Stantec

Memo

To:	Pelican River Watershed District Staff	From:	Marlon Mackowick, PE
File:		Date:	Revised May 26, 2021

Reference: Best Practices for the Design of Stormwater Management Systems

INTRODUCTION

The purpose of this memorandum is to provide the Pelican River Watershed District (PRWD) with a list of common "best practices" for evaluating stormwater management permit applications. Besides PRWD, Wenck now part of Stantec (Stantec) serves as the Engineer for several watershed districts throughout the state. The list is not all-inclusive, but it has been developed based on dozens of years of professional experience and the most current stormwater design guidelines.

BACKGROUND

Pelican River Watershed District is in the process of updating their rules and this document is meant to bridge the rules until the new rules are implemented. Since current the rules were approved, the practice of stormwater management has been advanced by the *Minnesota Stormwater Manual*, the MPCA Minimum Impact Design Standards study, and design guidance by MnDOT, the NRCS and others. Therefore, as Watershed District Engineer, it is our responsibility to ensure water resources within PRWD are protected according to the rules and best professional practices of stormwater management.

BEST PRACTICES

Rate Control (i.e. HydroCAD, XP-SWMM)

1. Stormwater features shall be designed using the Atlas 14 rainfall depths. The *Minnesota Stormwater Manual* states precipitation frequency estimates in Atlas 14 supersede the estimates produced in Technical Paper No. 40 and NWS HYDRO-35 (read guidance here). The Minnesota Department of Transportation (MnDOT) has required Atlas 14 depths for all hydraulic design since June 30, 2014 (read memo here).
2. Verify the proposed runoff rates do not exceed existing runoff rates across all downgradient site boundaries. Peak runoff rates shall not increase for the 2-, 10-, and 100-year, 24-hour storm events.
3. Time of concentration
    a. Presentation from MnDOT: http://www.dot.state.mn.us/bridge/hydraulics/atlas14/pdf/using-atlas14datafor-nrcs-hydrologyinmndot.pdf
        i. Slide 5
            1. Recommendation for ag watersheds

2. *MN Engineering Field Handbook* Chapter 2 states Tc may be determined by Chapter 2, Chapter 15 of *NRCS National Engineering Handbook*, or Folmar & Miller equation.
3. See page 12 of the NEH: http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=27002.wba
4. 100-foot sheet flow max length

ii. Slide 7

1. Recommendation for urban watersheds
2. Use *MN Drainage Manual* or TR-55
3. *MN Drainage Manual* dated August 30, 2000. MnDOT tech memo 15-10-B-02 supersedes *Drainage Manual* as does Chapter 15 of NEH supersedes because it is dated May 2010.
4. TR-55 dated June 1986. Superseded by MnDOT tech memo 15-10-B-02 and Chapter 15 of NEH.
5. 100-foot sheet flow max length

b. A shorter time of concentration likely produces a greater runoff rate. We prefer to be conservative, so we recommend a 100 foot max rather than 300 feet. The *Minnesota Stormwater Manual* recommends a maximum sheet flow length of 100' due to the tendency for flow to channelize beyond 100'.

c. If "direct entry" is used, ensure that it is reasonable or require applicant to calculate based on site conditions. Preferred method is to use a series of sheet flow and shallow concentrated flow. Alternatively, use the *MnDOT* recommended minimum time of concentration of seven minutes.

4. For Atlas 14 rainfall depths, use MSE 3 rainfall distribution per MnDOT slides referenced above.
5. HydroCAD or XP-SWMM model reports are required for pre- and post-project conditions. The project design must match the model inputs. Verify the HydroCAD is correct:
   a. For wet ponds, ensure the starting water elevation is set at the pond outlet elevation (normal water level).
   b. For infiltration or filtration basins, ensure the starting water elevation is set at the bottom of the basin.
   c. For outlet structures verify the most restrictive device is included in the model (i.e. the smallest area, flattest slope, etc.).
6. Verify curve numbers are accurate.
   a. Ensure that existing curve numbers reflect the existing land use and hydrologic soil group (HDG).
   b. Increase curve numbers based on the HSG in Table 1 for disturbed greenspace that is graded to account for soil compaction from construction. If soil/compost amendments are specified, proposed conditions grassed areas can be modeled as:
      i. HSG A/CN 39 for sandy loam.
      ii. HSG C/CN 74 for all other soil textures.

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Table 1. Uncompacted and compacted Hydrologic Soil Group and curve numbers.

Soil Classification	Uncompacted HSG/CN	Compacted HSG/CN	HSG/CN with Soil Correction
Sand	A/39	A/39	A/39
Loamy Sand	A/39	A/39	A/39
Sandy Loam	A/39	B/61	A/39
Silt	B/61	D/80	C/74
Loam	B/61	D/80	C/74
Silt Loam	B/61	D/80	C/74
Sandy Clay Loam	C/74	D/80	C/74
Clay Loam	D/80	D/80	C/74
Silty Clay Loam	D/80	D/80	C/74
Sandy Clay	D/80	D/80	C/74
Silty Clay	D/80	D/80	C/74
Clay	D/80	D/80	C/74

7. Verify that storage void ratios are assigned correctly:
    a. 100% for above ground or in pipe storage.
    b. 40% for clean, washed, angular rock.
    c. 30% for clean, washed sand.
8. Verify HydroCAD model corresponds with existing topography and proposed plans:
    a. Verify existing drainage directions; mark/show arrows on a plan sheet or use the existing drainage area map.
    b. Verify subcatchment areas in model match drainage directions indicated in the plans.
    c. Do plans indicate drainage from off-site?
    d. How many acres drain onto the site from off-site?
    e. Check proposed drainage directions; any areas diverted to a new direction? How many acres? If not diverted, are stormwater facilities sized to accommodate off-site runoff?
    f. Verify the total drainage area is the same in both existing and proposed HydroCAD models.

Water Quality (i.e., P8, MIDS, PondNet, WinSLAMM)

9. PRWD rules require water quality treatment using a permanent pool volume equivalent to the volume of runoff from a 3.2-inch rainfall. Alternatively, applicants can show a minimum of 90% removal of total suspended solids (TSS) and a minimum of 50% removal of total phosphorus (TP) for a 5-year, 24-hour rainfall event using Walker's Pond Net model.

    Practices besides wet ponds can be used to achieve the water quality standard (90% TSS removal and 50% TP removal) if it meets the Minimal Impact Design Standard (MIDS) performance goal. The MIDS performance goal is a design standard that was set by the MPCA to achieve a minimum annual removal of 90% total suspended solids and 50% total phosphorous. Information on the MIDS standard can be found here.

Alternative practices may include but are not limited to infiltration systems, filtration systems, iron-enhanced filtration systems, and water reuse systems.

Applicants using alternative practices may demonstrate the PRWD water quality standard is satisfied by submitting:

- Calculations showing that 1.1" of rainfall on impervious areas of the site will be fully infiltrated or filtered within 48 hours.
- Results from an acceptable model showing a minimum annual removal of at least 90% TSS and 50% TP.
- Greater treatment standards may apply if required for project approval by other local government units (LGUs).

The following equation should be used to design stormwater features to meet the MIDS standard:

Required Treatment Volume (ft^3) =
Impervious Surfaces (ft^2) * 1.1 (in) * 1/12 (ft/in)

The following resources can be used to calculate TSS and TP removal:

- P8 computer model (use NURP50 particle file)
- WinSLAMM computer model
- MIDS Calculator – download here
- Ramsey-Washington Metro Watershed District Stormwater Calculator – download here

10. The siting of infiltration practices shall concur with the *Minnesota Stormwater Manual* [i.e. follow recommended setbacks from buildings, guidance for wellhead protection areas, maximum drainage areas, and potential stormwater hotspots (PSHs)].
11. All stormwater entering an infiltration/filtration practice must be pretreated.
    a. Pretreatment is an integral part of best management practices. Pretreatment will help to prevent a stormwater feature from being overloaded by coarse sediment and reduce maintenance. The Minnesota Pollution Control Agency's (MPCAs) NPDES/Construction Stormwater (CSW) permit requires pre-treatment before stormwater enters an infiltration/filtration system. General information about pretreatment can be found here.
    b. Pretreatment options include, but are not limited to filter strips, SAFL Baffles, manhole sumps, forebays, and proprietary devices. Filter strips shall comply with the *Minnesota Stormwater Manual's* design standards.
12. If an infiltration or filtration practice is proposed, soil borings shall be provided with the practice footprint to demonstrate infiltration capacity of the native soils.
    a. Table 2 shows the required number of soil borings per practice as prescribed by the *Minnesota Stormwater Manual:*

Table 2. Number of soil borings required based on stormwater BMP footprint.

Surface Area of Stormwater BMP (ft^2)	Required Soil Borings
< 1,000	1
1,000 to 5,000	2
5,000 to 10,000	3
> 10,000	4*

*An additional soil boring should be completed for each additional 2,500 ft^2 above 12,500 ft^2.

   b. Soil borings shall be advanced at the location of the proposed practice and to a depth of at least five feet below the proposed bottom of the practice.
   c. Soil borings are necessary for filtration practices to demonstrate why infiltration is not practical (i.e., contamination, poor soils, high groundwater).

13. Verify the bottom of the infiltration or filtration practice is at least three feet from seasonally high groundwater or top of bedrock. An impermeable liner is required when bottom of filtration BMP is less than 3 feet from seasonal saturated soil, bedrock, or seasonally high-water table.
14. Verify design infiltration rate based on least permeable soil type within five feet of bottom of practice. *MN Stormwater Manual* design infiltration rates by soil classification can be found here. Alternatively, field measured infiltration rates can be used to determine infiltration rates but must be divided by two as a safety factor. It is recommended that designers perform field measurements when soil borings indicate HSG Type A soils to verify the rate is not above 8.3 inches per hour.
15. Ensure the required treatment volume will drain within 48 hours. Infiltration/filtration systems must have a means to visually verify that the system is discharging through the soil surface or filter media in 48 hour or less.
16. Ensure adequate maintenance access is provided (such as manholes, cleanouts, and vehicle access).
17. For above ground infiltration/filtration BMPs, use bioretention soil mixtures recommended by *MN Stormwater Manual*. The recommended filter media depth is 2.5 feet or more to allow adequate filtration processes to occur.
    a. Media mixes E and F are recommended for infiltration practices.
    b. Media mixes C and D are recommended for filtration practices.
18. For underground filtration practices, the filter media should consist of an 18-inch layer of clean washed medium sand (meeting AASHTO M-6 or ASTM C-33 concrete sand) on top of the underdrain system.
19. For iron-enhanced filters, provide a minimum of 5% iron by weight and ensure it is uniformly blended.
20. For pervious pavement, *MN Stormwater Manual* recommends 5:1 or less ratio of typical to pervious pavement.
21. Pollutant removal calculations (TSS and TP) shall be calculated using an area-weighted average. Project areas not routed to a proposed water quality practices shall be assigned 0% removal for the area-weighted calculation.
    a. Is upstream or off-site runoff directed to the pond or basin? If so, it must be included in the water quality and quantity calculations.

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22. If using P8 to model filtration pollutant removals, use the filtration efficiencies from the Table 3 in the Particles file as recommended by the *MN Stormwater Manual*:

Table 3. P8 pollutant removal filtration efficiencies.

Filtration Type	Dissolved (P0%)	Particulate (P10%)	Particulate (P30%-P80%)
Sand filters and biofiltration	0%	25%	100%
Iron-enhanced sand filter	60%	25%	100%

23. Calculate the provided treatment volume. Obtain volume by using either the submitted HydroCAD results or create a HydroCAD model. The volume provided is the volume under the lowest outlet and the bottom of the system. For filtration practices, only the volume provided below the low outlet of the BMP will be credited; perforated drainpipes for filtration will not be considered the low overflow outlet. No filtration volume credit shall be given to voids within the filter media.
24. Volume retention credit is given to the lower of the following values:
    a. Volume below the lowest controlling outlet.
    b. Volume of 3” rainfall over the impervious surfaces draining to infiltration/filtration practice.

25. If the infiltration practice must comply with the MPCAs Construction Stormwater Permit (CSW), the following prohibitions apply:
    a. areas that receive discharges from vehicle fueling and maintenance;
    b. areas with less than three feet of separation distance from the bottom of the infiltration system to the elevation of the seasonally saturated soils or the top of bedrock;
    c. areas that receive discharges from industrial facilities which are not authorized to infiltrate industrial stormwater under an NPDES/SDS Industrial Stormwater Permit issued by the MPCA;
    d. areas where high levels of contaminants in soil or groundwater will be mobilized by the infiltrating stormwater;
    e. areas of predominately Hydrologic Soil Group D (clay) soils;
    f. areas within 1,000 feet up-gradient, or 100 feet down-gradient of active karst features;
    g. areas within a Drinking Water Supply Management Area (DWSMA) as defined in Minn. R. 4720.5100, subp. 13., if the system will be located:
        i. in an Emergency Response Area (ERA) within a DWSMA classified as having high or very high vulnerability as defined by the Minnesota Department of Health; or
        ii. in an ERA within a DWSMA classified as moderate vulnerability unless a regulated MS4 Permittee performed or approved a higher level of engineering review sufficient to provide a functioning treatment system and to prevent adverse impacts to groundwater; or
        iii. outside of an ERA within a DWSMA classified as having high or very high vulnerability, unless a regulated MS4 Permittee performed or approved a higher level of engineering review sufficient to provide a functioning treatment system and to prevent adverse impacts to groundwater; and

   h. areas where soil infiltration rates are more than 8.3 inches per hour unless soils are amended to slow the infiltration rate below 8.3 inches per hour.
   i. At confirmed hotspots, it is required that the filter is lined and discharged in a manner that will not mobilize pollutants.

26. For traditional stormwater ponds:
    a. No infiltration below normal water level (pond outlet).
    b. Use the greater volume from the composite curve number or runoff from impervious areas to calculate the required treatment volume.

<u>Site Plans</u>

27. Verify existing and proposed drainage area maps. The drainage maps should include drainage arrows, areas, and labels that match the routing of the HydroCAD diagrams.
28. The plans shall contain property lines, existing and proposed grading, and all onsite or receiving waterbodies and streams should be identified.
29. The plans shall provide for permanent stabilization of all areas subject to land disturbance according to the NPDES permit.
30. Evaluate the proposed grading plan and drainage area to ensure stormwater will drain into the proposed practices as desired.
31. Confirm the HydroCAD, utility plan, and design details correspond. Design details may include: inlet/outlet inverts, pipe sizes and slopes, weir elevations, top and bottom elevations, and length, width and depth dimensions.
32. Verify detail to ensure it meets the following technical standards:
    a. No fabric below infiltration practices;
    b. Specify washed, angular, non-carbonate rock;
    c. At least 2.5' of filtration media if above ground or 18" of filtration media if below ground;
    d. Iron-enhanced media has a minimum of 5% fillings by weight and is uniformly blended;
    e. At least two inches of chocking stone shall surround three inches of underdrain washed stone on the top and the sides (alternatively, surround draintile (top and sides) with five inches of 1/2 inch washed, non-carbonate stone); and
    f. In general, no sock on drain tiles (pipe socks may be needed for underdrains imbedded in sand. If pipe socks are used, then use circular knit fabric.).
33. Erosion and sediment control plans or SWPPP:
    a. Basin perimeter control and erosion control practices shall remain in place until the final completion of the project or vegetation has been established (whichever is later).
    b. Installation of infiltration/filtration practices shall be done during periods of dry weather and completed before a rainfall event. Placement of engineered soils shall be on dry native soil only.
    c. Excavation of infiltration areas shall be completed using a backhoe with a toothed bucket.
    d. Native soils in infiltration areas shall be de-compacted to a minimum depth of 18 inches prior to placing engineered soil.
    e. The bottom excavation surface of infiltration areas shall be level without dips or swales.

f. Engineered soil shall remain uncontaminated (not mixed with other soil) before and during installation.
a. During construction, stormwater must be routed around infiltration areas until all construction activity has ceased and tributary surfaces are cleaned of sediment. It is required that impervious area construction be completed, and pervious areas established with dense and healthy vegetation prior to introduction of stormwater into an infiltration/filtration practices.
g. Dewatering plan to mitigate discharge of sediment ladened waters.
h. Plan for temporary and permanent stabilization following NPDES/CSW timeframes (i.e. 7 or 14 days).
i. Erosion prevention practices (i.e. erosion control blanket or Hydromulch) on steep slopes, ditches, and swales.
j. Sediment control practices (i.e. silt fence or bio-log) at down-gradient perimeter of site where runoff is expected to occur and at the base temporary sediment stockpiles.
k. Sediment control practices (i.e. silt fence, bio-log) at perimeter of basins to prevent erosion of sediment into bottom of basin. The sediment control should limit construction activity on top of the infiltration basin to prevent sediment deposition and compaction of subsoils.
l. Redundant sediment control practices (i.e. silt fence, bio-log) where a 50-foot vegetated buffer is infeasible between earth disturbances and stormwater flows to a surface water.
m. Vehicle tracking BMP (i.e. rock construction entrance/exit) to minimize the track out of sediment from the construction site or onto paved roads within the site.
n. Inlet protection for existing and proposed catch basins on site and immediately downstream of disturbed areas. Straw bales and/or silt fence placed under the grate are not recommended methods of inlet protection.
o. Energy dissipation (i.e. riprap) at all pipe outlets.
p. Calculate shear stress at outlets to ensure proper BMP is placed for erosion control that can manage appropriate shear stress.

34. Provide plans signed by a professional engineer per the Minnesota Board of AELSLAGID.
35. Provide a landscaping plan to include the following:
    a. Specify potted plants or plant plugs to vegetate infiltration/filtration areas. Basin seeding should be avoided.
    b. Specify deep rooted, salt tolerant, native plants according to *Plants for Stormwater Design* (Shaw and Schmidt, 2003).
    c. Provide signage that deters snow management from using the infiltration/filtration basin for snow storage.
36. Analyze outlet structure details. Ensure that detail corresponds to model input. Ensure at least 6” depth below NWL for floatable control.
37. Ensure that calculated NWL & HWL from model output corresponds with plans. Basins should be labeled with the NWL & 100-year HWL. Recommend an additional 0.5-foot of freeboard from the 100-year HWL to the top as a factor of safety due to construction practices.
38. Check storm sewer entrance locations to ponds. Inlets and outlet distances shall be maximized to the extent possible. MPCA recommends a minimum of 80 feet.

39. Check FEMA Flood Insurance Rate Map (FIRM) or Flood Insurance Study (FIS) for 1% chance flood elevation.
40. Check 100-year HWL, emergency overflow (EOF) routes, road elevations, and building elevations for freeboard requirements. Retention/detention practices must provide a 0.5-foot freeboard between the 100-year high water level and the top of the BMP.
41. Surface practices must provide a permanently reinforced EOF [i.e. riprap or turf reinforcement mat (TRM)]. 100-yr HWL shall be below the EOF and the EOF shall be at least 0.5' below top of berm. Reinforced EOF shall extend to the toe of the slope to prevent erosion.
42. Check backyard drainage swales. Swales used to convey runoff (instead of installing storm sewer) should be graded within a drainage easement to ensure drainage rights.
43. Check for land-locked basins. If land-locked, execute model for the back-to-back 100-year storm event to ensure structures are protected and roads are accessible.
44. How is each point discharge directed to a public conveyance system: tile, ditch, stream, lake, or wetland?
45. If there is a point discharge at property line with no public conveyance system, permission from adjacent property owner? Identify potential impacted downstream properties.
46. Verify capacity of downstream tiles or ditches.
47. If a ditch, evaluate ownership or right to discharge.
48. Verify that outlet is not submerged, or if submerged that calculations reflect this.

<u>Maintenance</u>

49. Provide a site-specific plan, schedule and narrative for maintenance of the proposed stormwater management practices that includes the following:
    a. List all stormwater management practices.
    b. Person(s) responsible for maintenance of stormwater devices(s).
    c. Frequency of inspection/ indicator that maintenance is needed.
    d. Description of inspection activities.
    e. Description of maintenance activities.
    f. Inspect in winter months to ensure plowed snow is not being stored on infiltration/filtration practices.
    g. Establish a watering plan that extends a minimum of one year after planting.
    h. At a minimum, require annual maintenance of infiltration areas to include trimming vegetation, replacing vegetation where needed, mulch replacement, and removal of accumulated sediment and debris.
50. Verify adequate maintenance access (manholes, cleanouts, and vehicle access) is provided.

REFERENCES

Introduction to Stormwater Modeling. *Minnesota Stormwater Manual*. May 17, 2016. http://stormwater.pca.state.mn.us/index.php/Introduction_to_stormwater_modeling

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