

# Project Drainage Report

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## 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 Jurisdictional 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 DNR and/or USACE. An application for a permit to construct will follow the Iowa DNR 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 will 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 (Section 2A-4, C). 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 2A-2.01, 2A-2.02, and 2A-2.03), 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), storm sewer, ditches, and natural and man-made features. Describe ground coverage, soil type, and physical properties, such as hydrologic soil group and infiltration. 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.

For the pre-development analysis where the area is rural and undeveloped, a land use description reflecting current use is typical; however, the jurisdiction may apply more stringent requirements due to downstream drainage conditions. In addition, some jurisdictions require use of pre-settlement (meadow) conditions for all development. The jurisdiction should be contacted to determine what pre-development conditions are required.

- 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 drainage way is filled, the runoff otherwise stored by the drainage way 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 Jurisdictional Engineer's approval. Total rainfall amounts for given frequency and duration should

be obtained from Bulletin 71, "Rainfall Frequency Atlas of the Midwest" (see Section 2B-2). Bulletin 71 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:** Describe method used to project runoff and peak discharge. Typical models are as follows:
  - a) Use the Rational Method for drainage areas up to 40 acres, and where flow routing is not required. Often used in storm sewer design. See Section 2B-4 for explanation of limitations.
  - b) As an alternative to the Rational Method, the SCS (NRCS) Peak Flow Method may be used.
  - c) For drainage areas where flow routing is required, use one of the following methods:
    - TR-55 Tabular Hydrograph Method (WIN-TR-55)
    - TR-20 Model (Computer Program for Project Formulation Hydrology).
    - Routines contained in HEC-1 or HEC-HMS computer models
    - Regression Equations and other hydrologic models approved by the Jurisdiction
  - d) TR-20 Methods are not recommended for small drainage areas less than 20 acres.
- 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.
- 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.
- 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 2A-2.01 and 2A-2.02.
  - 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) Calculate the allowable release rate from the site, based on two conditions:
  - a) After development, the release rate of runoff for rainfall events having an expected return frequency of 2 years and 5 years should not exceed the existing, pre-developed peak runoff rate from those same storms.
  - b) 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 5 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.
- 4) Describe assumptions made for portions of the drainage area that are not included in the current development area.

### 3. Stormwater Conveyance Design:

**a. Design Information References:** At a minimum, all stormwater conveyances will be designed according to this manual. The following references may be used for supplemental design information:

- 1) Federal Highway Administration (2009) *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22, Washington D.C.
- 2) Federal Highway Administration (2005) *Design of Roadside Channels with Flexible Linings*. Hydraulic Engineering Circular No. 15, Washington D.C.
- 3) Federal Highway Administration (2005) *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 (1993) *Design and Construction of Urban Stormwater Management Systems Manual of Practice No. 77*, 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 subdrain 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, and 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 dissipater design, and drainage impacts on downstream lands. Provide calculations for the energy dissipater dimensions, size, and thickness of rip rap 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 it. 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 - Storm Water 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 Facilities Design:**
- a. Design Standards:** All stormwater management facilities will 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) *Urban Drainage Design Manual* (Hydraulic Engineering Circular No. 22).

- 2) *Design and Construction of Urban Stormwater Management Systems*. Manual of Practice No.77
  - 3) *Urban Runoff Quality Management*. Manual of Practice No. 87
  - 4) *Stormwater Detention for Drainage, Water Quality, and CSO Management*
- 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:** The following summarize the recommended detention requirements. The Jurisdiction may adopt different standards or modify these requirements on a case by case basis depending on existing drainage conditions, flooding problems, or future development. The designer should verify the detention requirements with the Jurisdiction for each proposed project.
- 1) After development, the release rate of runoff for rainfall events having an expected return frequency of 2 years should not exceed the existing, pre-developed peak runoff rate from that same storm.
  - 2) For rainfall events having an expected return frequency of 5, 10, 25, 50, and 100 years, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff rate from a 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 also to be shown in Table 2A-4.03. State the minimum freeboard provided and at what recurrence interval the basin overtops.
  - 3) 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.
  - 4) 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 2A-4.03.
- 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 sedimentation 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, and downstream impact.
- 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:** TR-55 includes a method for estimating required storage volume based upon peak inflow, peak outflow, and total runoff volume. This method 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 utilizing methods such as WINTR-55 or TR-20.

5. **Permits:** Indicate what permits have been applied for and received. Submit Iowa DNR 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 are not limited to, the following items.

**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) Overall drainage basin (or sub-basin) and location of proposed site within the basin.
- 4) Soil map or geotechnical information.
- 5) Location and elevations of jurisdictional benchmarks. All elevations should be on jurisdictional datum.
- 6) Proposed property lines (if known).
- 7) 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.
- 8) 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.
- 9) 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.
- 10) Proposed outfall point for runoff from the study area.
- 11) 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.
- 12) 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) Determine times of concentration
- 3) Calculations for intake capacity, sewer design, and culvert design
- 4) Peak discharge calculations - show results in tabular format and pre- and post-developed hydrographs

- 5) Detention basin design - show tabular stage-storage-discharge results and inflow/outflow hydrographs
- 6) Detention basin outlet design
- 7) Open channel flow calculations
- 8) Erosion protection design

**Table 2A-4.01: Hydrology Summary**

	Area 1				Area 2			
	Onsite		Offsite		Onsite		Offsite	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Size (Acres)								
Predominant Land Use								
Watershed Length								
Time of Concentration								
Runoff Coefficient								
Runoff (Q)								
2 yr								
5 yr								
10 yr								
25 yr								
50 yr								
100 yr								

**Table 2A-4.02: Hydrology Summary (Critical Points)**

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



**Table 2A-4.03: 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
- 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

**D. Computer Analysis**

Hydraulic and hydrologic calculations can be iterative and tedious. Due to the time consuming and repetitive nature of these calculations, a high probability of error exists when performing the calculations by hand. For these reasons, the use of computer programs for analysis is both allowed and encouraged.

A variety of both proprietary and publicly available software programs are available. While this manual sets no standards as to the brand or version of analysis software allowed, the following tables list programs utilized in Iowa. Table 2A-4.04 provides a partial list of hydrologic models meeting the minimum requirements of the National Flood Insurance Program. Table 2A-4.05 lists additional programs that are used in Iowa.

Before using computer software, the user should thoroughly understand the theory behind the analysis method being used, understand the impact that various inputs have on the results, and verify that the program yields expected results for given inputs.

**Table 2A-4.04:** Hydrologic Models Meeting the Minimum Requirements of NFIP

Name	Version	Developer (available from)	Public Domain or Proprietary
<b>One Dimensional Steady Flow Models</b>			
Culvert Master	2.0 (Sept. 2000) & up	Bentley Systems	Proprietary
HEC-HMS	v. 1.1 and up	USACE	Public Domain
HEC-RAS	3.1.1 and up	USACE	Public Domain
HY-8	4.1 (Nov. 1992) & up	FHWA	Public Domain
PondPak	v. 8 (May 2002) & up	Bentley Systems	Proprietary
QUICK-2	1.0 & up	FEMA	Public Domain
SWMM 5	v. 5.0.005 (May 2005) & up	US EPA	Public Domain
StormCAD	4 (June 2002) & up	Bentley Systems	Proprietary
TR-20	Win 1.00	USDA - NRCS	Public Domain
WinTR-55	1.0.08 (Jan. 2005)	USDA - NRCS	Public Domain
WSPGW	12.96 (Oct. 2000) & up	LA Flood Control Dist.	Proprietary
WSPRO	June 1988 & up	USGS / FHWA	Public Domain
XP-STORM	10.0 (May 2006)	XP Software	Proprietary
XP-SWMM	8.52 & up	XP Software	Proprietary
<b>One Dimensional Unsteady Flow Models</b>			
FLDWAV	Nov. 1998	Nat. Weather Svc., NOAA	Public Domain
HEC-RAS	3.1.1 and up	USACE	Public Domain
SWMM 5	v. 5.0.005 (May 2005) & up	US EPA	Public Domain
XP-STORM	10.0 (May 2006)	XP Software	Proprietary
XP-SWMM	8.52 & up	XP Software	Proprietary

Source: FEMA website

**Table 2A-4.05:** Other Hydraulic Software Utilized in Iowa

Name	Version	Developer (available from)	Public Domain or Proprietary
Iowa DOT Bridge Backwater	v. 2	Iowa DOT	Public Domain
Iowa DOT Culvert	v. 1	Iowa DOT	Public Domain
SITES (dam hydraulics)	v. 2005	Kansas USDA	Public Domain

## E. References

Federal Emergency Management Agency (FEMA). *Hydrologic Models: Determination of Flood Hydrographs*.

Available at: <http://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping/hydrologic-models-meeting-minimum-requirement>. Accessed: October 2012.

Federal Emergency Management Agency (FEMA). *Hydraulic Models: Determination of Water-Surface Elevations for Riverine Analysis*.

Available at: <http://www.fema.gov/numerical-models-meeting-minimum-requirements-national-flood-insurance-program>. Accessed: January 2016.