition.
Regional Bains	Existing basins that the City has identified as being critical to the stormwater management plan and infrastructure of the Northwest Area of Inver Grove Heights. Grading within the HWL of these regional basins (defined by the critical event or 100-year 10-day snowmelt event) is generally prohibited. Potential encroachment on the basins storage volume or identified overflows shall be discussed with City Staff. A map of regional basin locations and overflows can be obtained from the City.
Sensitive Receiving Waters	The receiving waters in the NWA consist of landlocked wetlands which have been classified according to their sensitivity to stormwater impacts. Refer to Figure 2.10 and Table 2.4 for wetland management classifications and criteria.
Volume Control	Refers to volume of runoff which should be spread over pervious areas and otherwise infiltrated into the soil to promote groundwater recharge and maintain the natural hydrology of the system. The volume control standard for the NWA is: infiltrate the difference in the pre-and post-development volume for the 5-year 24-hour rainfall event.
Water Quality/Pretreatment	Generic term for the storage used to capture, treat and remove pollutants in stormwater runoff. It is normally expressed as a volume (watershed-inches or acre-feet).

Table 7.1 Review of Key Stormwater Sizing Terminology	
Term	**Definition:**
Worst-Case Design Event	The greatest runoff storage is used to detain the peak discharges of infrequent but very large storm events to predevelopment levels. The 100-year design storm, which has a statistical recurrence interval of occurring once in a hundred years is used by most communities. Extreme floods can cause catastrophic damage and even loss of life.

The goal of stormwater management is to provide effective control for each management scenario in order to produce post-development hydrology that most closely resembles the City's defined pre-development conditions at the development site. Each criterion defines a unique storage volume that should be managed at the site. Table 7.2 profiles the required sizing criteria for each of the stormwater management standards. The next four sections of the chapter describe each of the sizing criteria, including how they are calculated.

Table 7.2 Review of Stormwater Sizing Criteria	
Term	**Definition:**
Volume Control Standard	No increase in runoff volume from the site for the 5-year 24-hour rainfall event (3.6 inches).
Peak Discharge (Rate Control Standard)	Rate control for the 2-, 10- and 100-year 24-hour rainfall events.
Water Quality / Pretreatment Standard	The amount of pretreatment required depends upon both the amount of impervious area and type of drainage system that is being used. Figure 7.1 should be used to clarify the type of drainage system that is being utilized and decide when structural pretreatment devices are necessary to meet the 85% TSS removal requirement.
Wetland Bounce	No increase in bounce for Manage 1 Wetlands and up to a half a foot of bounce for Manage 2 Wetlands for the 100-year 24-hour rainfall event.

III. Volume Control (Recharge and Infiltration) Standard

The intent of this sizing criterion is to maintain the pre-development hydrology of the NWA, a landlocked system, as closely as possible. Under natural conditions, the amount of recharge that occurs at a site is a function of slope, soil type, vegetative cover, precipitation and evapotranspiration. Sites with natural ground cover, such as forest and meadow, typically exhibit higher recharge rates, less runoff and greater transpiration losses than sites dominated by impervious cover. Since development increases impervious cover, there is a net decrease in recharge and a corresponding increase in stormwater runoff volume.

The recharge volume is determined by taking the difference between the pre-development volume for the 5-year 24-hour event and the post-development volume for the same event. Recharge can be achieved either by a structural BMP (e.g. infiltration, bioretention, vegetated swale), better site design techniques, or a combination of both.

For additional information on how this standard was established see the following report: City of Inver Grove Heights – Northwest Area Surface Water Modeling Report, August 2006.

IV. Peak Discharge (Rate Control Standard)

The intent of this sizing criterion is two-fold: controlling peak discharge for the 2-year 24-hour event prevents habitat degradation and erosion in urban streams (open ditch flow) and controlling peak discharge for the 10- and 100-year 24-hour events prevents flood damage to conveyance systems and infrastructure and reduces minor flooding caused by overbank floods.

Channel Protection Volume (2-year 24-hour Rate Control)

Historically, 2-year 24-hour peak discharge control has been the most widely applied local criteria to control channel erosion in Minnesota, and many communities continue to use it today. More specifically, 2-year peak control seeks to keep the post-development peak discharge rate for the 2-year 24-hour rainfall event at pre-development rates. The reasoning behind this criterion is that the bankful discharge for most streams has a recurrence interval of between 1 and 2 years, with approximately 1.5 years as the most prevalent (Leopold, 1964 and 1994), and maintaining this discharge rate should act to prevent downstream erosion.

Overbank Flood Volume (10- and 100-year 24-hour Rate Control)

Most local reviewing authorities establish an overbank design storm that is matched with the same design storm used to design open channels, culverts, bridges, and storm drain systems. Most localities in Minnesota require that post-development peak discharge rates from the 10-year and 100-year, 24 hour design storm event be controlled to predevelopment rates.

In general, the storage volume needed to manage the 100-year return design storm is much greater than the 10-year design storm. Modeling has shown that control of the 10-year storm coupled with control of the 100-year storm effectively attenuates storm frequencies between these two events (e.g., the 25-year storm).

V. Water Quality/Pretreatment Standard

As stormwater runoff travels across the landscape, it picks up pollutants associated with urban and agricultural practices, transporting them to the nearest downstream receiving water body. For example, runoff from parking lots picks up oil and grease dripped from cars, asbestos from worn brake linings, and zinc from tires. Pesticides, herbicides and fertilizers are washed off from landscaped areas, and soils are washed away from construction sites. The most common pollutants associated with stormwater runoff include: oils and greases, metals, sediments, oxygen-demanding substances, nutrients, toxic organic compounds, fecal coliform, bacteria and pH. To reduce the amount of pollutants found in stormwater runoff make sure you are practicing proper pollution prevention techniques by reviewing Chapter 5 of the manual.

In a traditional pipe and pond scenario, these pollutants find their way to lakes, wetlands and streams. In a landlocked system, such as the NWA, where there is no outlet, these stormwater pollutants can end up in the most downstream water body or depression and sometimes in the groundwater system as the stormwater is retained and allowed to infiltrate. The pretreatment of stormwater prior to infiltration is important for the following reasons:

- The infiltration of significant volumes of stormwater runoff may contribute to the pollution of groundwater resources
- The maintenance requirements of stormwater infiltration practices are dependent upon the amount of sediment and other pollutants being delivered to the practice

In addition, pretreatment can be used to dampen the effects of high or rapid inflow, dissipate energy levels of stormwater runoff and provide additional storage.

Methods of Pretreatment

There are a number of pretreatment practices available to the design engineer for treating stormwater runoff prior to infiltration. In general, pretreatment practices should be included in the treatment train approach to stormwater management and be designed to handle the first flush of runoff generated during a precipitation event. The Designer shall ensure that the design of pretreatment practices complies with the NPDES Stormwater Permitting Program.

Non-Structural Pretreatment Practices/Source Reduction or Pollution Prevention

Source reduction is an effective non-structural way of controlling the amounts of pollutants entering stormwater runoff. A wide range of pollutants are washed off of impervious surfaces during runoff events. Removing these contaminants from the urban landscape prior to precipitation can effectively limit the amounts of pollutants contained in the stormwater runoff. Source reduction can be accomplished by a number of different processes including:

- Limiting applications of fertilizers, pesticides and herbicides;
- Periodic street sweeping to remove trash, litter and particulates from streets;
- Collection and disposal of lawn debris;
- Periodic cleaning of catch basins;
- Elimination of improper dumping of used oil, antifreeze, household cleaners, paint, etc. into storm drains;
- Identification and elimination of illicit cross-connections between sanitary sewers and storm sewers.

For more information on source reduction or pollution prevention techniques see Chapters 5 and 8.

Structural Pretreatment Practices

- Filtration Systems – Use some combination of a granular filtration media such as sand, soil, organic material, carbon or a membrane to remove constituents found in runoff.
- Vegetated Systems – Designed to convey and treat shallow flow or sheet flow runoff. Includes grass channels (biofilters), dry swales, wet swales and filter strips.
- Proprietary settling/swirl chambers – Include systems that remove particulates and litter prior to discharge to BMP that do not fit in any of the above categories (e.g. catch basin inserts, hydrodynamic devices and filtration systems).
- Stormwater Ponds/Detention Systems – Capture a volume of runoff and temporarily retain that volume for subsequent release. Detention systems do not retain a significant permanent pool of water between runoff events.

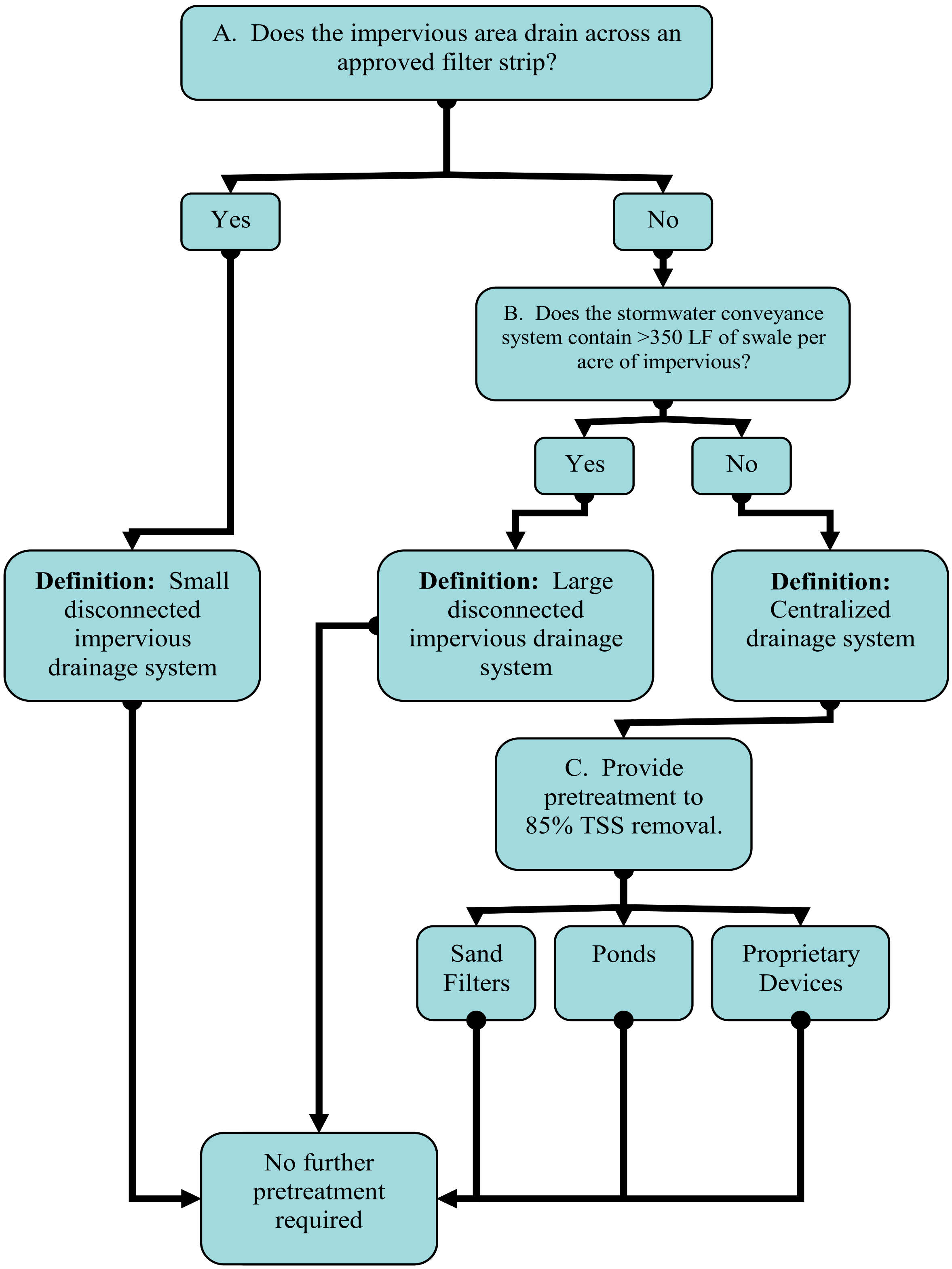
For more detailed information on the design and construction of structural pretreatment practices see Chapter 8.

Applying Structural Pretreatment Practices in the Northwest Area

Various land use settings inherently provide for more pretreatment than other landuse settings. For example: stormwater runoff from residential rooftops that discharges to the rear-yard area receives more pretreatment than residential rooftops that drain directly to the stormwater system. Therefore, the pretreatment requirements that are required for each site will depend on the site characteristics and grading plan.

Every infiltration practice will require some pretreatment to extend the life of the practice. The amount of pretreatment required depends upon both the amount of impervious area and type of drainage system that is being used. Figure 7.1 should be used with the following text to define the type of drainage system

Figure 7.1 Pretreatment Flow Chart



that is required and decide where structural pretreatment devices are necessary. The three types of drainage systems are 1) "small disconnected drainage system", 2) "large disconnected drainage system" or 3) "centralized drainage system". Drainage systems 1 and 2 do not require any additional pretreatment devices because pretreatment is met through disconnection of impervious surfaces. Drainage system 3 requires the use of a BMP to accomplish 85% TSS removal. Design requirements for these BMPs are discussed in further detail in Chapter 8.

A. Identify all impervious areas that flow over an approved filter strip.

Definition - Approved Filter Strip
There are two general settings in which pretreatment may be provided by filter strip. Areas that fall under this category do not need to provide additional pretreatment. Filter strip pretreatment for settings not covered here require pre-approval by the City Engineer. More information about filter strips can be found in chapter 8.

- Impervious areas less than 0.25 acre that drain across grass filter strips with the minimum dimensions shown in Table 7.3 meet pretreatment requirements and no further pretreatment is required. Use Table 7.3 to find the necessary length of filter strip. The purpose of this drainage system distinction is to recognize pretreatment for disconnected impervious areas such as rooftops that drain through yards, crowned driveways, patios, sheds and other small areas of impervious that drain over large pervious areas before entering the stormwater system.

Table 7.3 Filter Strip Sizing

Parameter	Impervious Parking Lots & Streets				Rooftops			
Inflow Approach Length [ft.]	0-35		>35		0-35		>35	
Filter Strip Slope	<2%	2-5%	<2%	2-5%	<2%	2-5%	<2%	2-5%
Filter Strip Minimum Length	10'	15'	20'	25'	10'	12'	15'	18'

- Filter strips may be used as pretreatment for linear infiltration practices such as infiltration trenches along roadways. The roads, filter strip, and infiltration practices must be designed to allow sheetflow from the road through the filter strip before the runoff enters the infiltration practice. If runoff is concentrated and channelized then the drainage area is considered connected and additional pretreatment is necessary.

To establish that the impervious area falls into this category, it is helpful to examine the impervious/pervious interface. If more than 0.25 acres of impervious surface drains to any one point, then the impervious surface is NOT a small disconnected impervious drainage system. The dimensions in Table 7.3 must also be met.

- Small disconnected impervious areas must be identified on the site plan to be excluded from sizing of pretreatment facilities.

B. Identify all areas that are part of a large disconnected impervious drainage system

Definition – Large Disconnected Drainage System
If the drainage area to the infiltration BMP is conveyed through vegetated swales or buffers that meet the specified criteria, the BMP is considered a large disconnected drainage system.

- Large disconnected drainage systems meet the pretreatment requirement through filtering in vegetative channels but must contain at least 350 LF of channel per acre of impervious. Large disconnected drainage systems generally exist in areas developed with rural road cross-sections where stormwater is conveyed through grassed channels and/or swales.

- Large disconnected drainage areas must be shown on the site plan to be excluded from sizing of pretreatment facilities.

C. Design Filter, Pond, or Proprietary device to remove 85% TSS for remaining impervious drainage area. The remaining impervious area is classified as a centralized drainage system. Filters, ponds and other BMPs are discussed in detail in Chapter 8.

- Identify the remaining impervious area on the site plan. This is the runoff area that should be used to size pretreatment facilities.
- Use the following sizing criteria for pretreatment facilities. Other practices may be pre-approved at the city engineer's discretion.

Sand Filters

An operation and maintenance plan must be developed to ensure that sand filters are adequately maintained to provide pretreatment.

Recommendations:

- Use an 18-inch thick filter bed
- Use a sand media with a coefficient of permeability of 3.5 ft/day (1.75 in/hr)
- Set the maximum head on the filter to 6 feet
- Drain the filter bed within 72 hours, 48 hours if need to meet MPCA permit requirements

The filter area for a sand filter that has the recommended characteristics can be sized based on the following equation.

$$A_f = 0.0476 * V_{wq}$$

The filter area for a non-standard filtration system is sized using the following equation (based on Darcy's Law).

$$A_f = (V_{wq})\ (d_f)\ /\ [(k)\ (h_f + d_f)\ (t_f)]$$

Where:

A_f = Surface area of filter bed ft^2
V_{wq} = Water quality volume (ft^3)
d_f = Filter bed depth (ft)
k = Coefficient of permeability of filter media (ft/day)
h_f = Average height of water above filter bed (ft)
t_f = Design filter bed drain time (days)

Ponds

- Design to NURP standards
- Permanent Pool Volume =1800 CF/Acre of Drainage
- Permanent Pool Depth = 3' – 10'

Proprietary Devices

- Must meet 85% TSS removal efficiency using standard particle size distribution
- Must have a means to remove soils and floatables
- Must have a maintenance plan for removing sediments

VI. Wetland Bounce Standard

Until recent years, wetlands were viewed as wastelands that were better drained or filled. It is estimated Minnesota has lost nearly 42 percent of its original wetland acreage (MN SWAG, 1997). Wetlands are now recognized as performing many important watershed functions and services, and their direct disturbance is closely regulated.

Stormwater runoff has the potential to impact the soils, flora and fauna, and water quality of wetlands. Disturbance to wetland hydrology can cause changes in the character of the ecosystem including species composition and richness, primary productivity, organic deposition and flux, and nutrient cycling. Naturally occurring quantities of runoff with seasonal fluctuations are essential for the maintenance of a wetland, and moderate amounts of nutrients and sediment in the runoff can increase a wetland's productivity. However, excessive stormwater runoff has the potential to alter the hydrology, topography, and the vegetative composition of a wetland (U.S. EPA, 1993). For example, an increased frequency and duration of inundation can degrade native wetland plant communities or deprive them of their water supply.

Stormwater runoff increases the temperature, conductivity, nutrients, metal and sediment loads to wetlands. Changes in wetland water quality alter the nature of the plant community, encouraging invasive species, and reducing sensitive species that are preferred by fish, mammals, birds, and amphibians for food and shelter (U.S. EPA, 1993).

Stormwater runoff inputs can exceed the water depths and frequency/duration of inundation prevalent in natural wetlands, leading to a die-out of vegetative species. Deposition of sediment carried by urban stormwater can have the same effect, causing replacement of diverse species with monotypes of reed canary grass or cattails, which are much more tolerant of sedimentation and fluctuating water levels. Schueler (2000b) reported that invasive or aggressive plant species are favored when water level fluctuation (WLF) is high (e.g., reed canary grass). The result is low vegetative diversity and lower quality wildlife habitat values (MN SWAG, 1997). A modest change in WLF sharply decreases plant species richness, and amphibian species richness a study in the Pacific Northwest (Horner, et al. 1996).

Not all wetlands respond in the same way to the impact of stormwater runoff. In the context of this manual, wetlands can be defined as Susceptible or Non-susceptible to stormwater runoff, based on the MN SWAG (1997) wetland classification scheme. This classification provides a useful framework for managing stormwater inputs to different types of wetlands.

Highly susceptible wetland communities can be composed of dozens of plant species. Table 7.4 presents the MN SWAG classification of wetland types according to their presumed susceptibility to degradation by stormwater. Given this diversity of wetland types, it is not surprising that wetlands have a broad range of tolerance to stormwater runoff input. Some wetlands (i.e. calcareous fens) are sensitive to any disturbance and will show signs of degradation with even low-level inputs of urban stormwater. Note that Susceptible Wetlands are defined as highly and moderately susceptible in Table 7.4 and Non-susceptible Wetlands are defined as slightly and least in the table.

Table 7.4: Susceptibility of Wetland Types to Degradation by Stormwater Input			
Highly Susceptible Wetland Types[1]	**Moderately Susceptible Wetland Types[2]**	**Slightly Susceptible Wetland Types[3]**	**Least Susceptible Wetland Types[4]**
▶ Sedge Meadows ▶ Open Bogs ▶ Coniferous Bogs ▶ Calcareous Fens ▶ Low Prairies ▶ Coniferous Swamps ▶ Lowland Hardwood Swamps ▶ Seasonally Flooded Basins	▶ Shrub-carrs[a] ▶ Alder Thickets[b] ▶ Fresh (Wet) Meadows[c,e] ▶ Shallow Marshes[d,e] ▶ Deep Marshes[d,e]	▶ Floodplain Forests[a] ▶ Fresh (Wet) Meadows[b] ▶ Shallow Marshes[c] ▶ Deep Marshes[c]	▶ Gravel Pits ▶ Cultivated Hydric Soils ▶ Dredged Material / Fill Material Disposal Sites

Notes: Pristine wetlands are those that show little disturbance from human activity. There will always be exceptions to the general categories listed above. Use best professional judgment.

1. Special consideration must be given to avoid altering these wetland types. Inundation must be avoided. Water chemistry changes due to alteration by stormwater impacts can also cause adverse impacts. Note: All scientific and natural areas and pristine wetlands should be considered in this category regardless of wetland type.

2a, 2b, 2c**. Can tolerate inundation from 6 inches to 12 inches for short periods of time. May be completely dry in drought or late summer conditions**.

2d. Can tolerate +12" inundation, but adversely impacted by sediment and/or nutrient loading and pro- longed high water levels.

2e. Some exceptions.

3a. Can tolerate annual inundation of 1 to 6 feet or more, possibly more than once/year.

3b. Fresh meadows which are dominated by reed canary grass.

3c. Shallow marshes dominated by reed canary grass, cattail, giant reed or purple loosestrife.

4. These wetlands are usually so degraded that input of urban stormwater may not have adverse impacts.

Source: State of Minnesota Storm-Water Advisory Group, 1997

The following stormwater sizing criteria are required to protect wetlands from the indirect impact of stormwater runoff:

Maintain the hydroperiod of susceptible wetlands following development to prevent detrimental impacts. The wetland types found in the NWA are identified in the Natural Wetland Resource Inventory (NRI) Report (2004). The NRI also assigns management classifications based on the susceptibility of these wetland types to stormwater impacts ranging from 1 (high susceptibility to stormwater bounce) to 4 (low susceptibility to stormwater bounce). This report also provides recommended buffer widths and phosphorus pretreatment requirements based on the wetland classifications. Table 7.5 summarizes these wetland management standards.

The term "existing" in this chart means the existing hydrologic conditions. If there have been recent significant changes in conditions, it means the conditions that established the current wetland. Designers then model the effect of runoff discharge from the site on the wetland to ensure they conform to the storm bounce and inundation duration guidelines standards set forth in Table 7.5 using infiltration, extended detention, diversion or other methods.

Table 7.5 Wetland Management Standards			
Management Classification	Buffer Strip (feet)	Structural Setback from Edge of Buffer (feet)	Stormwater Quantity Requirement
	Slopes <15%		
Manage 1	60	10	Storm Bounce - Maintain HWL at or below existing conditions for 100-year storm
Manage 2	30	10	Storm Bounce - Maintain HWL at or below existing conditions plus 0.5 feet for 100-year storm
Manage 3	20	10	no requirement
Manage 4	15	10	no requirement

Additional guidance on BMP design to protect wetlands is offered below:

- BMPs such as stormwater wetlands, infiltration systems, and bioretention are encouraged to treat runoff prior to discharge to a wetland
- Direct pipe outfalls to wetlands should be restricted (e.g., not allowed, allowed if energy dissipated, or routed through pre-treatment system).
- Stormwater should be routed around sensitive wetlands using a diversion or bypass system.
- Constrictions at wetland outlets should be avoided.
- Natural wetlands should not be used for stormwater treatment, unless they are severely impaired and construction would enhance or restore wetland functions; if natural wetlands are used in this manner, 7050 establishes the sequence of avoid, minimize and compensatory replacement
- The discharge of untreated stormwater to a wetland is prohibited.

VII. Evaluation of Regional Basins

During the development of the Inver Grove Heights NWA Stormwater Management Plan a number of regional depressions, or basins, were identified as being critical to the success of the plan. These basins, most of which are landlocked, currently capture stormwater runoff for retention and infiltration. In order to preserve the hydrologic balance of this system under post-development conditions, these regional basins shall be preserved and operated in the same manner they are functioning today.

In order to maintain their current function in the landscape, the regional basins should be subject to the same drainage characteristics and should be protected from any grading or construction activities which may alter the storage volume below the HWL or the infiltration capacity of the soils. In addition, the natural overflows or City identified overflow areas shall be protected from construction activities.

If the proposed development activity proposes one of the following, the Permit Applicant shall consult with City Staff immediately:

1. Grading and/or filling the storage volume of a regional basin below the HWL;

2. Modifying the hydrologic boundary so that the drainage area to a regional basin is larger than the existing conditions drainage area; or

3. Grading or otherwise impacting the natural overflow of a regional basin or the overflow area identified in the City of Inver Grove Heights Overflow Contingency Plan.

VIII. Stormwater Sizing for Redevelopment Projects

Small redevelopment sites can pose special challenges for stormwater design, given their small size, intensive use, and compacted soils. All redevelopment projects in the NWA will be required to meet the stormwater management standards identified in Table 7.2.

IX. References

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