2A-5 Project Drainage Report

A. Purpose

The purpose of the Project Drainage Report is to identify and propose specific solutions to stormwater runoff and water quality problems resulting from existing and proposed development. The report must include adequate topographic information (pre- and post-development) to verify all conclusions regarding offsite drainage. Unless known, the capacity of downstream drainage structures must be thoroughly analyzed to determine their ability to convey the developed discharge.

The drainage report and plan will be reviewed and approved by the Engineer prior to preparation of final construction drawings. Approval of these preliminary submittals constitutes only a conceptual approval and should not be construed as approval of specific design details. The Project Engineer may be required by law to submit the drainage report and plan to the Iowa Department of Natural Resources (IDNR) and/or US Army Corps of Engineers (USACE). An application for a permit to construct will follow the IDNR and NPDES applicable permit requirements and USACE rules and regulations, and the application will be the responsibility of the Project Engineer.

B. Instructions for preparing report

1. Include a cover sheet with project name and location, name of firm or agency preparing the report, Professional Engineer’s signed and sealed certification, and table of contents. Number each page of the report.

2. Perform all analyses according to the intent of professionally-recognized methods. Support any modifications to these methods with well-documented and industry-accepted research.

3. It is the designer’s responsibility to provide all data requested. If the method of analysis (for example, a computer program) does not provide the required information, then the designer must select alternative or supplemental methods to ensure the drainage report is complete and accurate.

4. Acceptance of a drainage report implies the Jurisdiction concurs with the project’s overall stormwater management concept. This does not constitute full acceptance of the improvement plans, alignments, and grades, since constructability issues may arise in plan review.

5. Use all headings listed in the Contents. A complete report will include all the information requested in this format. If a heading listed does not apply, include the heading and briefly explain why it does not apply. Include additional information and headings as required to develop the report.

6. This manual does not preclude the utilization of methods other than those referenced, nor does it relieve the designer of responsibility for analysis of issues not specifically mentioned.

C. Contents

The following information contains summaries for hydrology and detention (see Tables 1, 2, and 3), as well as design considerations for the preparation of project drainage reports. They are provided as a minimum guide and are not to be construed as the specific information to be supplied on every project drainage report, and other information may be required. Existing and proposed conditions for each development will require analysis unique to that area.

1. **Site characteristics.**

   a. **Pre-development conditions.** Describe pre-developed land use, topography, drainage patterns (including overland conveyance of the 100-year storm event), and natural and man-made features. Describe ground coverage, soil type, and physical properties, such as hydrologic soil group and infiltration. For the pre-development analysis where the area is rural and undeveloped, a land use description of "meadow/good condition" is recommended. If a geotechnical study of the site is available, provide boring logs and locations in the appendix of the report. If a soil survey was used, cite it in the references.

   b. **Post-development conditions.** Describe post-developed land use and proposed grading, change in percent of impervious area, and change in drainage patterns. If an existing drainageway is filled, the runoff otherwise stored by the drainageway will be mitigated with stormwater detention, in addition to the post-development runoff.

   c. **Contributing off-site drainage.** Describe contributing off-site drainage patterns, land use, and stormwater conveyance. Identify undeveloped contributing areas with development potential and list assumptions about future development runoff contributed to the site.

   d. **Floodways, floodplains, and wetlands.** Identify areas of the site located within the floodway or floodplain boundaries as delineated on flood insurance rate maps, or as determined by other engineering analysis. Identify wetland areas on the site, as delineated by the National Wetlands Inventory, or as determined by a specific wetland study.

   e. **Pre-development runoff analysis.**
      1) **Watershed area.** Describe overall watershed area and relationship between other watersheds or sub-areas. Include a pre-development watershed map in the report appendix.
      2) **Time of concentration.** Describe method used to calculate the time of concentration. Describe runoff paths and travel times through sub-areas. Show and label the runoff paths on the pre-development watershed map.
      3) **Precipitation model.** Describe the precipitation model and rainfall duration used for the design storm. Typical models may include one or more of the following:
         a) NRCS Type-II distribution
         b) Huff rainfall distribution (select the appropriate distribution based on rainfall duration)
         c) Frequency-based hypothetical storm.
         d) Rainfall intensity duration frequency (IDF) curve.
         e) User-defined model based on collected precipitation data, subject to the Engineer's approval. Total rainfall amounts for given frequency and duration should be obtained from Bulletin 71, "Rainfall Frequency Atlas of the Midwest." (See Table 2 in Section 2C-2) This publication supersedes Technical Paper Number 40, "Rainfall Frequency Atlas of the United States."

4) **Rainfall loss method.** List runoff coefficients or curve numbers applied to the drainage area. The Green-Ampt infiltration model may also be used to estimate rainfall loss by soil infiltration.
5) **Runoff model.** (See Part 2C). Describe method used to project runoff and peak discharge. Typical models are as follows:
   a) Use the Rational Method for drainage areas up to 160 acres, and where flow routing is not required. Often used in storm sewer design.
   b) Use the WINTR-55 Method for drainage areas up to 2000 acres.
      - TR-20 Model
      - Routines contained in HEC-1 or HEC-HMS computer models
      - Regression equations and other hydrologic models approved by the Jurisdiction
6) **Summary of pre-development runoff.** Provide table(s) including drainage area, time of concentration, frequency, duration, peak discharge, routing, and accumulative flows at critical points where appropriate.

2. **Post-development runoff analysis.**

a. **Watershed area.** Describe overall watershed area and sub-areas. Discuss if the post-development drainage area differs from the pre-development drainage area. Include a post-development watershed map in the report appendix. Include an analysis of the proposed increase in impervious area. Provide a summary of the total impervious area and the % impervious are for each sub-watershed/catchment.

b. **Time of concentration.** The method used will be the same as used in the pre-development analysis. Describe change in times of concentration due to development (i.e. change in drainage patterns). Show and label the runoff paths on the post-development watershed map.

c. **Precipitation model.** Storm event, total rainfall, and total storm duration will be the same as used for the pre-development model. If IDF curves are used, describe the change in design rainfall intensity.

d. **Rainfall loss method.** Method will be the same as pre-development analysis. Describe the change in rainfall loss due to development.

e. **Runoff model.** The runoff method will be the same as used in the pre-development analysis, except for variables changed to account for the developed conditions.

f. **Summary of post-development runoff.**
1) Provide table(s) including drainage area, time of concentration, frequency, duration, and peak discharge. Summarize in narrative form the change in hydrologic conditions due to the development. Provide a runoff summary using Tables 1 and 2.
2) Post-developed discharge should take into account any upstream offsite detention basins and undeveloped offsite areas assumed to be developed in the future with stormwater detention.
3) Provide a summary of the respective volumes and discharge rates from the unified sizing criteria: WQv, CPv, Qp, and Qf for the project area.
4) Calculate the allowable release rate from the site, based on three conditions:
   a) The peak runoff rate for the 1-year, 24-hour design storm based on the CPv. See Section 2C-6.

b) After development, the release rate of runoff for rainfall events having an expected return frequency of two years and five years should not exceed the existing, pre-developed peak runoff rate from those same storms.
c) For rainfall events having an expected return frequency of 10 years to 100 years inclusive, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff from a five-year frequency storm of the same duration. The allowable discharge rate may be restricted due to downstream capacity. Include this calculation in the Executive Summary.

3. **Stormwater conveyance design.**

a. **Design information references.** All stormwater conveyances should be designed according to this manual, at a minimum. The following references may be used for supplemental design information:
1) Federal Highway Administration (1996) *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22, Washington D.C.
2) Federal Highway Administration (1988) *Design of Roadside Channels with Flexible Linings*. Hydraulic Engineering Circular No. 15, Washington D.C.
3) Federal Highway Administration (1985) *Hydraulic Design of Highway Culverts*. Hydrologic Design Series Number 5, Washington D.C.
4) US Geological Survey (1968) *Measurement of Peak Discharge at Culverts by Indirect Methods*. Book 3, Applications of Hydraulics, Washington D.C.
5) American Society of Civil Engineers (1986) *Design and Construction of Sanitary and Storm Sewers.* Manual of Practice No. 37, New York, N.Y.

b. **Storm sewer.**
1) List design criteria, including storm event and runoff model. Describe the hydraulic grade line and whether pressure flow or surcharging is possible. Provide a graphic of the hydraulic grade line.
2) List design criteria for intake size and spacing. Describe the anticipated gutter flow and spread at intakes.
3) List any special considerations for sub-drainage design, such as high water tables.
4) Provide tables of storm sewer (inlet and pipe) and intake design data.
5) Water spread on the street for intake design year and 100-year elevation in all streets in which the curb is overtopped.

c. **Culverts.**
1) Describe culvert capacity, inlet or outlet control conditions, estimated tailwater and headwater. Determine if 100-year or lesser storm event will flood roadway over culvert.
2) Sketch a contour of the 100-year headwater elevation on a topographic map and/or grading plan. This delineated 100-year flood elevation is used to determine drainage easement and site grading requirements.

d. **Open channel flow – swales and ditches.**
1) Describe swale and ditch design. State the assumed Manning's roughness coefficients. State the anticipated flow velocity, and whether it exceeds the permissible velocity based on soil types and/or ground coverage. If the permissible velocity is exceeded, describe channel lining or energy dissipation.
2) Discuss design calculations. Depending on the complexity of the design, these may range from a single steady-state equation (i.e. Manning's) to a step calculation including several channel cross-sections, culverts and bridges.

3) Discuss the overall grading plan in terms of controlling runoff along lot lines and preventing runoff from adversely flowing onto adjacent lots.
4) The limits of swale and ditch easements will be established based upon the required design frequency. This includes 100-year overflow easements from stormwater controlled structures.

e. **Storm drainage outlets and downstream analysis.**
   1) Discuss soil types, permissible and calculated velocity at outlets, energy dissipator design, and drainage impacts on downstream lands. Provide calculations for the energy dissipator dimensions, size, and thickness of riprap revetment (or other material) and filter layer.
   2) Include a plan and cross-sections of the drainage way downstream of the outlet, indicating the flow line slope and bank side slopes. Identify soil types on the plan.
   3) Perform downstream analysis. The downstream analysis will show what impacts, if any, a project will have on the drainage systems downstream of the project site. The analysis consists of three elements: review of resources, inspection of the affected area, and analysis of downstream effects.
      a) During the review of resources, review any existing data concerning drainage of the project area. This data will commonly include area maps, floodplain maps, wetland inventories, stream surveys, habitat surveys, engineering reports concerning the entire drainage basin, known drainage problems, and previously completed downstream analyses.
      b) Physically inspect the drainage system at the project site and downstream of the site. During the inspection, investigate any problems or areas of concern that were noted during the review of resources. Identify any existing or potential capacity problems in the drainage system; flood-prone areas; areas of channel destruction, erosion and sediment problems; or areas of significant destruction of natural habitat.
      c) Analyze the information gathered during the review of resources and field inspection, to determine if the project will create any drainage problems downstream or will make any existing problems worse. Note there are situations that even when minimum design standards are met, the project will still have negative downstream impacts. Whenever this situation occurs, mitigation measures must be included in the project to correct for the impacts.

f. **Hydraulic model.** If the design warrants hydraulic modeling, state the method used. Typical modeling programs include:
   1) HEC-RAS – river analysis systems
   2) HEC-2 – water surface profiles
   3) SWMM – stormwater management model
   4) WSPRO – water surface profiles
   5) HY-8 – hydraulic design of highway culverts
   6) Other commercial or public domain programs approved by the Jurisdiction

4. **Stormwater management design.**

a. **Design standards.** All stormwater management facilities should be designed according to these design standards at a minimum. The following references may provide helpful design information for stormwater detention and water quality issues:

   1) Federal Highway Administration (1996) *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22, Washington D.C.

2) American Society of Civil Engineers (1985) Final report of the Task Committee on Stormwater Detention Outlet Control Structures. Am. Soc. Civ. Eng., New York, N.Y.
3) American Society of Civil Engineers (1992) *Design and Construction of Urban Stormwater Management Systems*. Manual of Practice No.77, New York, N.Y.
4) American Society of Civil Engineers (1998) *Urban Runoff Quality Management*. Manual of Practice No. 87, New York, N.Y.
5) Stahre, P and Urbonas, B (1990) *Stormwater Detention for Drainage, Water Quality, and CSO Management.* Prentice-Hall, Englewood Cliffs, N.J.
6) American Public Works Association (1991) *Water Quality Runoff Solutions.* Special Report No. 61, Chicago, IL.

b. **Detention basin location.** Describe basin site. Discuss existing topography and relationship to basin grading. Determine if construction will be affected by rock deposits. Also determine if a high water table precludes basin storage. Floodplain locations should be avoided.

c. **Detention basin performance.**
1) For rainfall events having an expected return frequency of two, five, and 100 years inclusive, the rate of runoff from the developed site will not exceed the existing, pre-developed peak runoff from the 5-year frequency storm of the same duration unless limited by downstream conveyance. Provide a table summarizing these release rates. Also provide a stage-storage-discharge table. These tables are shown in Table 3. State the minimum freeboard provided, and at what recurrence interval the basin overtops.
2) Discuss the effects on the overall stormwater system by detention basins in contributing offsite areas. If contributing offsite areas are presently undeveloped, discuss assumptions about future development and stormwater detention.
3) Calculate the basin overflow release rate. This equals the onsite 100-year post-developed peak discharge plus the contributing offsite 100-year post developed peak discharge. Include this calculation with Table 3.

d. **Detention basin outlet.**
1) The single-stage outlet (i.e. one culvert pipe) is not recommended because of its inability to detain post-developed runoff from storms less than the 5-year interval. In many cases, runoff from storm events less than the 5-year recurrence interval has created erosion and sediment problems downstream of the detention basin.
2) A more desirable outlet has two or more stages. An orifice structure serves to detain runoff for water quality purposes and release runoff for low-flow events of a 2-year storm. Greater storm events are usually discharged by a separate outlet.
3) Discuss the basin outlet design in terms of performance during low and high flows, downstream impact (see Section 2C-13 and Part 2G).
4) State whether the detention basin volume is controlled by the required flood control volume or the water quality volume.

e. **Spillway and embankment protection.**
1) Design the spillway for high flows using weir and/or spillway design methods. The steady-state open channel flow equation is not intended for use in spillway design.
2) Describe methods to protect the basin during overtopping flow.

f. **TR-55 design limitations.** Note the TR-55 method of sizing detention basins may result in storage errors of 25%, and should not be used in final design. The detention basin size in final design should be based upon actual hydrograph routing for the design storms controlled by the basin.

5. **Permits.** Indicate what permits have been applied for and received. Submit IDNR approval letter and report for sites affecting unnumbered A-zones, as delineated on flood insurance rate maps.

6. **References.** Provide a list of all references cited, in bibliographical format.

7. **Appendix.** Drawings and calculations in the Appendix should include, but not be limited to:

   a. **Drawings.**
      1) A preliminary plat (pre-and post-topography) may be used to show the proposed development. Minimum scale of 1 inch = 500 feet or larger to ensure legibility should be used for all drainage areas. (Drawings no larger than 24 inches by 36 inches should be inserted in 8-1/2 inch by 11-inch sleeves in the back of the bound report). The plat is to show street layout and/or building location on a contour interval not to exceed 2 feet. The map must show on- and off-site conditions. Label flow patterns used to determine times of concentration.
      2) Drainage plans (preliminary plat or topography map) must extend a minimum of 250 feet from the edge of the proposed preliminary plat boundary, or a distance specified by Jurisdiction. The limits of swale and ditch easements should be established based upon the required design frequency. This includes 100-year overflow easements from stormwater controlled structures.
      3) Soil map or geotechnical information.
      4) Location and elevations of Jurisdictional benchmarks. All elevations should be on Jurisdictional datum.
      5) Proposed property lines (if known).
      6) If the preliminary plat does not include proposed grades, submit a grading and erosion control plan showing existing and proposed streets, names, and approximate grades.
      7) Existing drainage facilities and structures, including existing roadside ditches, drainageways, gutter flow directions, culverts, etc. All pertinent information such as size, shape, slope location, 100-year flood elevation, and floodway fringe line (where applicable), should also be included to facilitate review and approval of drainage plans.
      8) Proposed storm sewers and open drainageways, right-of-way and easement width requirements, 100-year overland flow easement, proposed inlets, manholes, culverts, erosion and sediment control, water quality (pollution) control and energy dissipation devices, and other appurtenances.
      9) Proposed outfall point for runoff from the study area.
      10) The 100-year flood elevation and major storm floodway fringe (where applicable) are to be shown on the plans, report drawings, and plats (preliminary and final). In addition, the report should demonstrate that the stormwater system has adequate capacity to handle a 100-year storm event, or provisions are made for overland flow.
      11) Show the critical minimum lowest opening elevation of a building for protection from major and minor storm runoff. This elevation is to be reviewed with the Jurisdiction to confirm if previous changes were made to the minimum lowest opening elevation for major storm event.

   b. **Calculations.**
      1) Determine runoff coefficients and curve numbers
      2) Total impervious area (ft^2 and % of total drainage area)
      3) Determine times of concentration
      4) Calculations for WQv, rev, peak flow rate for the water quality design storm (cfs), and CPv.
      5) Calculations for intake capacity, sewer design, and culvert design

6) Peak discharge calculations – Show results in tabular format and pre- and post-developed hydrographs
7) Detention basin design – Show tabular stage-storage-discharge results and inflow/outflow hydrographs
8) Detention basin outlet design
9) Open channel flow calculations
10) Erosion protection design

c. **Computer calculations.** Attach computer-generated reports and output if software was used. Underline and label results, such as the peak discharge.

d. **Stormwater quantity and quality.** See Part 2A of this manual for submittal of stormwater quality and quantity information.

Table 1: Hydrology summary

	Area 1				Area 2			
	Onsite		Offsite		Onsite		Offsite	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Size (acres)								
Predominant land use								
Impervious area (acres or ft^2)								
Watershed length								
Time of concentration								
Runoff coefficient (C)								
NRCS CN								
Runoff (Q)								
1 yr								
2 yr								
5 yr								
10 yr								
25 yr								
50 yr								
100 yr								

Table 2: Hydrology summary (critical points)

Design Flows	Critical Point 1	Critical Point 2	Critical Point 3	Critical Point 4
1 yr				
2 yr				
5 yr				
10 yr				
25 yr				
50 yr				
100 yr				

Table 3: Detention summary

Detention Basin

A. Inlet design storm frequency: _______

B. Outlet design storm frequency: _______

Standard Release Rate

A. Allowable release rate: _____ cfs

B. Offsite (developed) rate: _____ cfs

WQv release rate _____ cfs (if applicable)

CPv rate _____ cfs

Total release: _____ cfs

Overflow Release Rate

A. Onsite pre-developed (100-yr) ______ cfs

B. Offsite developed (100-yr)* ______ cfs

Total release: ______ cfs

Structures

A. Inflow structure: ____________

B. Outflow structure: ____________

	Stage**	Storage (ac-ft)	Inflow (cfs)	Outflow (cfs)	Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

* Routed through basin ** Max. 1-foot interval