Billings PUBLIC WORKS

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316 N. 26th – 5th Floor
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To: Users of the 2018 Stormwater Management Manual

From: City of Billings – Public Works Engineering

Date: February 28, 2025

Re: Addendum #1 to the 2018 SWMM

The purpose and intent of this addendum is to allow for "infill" development of certain three-unit, four-unit, and small mixed-use residential and commercial buildings to be considered under *Residential Lot Development* standards of the Stormwater Management Manual (SWMM) in lieu of *Commercial Lot Development* standards of the SWMM. This addendum is created and administered under the presumption that these updates to SWMM will not substantially degrade the existing adjacent stormwater system.

Effective February 28, 2025, the following sections to the February, 2018 Stormwater Management Manual are amended as noted below. Professional engineering judgment in application of the SWMM shall continue to be used when applying conditions of this addendum.

- **Section 2.1.3 Residential Lot Development**

  The text paragraph in Section 2.1.3 is amended in its entirety to read:

  > *The requirements presented in Table 2.1 apply to residential lot development, including single-family homes, mixed-use and multi-family homes (up to and including fourplexes), condos, townhomes, and other similar nature facilities constructing four or fewer living units located on a single lot, provided the total lot impervious surface does not exceed the greater of 5,000 square feet or 60% of the gross lot area.*
  >
  > *Furthermore, for all non-single-family home development as listed above, this section is only applicable to "infill" development, which for the purpose of this Addendum, is defined as isolated residential lot development projects not covered under the requirements of a Master Site Plan, an overall subdivision comprehensive drainage plan, or the requirements of Section 2.1.4; Commercial Lot Development. Infill development is subjective and will be determined by the City Engineers' Office on a case-by-case basis, but is generally understood to be development of single, "one-off" lots which is surrounded by existing development. General examples of*

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what is and what is not considered infill development is shown in Appendix A.

Additionally, this section applies to "minor" building projects such as shops, sheds, garages, accessory dwelling units, and other similar nature projects that construct or add to a lot's overall impervious surface, provided that the total lot impervious surface does not exceed the greater of 5,000 square feet or 60% of the gross lot area.

Please note, Table 2.1 – *Requirements for Residential Lot Developments*, within Section 2.1.3 of the February 2018 SWMM remains unchanged.

Due to the varying nature of building projects, site conditions, surrounding land uses, and the potential impacts of water runoff to nearby areas, the City reserves the right to permit these types of developments under the requirements of Section 2.1.4 of this SWMM where circumstances warrant onsite stormwater management.

- **Section 2.1.4 Commercial Lot Development**

The first text paragraph in Section 2.1.4 is amended in its entirety to read:

The requirements presented in Table 2.2 apply to commercial and industrial development projects and residential living unit development projects, including mixed-use and multi-family homes (in excess of fourplexes), condos, townhomes, and other similar nature facilities constructing greater than four living units located on a single lot, or that are part of a Master Site Plan Development or larger subdivision development plan. For developments constructing private streets, the private street corridors shall be constructed in accordance with Section 4.3 of this manual and designed to the 50-year storm.

The second text paragraph in Section 2.1.4 is amended in its entirety to read:

Commercial expansion creating more than 5,000 square feet of new impervious surface shall be governed by this manual. Runoff from existing hard surfaces will not be governed by this manual if the new hard surface is shown to be hydraulically disconnected from the existing hard surface. However, for commercial sites where the existing commercial facility and related impervious surfaces are removed, or substantially removed (as defined by the City), and new development or

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redevelopment is occurring, the new commercial development, or reconstructed portion thereof, shall meet the full requirements of this section.

Please note, the remaining text paragraph sections of Section 2.1.4 and Table 2.2 – Requirements for Commercial Property Developments, within Section 2.1.4 of the February 2018 SWMM remain unchanged.

Developer and developer agents shall understand that additional requirements from other City of Billings policy documents and processes may exist and could also apply to developments considered under this addendum. Please contact our office if you have any questions.

Sincerely,

Mac Fogelsong, PE
City Engineer

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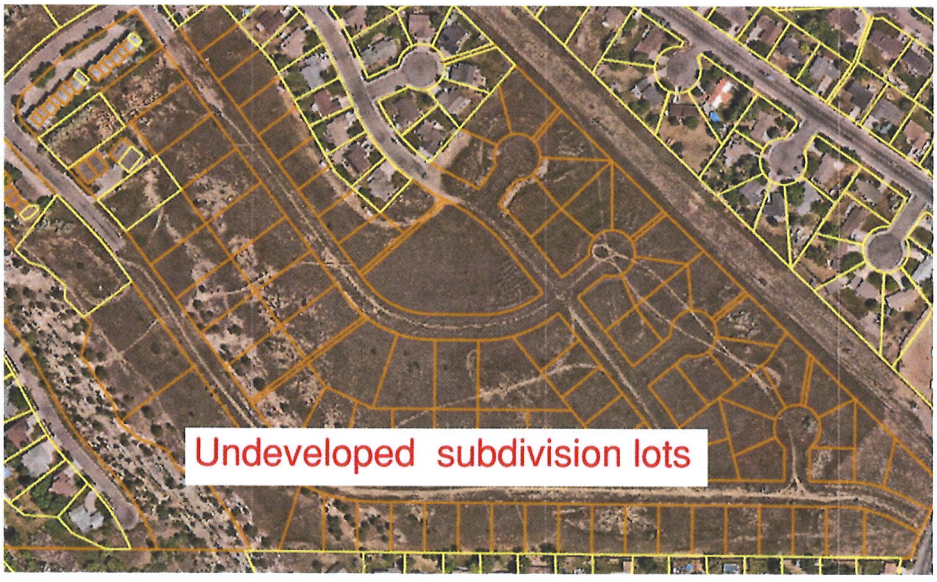
Appendix A

Example of what <u>is</u> considered infill development

Example of what <u>is not</u> considered infill development



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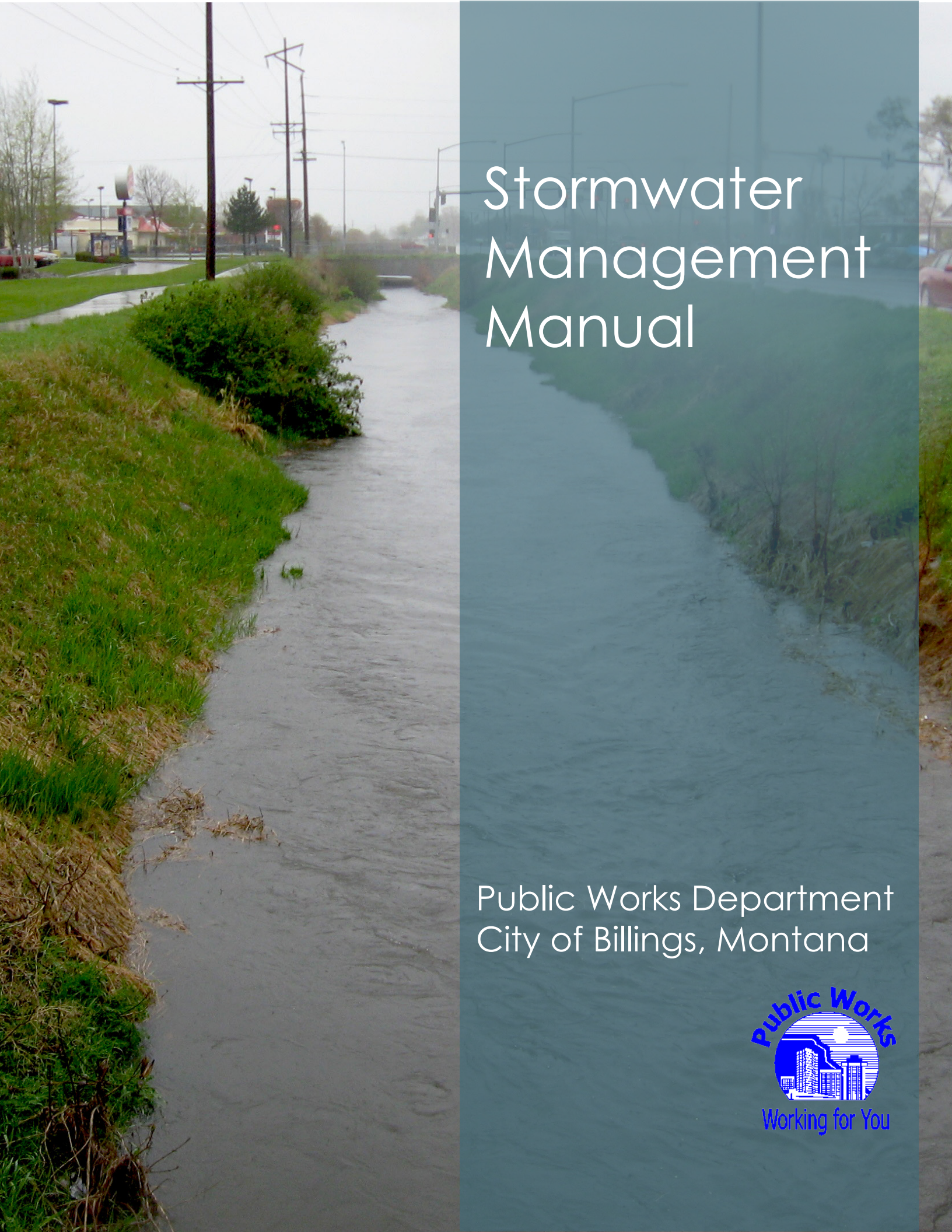

Stormwater Management Manual

Public Works Department
City of Billings, Montana

Public Works
Working for You

Stormwater Management Manual

Developed by

Public Works Department
City of Billings, Montana

With assistance from

DOWL

Debi Meling, PE
City Engineer

February 2018

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Chapter 1 - Introduction

1.1 OVERVIEW

The policies and requirements of this manual shall apply to developments and construction activities submitted after the date listed on the front cover. Developments and construction activities created prior to this date shall be governed under previous appropriate manuals and associated addendums. This manual shall be read in relation to City Code, Chapter 28, to ensure proper stormwater management practices are met.

The purpose of this Manual is to provide the minimum standards to be used for the analysis and design of storm drainage systems for private development projects and City contracted projects within the City of Billings. This manual provides direction and guidance to allow responsible development in and around the City of Billings while improving water quality within the Yellowstone River drainage. This manual provides guidance for the policy, design and permitting process to address stormwater runoff and treatment from proposed development and land disturbance.

The design criteria presented in this manual are based on industry standard engineering practice for stormwater management, modified to suit the needs of the City of Billings. Depending on specific site conditions, the design of storm drainage systems may need to exceed the minimum standards presented here in order to provide adequate protection from flooding. Criteria not specifically detailed herein shall be determined in accordance with sound engineering practices with the City's approval.

The City will conduct a limited review of Drainage plans for compliance with requirements set forth in this Manual. Content and scope of the drainage plan will vary based upon development type, location and site characteristics. The Applicant is exclusively responsible for ensuring that the design, construction drawings, completed construction, and record drawings comply with acceptable engineering practices and this Manual. The City's limited plan review of Drainage plans is not a substantive review of the plans and engineering. The City's ultimate approval of a Drainage plan is not an endorsement of the plan or approval or verification of the engineering data and plans. Neither the Applicant nor any third party may rely upon the City's limited review or approval.

This manual is written for use by engineers who are familiar with generally accepted hydrologic, hydraulic, water quality and hydrogeologic design practices. A detailed presentation of design methods and procedures is not included, as this information is readily available through industry-accepted publications. This manual relies, in part, on methods and procedures published in the Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 22 (HEC-22), "Urban Drainage Design Manual", Publication No. FHWA-NHI-10-009, dated August 2013. References to specific sections of HEC-22 to be used for the design of storm drainage systems in the City of Billings are included throughout this document. HEC-22 is available as a PDF document from the FHWA Website (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**). This manual also references the *Montana Post-Construction Storm Water BMP Design Guidance Manual* for design of stormwater quality improvements. This document is available from the City of Billings website

(**http://ci.billings.mt.us/567/Stormwater-Management**). In addition, this manual relies on general application, design, and installation procedures for temporary BMPs from the most current edition of the Montana Department of Transportation "Erosion and Sediment Control Management Practice Manual" (**http://www.mdt.mt.gov/publications/docs/manuals/env/bmp-manual-dec16.PDF**).

The City reserves the right to make periodic changes and modifications to the guidelines and template forms to reflect updates of city practices. It is the responsibility of the user to determine that they are utilizing the most current version of these standards and forms.

1.2 AUTHORITY

This Manual has been adopted by the City Engineer's office, and shall be read with the Billings Municipal City Code and all other listed appurtenant referenced documents and manuals. Failure to comply with any portion of this manual may result in rejection of all permits and actions as described within the City Code. In addition, Developer may be required, at their own costs, to mitigate design deficiencies found within the system outside the required warranty period, if the deficiencies were found to be the result of improper construction and/or design assumptions.

1.3 ADMINISTRATIVE VARIANCE

The City Engineer shall have the authority to approve a variance from any or all parts of this manual if it is deemed a variance will be in keeping with the intent of the manual and will be in the best interest of the City of Billings and the existing system adequacy. Such variance may be granted on a case-by-case basis and shall not apply to previous or future construction or development activities. The City Engineer does not have the authority to grant a variance from the requirements of State and Federal codes and conditions such as, but not limited to, the City's General Permit or conditions of DEQ Circular 8.

1.4 APPLICABILITY

This manual shall apply to all development, redevelopment and construction activities on public and private property within the City of Billings.

1.5 SEVERABILITY

If any section, clause, sentence, or phrase of these regulations is held to be invalid or unconstitutional by any court of competent jurisdiction, then said holding will in no way affect the validity of the remaining portions of these regulations.

Chapter 2 - Policy Requirements

The following sections provide the requirements for stormwater management related to construction and development activities as defined by the City Engineer's Office. Details of the design criteria for stormwater management facilities are provided in subsequent chapters.

The rate and volume of stormwater runoff from proposed land developments shall be estimated in accordance with this Manual and shall be the foundation of the drainage plan. Drainage plans shall be prepared by a Professional Engineer licensed in the State of Montana and shall be submitted to the City Engineer's Office for review and approval.

Throughout this manual, references are made to the City's storm drain system or network. For the purposes of this manual, the City's storm drain system or network is defined as any pipe, drain, pond, lake or stream owned and operated by the City of Billings. Roadside borrow ditches, irrigation ditches and irrigation waste drains shall not be considered a part of the City's dedicated storm drain system or network unless such facility has been previously identified and formally incorporated as such. Please contact the City Engineer's Office for the current map of the City's storm drain system.

2.1 PROJECT CLASSIFICATIONS

Stormwater management requirements vary based on the classification of the project. The City Engineer's Office has classified construction and development projects into five categories: 1) City Contracted Projects; 2) Residential Lot Developments; 3) Commercial Property Developments; 4) Subdivisions; and 5) Business District Development/Redevelopment. The following sections describe and summarize each classification and the associated stormwater requirements.

2.1.1 General Requirements for All Developments

- Natural drainages, such as depressions, swales, ditches, drains, channels, etc. shall be preserved to the maximum extent possible. If preservation of existing drainages is not possible, Developer shall provide adequate accommodations ensuring flows through natural drainages are properly mitigated. Applicable regulations from other agencies will need to be met in the event existing drainages are not preserved.

- Non-stormwater discharge (illicit discharge) is prohibited from entering the storm drain system as defined and detailed by Chapter 28 of the Billings Municipal City Code.

- Billings Municipal City Code, Chapter 6, Section 1209 identifies specific subdivisions that shall have no off-site runoff as a result of development. Runoff within these areas shall be entirely mitigated onsite.
  - In addition to the specific areas listed by City Code, development of all areas between the Rims and Highway 3, not currently identified by City Code, shall result in no off-site runoff from the Major storm as defined in subsequent sections of this manual.

- Stormwater discharge to private irrigation ditches, drains and laterals is acceptable provided approval has been granted by such facility owner/operator, the discharge rate is

metered per the requirement of Sections 2.1.4 and 2.1.5 and discharge is delayed (controlled) to ensure the ditch, drain or lateral facility is not adversely impacted beyond existing conditions. An agreement shall be signed between the facility owner/operator and developer with the City named as a third party. Agreement must state at a minimum the following: Development's discharge requirements, conditions of use, term of agreement, maintenance responsibilities and a note stating that the City shall have the first right to accept the automatic transfer of all interests and easements of the ditch/drain facility should the ditch/drain facility operator abandon their facility adjacent to the development.

- Subdivisions or commercial property developing adjacent to ditches and drains shall provide right-of-way or an easement from the top of bank along the property frontage for maintenance access. The width of right-of-way or easement shall be specified by the ditch or drain facility owner to accommodate both appropriate heavy equipment access, cleaning and maintenance activities. However, in no case shall the width be less than 20-feet on either side of the ditch/drain facility. Easement document and/or plat SIA shall specify that no fences, trees, structures or other permanent improvements can be constructed within the easement area.

- Developers shall acknowledge that there exists the potential for ditches/drains to overtop during rain events, resulting in flooding to adjacent properties. The locations and rate of overtopping is unknown; however, developers shall account for this potential when subdividing, constructing homes or businesses and shall use flood proofing or establish elevations and grading plans accordingly. The degree of improvements required will depend on the character of the adjacent ditch/drain and the location of development along the ditch/drain.

    - In addition, developers shall acknowledge that there exists the potential for adjacent ditches/drains to leak contributing to seasonally high groundwater conditions within the development; which will need to be accommodated in the design of stormwater management facilities and within the SIA.

2.1.2 City Contracted Projects

The following requirements apply to projects contracted by the City of Billings, including road reconstruction projects, new road construction, and other projects that impact existing drainage patterns within the City of Billings right of way.

- City Contracted projects shall follow design criteria included in this manual. Runoff control and water quality treatment requirements will be established by the City Engineer managing the project.

- Submit a Storm Drainage Memo for projects which result in only minor impacts to existing drainage patterns. The City Engineer's Office will determine whether the impact will be considered "minor" or "major" on a case-by-case basis.

- ❖ Submit a Comprehensive Drainage Plan (CDP), in accordance with Chapter 3 of this manual, for projects which result in major impacts to existing drainage patterns. The CDP shall identify any changes in flood hazards during the Major Storm for projects which result in major impacts to existing drainage patterns.

2.1.3 Residential Lot Developments

The requirements presented in Table 2.1 apply to residential lot development, including single family homes, duplexes, townhomes, and condo developments constructing two or less living units located on a single lot and for "minor" construction and building projects in which either the improvements necessitate a building permit and/or improvements create more than 2,500 SF of impervious surface.

Table 2.1 – Requirements for Residential Lot Developments

Drainage Design Criteria	***Reference***
Site grading requirements shall follow specific requirements established in/on the subdivision plat, SIA or any covenants within the subdivision.	N/A
Unmitigated runoff generated from a residential site (or new improvements) shall not drain from that site to a neighboring property.	N/A
If a common drainage approach is used which develops a solution for side and backyard runoff, developer shall specify in the subdivision plat/SIA the details and practices to be followed by subsequent property owners. For existing developments, a Declaration of Common Drainage shall be completed identifying drainage solutions.	N/A
Hard surfaces, including gutter downspouts shall drain onto lawns or pervious areas providing a minimum length of 15-feet for runoff to disperse prior to reaching the property line with slopes no greater than 5% for lawns and no greater than 2% for other pervious areas.	N/A
Property owners may not alter existing drainage patterns of their lot without prior approval from the City Engineer.	N/A
Residential lot owners are encouraged to use LID methods on their lot.	Section 8.16
The elevation of residential dwellings and other lot features must be established in recognition of the City's policy that storm runoff flows are allowed to a depth of 18-inches in the gutter flowline of adjacent streets during the Major storm.	Section 6.2
Verify that your project requires a Stormwater Pollution Prevention Plan (SWPPP); if so submit SWPPP and NOI Forms.	Chapter 9
Downspouts with unfinished landscaping shall be equipped with sediment bags and/or energy dissipaters until landscaping establishes.	
Stormwater features shall be preserved per the initial design and maintained by the property owner.	SIA & Section 7.4
Submittals	***Reference***
Submit a Site Stormwater Plan (SSP) detailing lot grading and drainage plan.	Section 3.1.1

2.1.4 Commercial Property Development

The requirements presented in Table 2.2 apply to commercial and industrial development projects and residential home construction projects including single family homes, duplexes, townhomes, condo developments and residential manufactured homes constructing three or more living units located on a single lot or that are part of a Master Site Plan Development. For developments constructing private streets, the private street corridors shall be constructed in accordance with Section 4.3 of this manual and designed to the 50-year storm.

Commercial expansion creating more than 2,500 square feet of new impervious surface shall be governed by this manual. Runoff from existing hard surfaces will not be governed by this manual if the new hard surface is adequately hydraulically disconnected from the existing hard surface. However, for commercial sites where the existing commercial facility and related impervious surfaces are removed, or substantially removed (as defined by the City), and new or redevelopment is occurring, the new commercial development, or reconstructed portion thereof, shall meet the full requirements of this section.

If a new connection to the City's storm drain system is installed, regardless of the activities completed under Section 2.2 of this manual, the development's stormwater system which connects to the City storm drain system shall be brought into compliance with the requirements of this section.

Some commercial project developments may be classified as "Business District Development/Re-Development." For a description of Business District Development/Redevelopment and the associated requirements, see Section 2.1.6.

Due to the potential for increased pollutant runoff, some sites may require additional regulatory and design requirements. Refer to Appendix A for the following facilities:

- Fueling station, facility storing/transporting more than 1,500 gallons of petroleum products, hydraulic equipment storage, property zoned controlled or heavy industrial, vehicle maintenance/repair, nurseries, lawn care/fertilizer facility, agricultural or animal care facility, or other similar facilities.

The table identifying Requirements for Commercial Property Developments can be found within Table 2.2 on Page 2-5.

2.1.5 Subdivision Development

The table identifying requirements for Subdivision Development can be found within Table 2.3 on Page 2-6. The requirements of this section and Table 2.3 apply to subdivisions within City Limits as well as tracts of land under review for annexation.

2.1.6 Business District Development/Redevelopment

Where existing buildings within the general downtown limits are currently constructed to property lines and development is being reviewed by the City Engineer's Office because of a change in use or other qualifying alteration, the following criteria shall apply:

- If identified by the City, Developer shall install the necessary improvements to ensure runoff from the site is managed in a manner that improves offsite drainage from that of existing conditions. Any know, existing storm drain problems will be addressed at this time.

Reconstruction of these sites (as defined by the City) shall be governed by Section 2.1.4. Prior to design, Developer shall meet with City Engineer's Office to discuss site-specific stormwater improvement requirements.

Table 2.2 – Requirements for Commercial Property Developments	
General Criteria	***Reference***
Design Storm Frequencies.	Section 4.2 – 4.5
Acceptable Runoff Calculation Methods.	Section 5.3
Contribution to regional facility if identified in SIA or other project agreements	N/A
Water Quality Requirements	***Reference***
Water Quality Volume and Flow (WQV and WQF).	Section 8.2 & 8.3
Water Quality Treatment Methods.	Section 8.4
Runoff Control Requirements	***Reference***
Runoff generated from the 50-year, 24-hour storm shall be mitigated onsite, with no discharge onto neighboring property or the public right-of-way. The volume of required storage shall be based upon the assumption of no discharge to the City's storm drain system. Infiltration to native soils is allowed in the calculations. This requirement applies to both areas inside and outside of the *Special Discharge Area*, which is found within Appendix I.	N/A
For properties not identified in Appendix I as being within the *Special Discharge Area*: With City approval, water quality mitigated, and on-site storage provided for 50-year, 24-hr storm, a connection to the storm drain system may be allowed, with discharge metered to not exceed pre-developed runoff rates for the 2, 10 and 50-year storms.	Section 6.3.5 Appendix I
For properties identified in Appendix I as being within the *Special Discharge Area*: With City approval, water quality mitigated, and on-site storage provided for 50-year, 24-hr storm, a connection to the storm drain system may be allowed, with discharge metered to a prorated value of 1 cfs per 10 acres of development. i.e. a 0.5 acre development would be allowed a 0.05 cfs (appx. 22 gpm) discharge.	Appendix I
Commercial development constructed within any subdivision shall be governed by the requirements of this section independent of the requirements of Section 2.1.5. However, for new developments, a comprehensive solution that combines the subdivision stormwater management facilities with the commercial stormwater management facilities may be considered if an upfront plan is developed.	N/A
Overland/sheet flow to the City's storm drain system, including streets and alleys, is not allowed, unless approved by the City Engineer.	N/A
Design stormwater runoff control facility to meet above criteria.	Chapter 7
Stormwater Facility Design Requirements	***Reference***
Above ground storage in parking lots may not pond to a depth greater than 12 inches during the Major Storm.	N/A
The elevation of commercial properties must be established in recognition of the City's policy allowing for an 18-inch depth of flow in the gutter flowline of adjacent streets during the Major Storm.	Section 6.2
Geotechnical and Hydrogeologic Evaluation and Recommendations.	Appendix D, H
Submittals, Permits, and Easements	***Reference***
Submit a Comprehensive Drainage Plan (CDP).	Section 3.1.2
A SWPPP and NOI may be required to address stormwater runoff during construction and until landscaping has established. Determine whether your project will require these permits and submit as necessary.	Chapter 9
Commercial property developing adjacent to ditches/drains.	Section 2.1.1
Owner shall call for City inspection of drainage features prior to backfilling.	N/A
TV report shall be submitted for connections within the public right-of-way.	COB Standard Mods
Operation and Maintenance	***Reference***
All facilities shall be owned, operated and maintained by the development.	Appendix E, F Section 6.3.5

Table 2.3 – Requirements for Subdivision Development	
General Criteria	***Reference***
Design Storm Frequencies.	Section 4.2 – 4.5
Acceptable Runoff Calculation Methods.	Section 5.3
Hydraulic Analysis and Design.	Chapter 6
Contribution to regional facility if identified in SIA or other project agreements.	N/A
Water Quality Requirements	***Reference***
Adjacent subdivisions may work in conjunction to develop a common solution to achieve WQV and WQF drainage requirements, with approval from the City Engineer's Office.	Chapter 8
Water Quality Volume and Flow (WQV and WQF).	Section 8.2 & 8.3
Water Quality Treatment Methods.	Section 8.4
Runoff Control Requirements	***Reference***
For properties not identified in Appendix I as being within the *Special Discharge Area*; runoff during the 2, 10 and 100-year storm events shall not exceed the runoff rate of natural (pre-developed) conditions, prior to subdividing and developing the land. Off-site runoff from the subdivision must maintain existing drainage characteristics of pre-developed conditions.	N/A
For properties identified in Appendix I as being within the *Special Discharge Area*; runoff generated by the 100-year event shall be mitigated and stored onsite. The maximum allowable discharge shall be limited to a metered rate of 1 cfs/ 10 acres of subdivision development.	Appendix I
Runoff entering the subdivision from upstream properties shall also be evaluated and included in the composite rate and volume of runoff from the subdivision.	N/A
Design stormwater runoff control facility to meet above criteria.	Chapter 7.0
Stormwater Facility Design Requirements	***Reference***
The elevation of residential dwellings, buildings, or other permanent facilities must be established in recognition of the City's policy allowing for an 18-inch depth of flow in the gutter flowline of adjacent streets during the Major Storm. Established minimum building elevations shall be documented in the SIA, plat or other applicable recorded document.	Section 6.2
Consider individual lot grading and drainage issues and provide necessary drainage easements to provide effective drainage to public right-of-way or approved downstream areas.	N/A
Geotechnical and Hydrogeologic Evaluation and Recommendations.	Appendix D
Submittals, Permits, and Easements	***Reference***
Submit a Comprehensive Drainage Plan (CDP) and Geotechnical/Hydrogeological Evaluation.	Section 3.1.2
Submit HOA Agreement, O&M Manual and BMP Inspection Checklist.	Appendix F, G
A Stormwater Pollution Prevention Plan (SWPPP) and Notice of Intent (NOI) may be required to address stormwater runoff during construction and until landscaping has established. Determine whether your project will require these permits and submit as necessary.	Chapter 9
If off-site discharge onto neighboring properties is required, a drainage easement must be obtained through the downstream neighboring properties to the point at which the runoff is collected in a public drainage facility.	Appendix G
Discharge leaving site must leave in same manor/characteristics as pre-developed conditions.	N/A
Subdivisions developing adjacent to ditches/drains.	Section 2.1.1
If curb cuts for drive approaches are included during initial subdivision construction, the associated driveway aprons (or other approved feature) shall also be constructed to accommodate gutter flow to the full gutter depth throughout the subdivision.	N/A
As-Builts (PDF) shall be stamped and submitted by the Professional Engineer of record.	N/A
TV report shall be submitted for all pipe within the public right-of-way.	COB Standard Mods
Operation and Maintenance	***Reference***
Stormwater facilities within a subdivision (excluding mainline and inlets) shall be owned, operated and maintained by the subdivision HOA. Stormwater facilities outside of the R.O.W. shall be located within a lot owned by the HOA and shall include a platted easement and associated access to the R.O.W. Access easement shall detail property owner/HOA use and maintenance of easement area. Landscape plans shall be submitted with the development plans.	Appendix E, F, G

2.2 Maintenance Activities

The activities listed below are considered to be "maintenance" and are therefore not governed by the requirements of this manual. Exclusion from these stormwater management requirements does not relieve the development of other required permits and submittals. Contact the City Engineer's Office to determine what (if any) permits or submittals will be required.

- Replacement of existing infiltration facilities; i.e., boulder pits or French drains.
- Resurfacing of an existing parking lot, including reconstruction of base gravel if grades of the parking lot have not altered drainage patterns.
- City of Billings maintenance projects.
- Private utility improvement projects disturbing less than one-acre of land surface.

If a new connection is made to the City's storm drain system, the development shall meet the requirement of Section 2.1.4. Failure to properly maintain a stormwater facility is governed by the requirements of Chapter 28 of the Billings Municipal City Code.

Chapter 3 - Plan/Permit Submittal Requirements

The intent of this chapter is to provide a framework for uniformity in plan preparation, submittal, and review to promote efficiency in the review process. In addition, properly developed drainage plans will facilitate proper operation and maintenance of drainage facilities following construction. Acceptance by the City does not relieve applicants from responsibility for ensuring system performance, safety, and compliance with other local, state, and federal regulations.

The City will conduct a limited review of Drainage plans for compliance with requirements set forth in this Manual. Content and scope of the drainage plan will vary based upon development type, location and site characteristics. The Applicant is exclusively responsible for ensuring that the design, construction drawings, completed construction, and record drawings comply with acceptable engineering practices and this Manual. The City's limited plan review of Drainage plans is not a substantive review of the plans and engineering. The City's ultimate acceptance of a Drainage plan is not an endorsement of the plan or approval or verification of the engineering data and plans. Neither the Applicant nor any third party may rely upon the City's limited review or acceptance.

3.1 PLAN SUBMITTAL REQUIREMENTS

Stormwater Drainage Plans are divided into two categories based upon the development type; Site Stormwater Plan (SSP) and Comprehensive Drainage Plan (CDP). The applicability and requirements for each are described as follows:

3.1.1 Site Stormwater Plan (SSP)

The SSP applies to all developments listed in Section 2.1.3 and shall be reviewed and accepted prior to issuance of a building permit. The following shall be addressed in an SSP submittal:

- Inform the City as to the drainage plan, the nature of the construction, project schedule, downstream conveyances, and project contact information. Plan shall include all finished floor elevations, drainage flow paths, top back of curb elevations, downspout, window well locations and similar critical elevations.
- Identify the drainage pattern of adjacent lots to ensure a common drainage approach within the subdivision is being met.
- Show all easements within lot and show/identify all site specific criteria and requirements listed within the subdivision SIA.

If after review of the SSP, the City determines that more detail or information is required, the City may require a Comprehensive Drainage Plan (CDP).

3.1.2 Comprehensive Drainage Plan (CDP)

The CDP applies to all developments listed in Section 2.1.4 through 2.1.6 and shall be reviewed and accepted prior to issuance of a building and/or right-of-way permit. Table 3.2 shall be used to identify required information to be submitted for various development activities. Additional information to guide these submittals is provided in the referenced appendices.

Table 3.2 – Comprehensive Drainage Plan (CDP) Submittals

	Required Submittal						
Development Activity	Preliminary Drainage Report	Final Drainage Report	Geotechnical/ Hydrogeological Report	O & M	HOA	SIA	Reference
Commercial		X	X	X			Appendix A, C, D, E, G, H
Preliminary Plat	X		X			X	Appendix B, D, G, H
Private Contract		X	X	X	X		Appendix C - H

3.1.2.1 Preliminary Drainage Report

The purpose of the Preliminary Drainage Report is to identify and describe site drainage impacts and illustrate preliminary solutions to the drainage system and any problems which may occur on-site and off-site as a result of the development, or any phase of the development.

The report shall provide an appropriate level of detail to address drainage issues and present the overall plan for the property. The report shall be based on the outline in Appendix B and include appropriate background information, supporting data, preliminary calculations and preliminary plan drawings.

3.1.2.2 Final Drainage Report

The purpose of the Final Drainage Report is to provide in depth details and calculations to address the drainage issues and present sizing and locations for all proposed improvements. The report shall be based on the outline provided in Appendix C and shall include appropriate background information and supporting data, calculations and final plan drawings.

In addition to details and calculations, the Final Drainage Report shall include a narrative describing in detail how the site and site features will function for the water quality storm and the Minor and Major storm events. It is imperative that the written narrative provide sufficient information and details such that in reading the main body of the report, the reader has a clear understanding of how the site's stormwater system functions for each storm event. Insufficient report content will be grounds for rejection of the submittal.

The Final Drainage Report shall contain the signed project certification cover sheet found in Appendix G.

If infiltration to underlying soils will be used to manage any portion of the site runoff, refer to procedures outlined in Appendix D and G and the geotechnical/hydrogeological requirements of this manual.

3.1.2.3 Geotechnical/ Hydrogeological Report

The purpose of the Geotechnical/Hydrogeological Report is to provide sufficient information such that reviewer has a clear understanding of underlying soils and groundwater characteristics and how those will interact with and be impacted by the proposed development. The report shall be based upon the outline provided in Appendix D and shall include appropriate background information and supporting data, calculations and plan drawings.

In addition to the report, a letter from the geotechnical or hydrogeological professional shall be submitted stating the impacts that the stormwater runoff will have to groundwater levels, structures and facilities both within and outside the limits of developments. If impacts are identified, the report shall provide mitigation solutions for the development.

A groundwater mounding calculation shall be provided to identify the impacts of infiltrated stormwater runoff. An example calculation method and spreadsheet is made available from the United States Geological Survey (USGS); however, other approved, similar calculation methods may be accepted.

The Geotechnical/Hydrogeological Report shall contain the signed project certification cover sheet found in Appendix G.

3.1.2.4 Operation and Maintenance (O&M) Manual

The general purpose of the O&M manual is to identify the party responsible for operations and maintenance of the stormwater facility, detail maintenance schedules/activities and to ensure adherence with approved design operating conditions.

Appendix E outlines further requirements and information that shall be included in the O&M manual.

3.1.2.5 Homeowners' Association (HOA) Agreement

For subdivision development, an HOA agreement shall be submitted and approved to ensure perpetual legal validity and financial stability of the party responsible for ownership and maintenance of the stormwater facility and the template form found in Appendix G.

Appendix F outlines further requirements and information that shall be included in the HOA agreement.

3.1.2.6 Subdivisions Improvements Agreement (SIA) Requirements

The SIA shall include language describing HOA agreements, O&M requirements, easements, property owner responsibilities and any other subdivision or building-specific stormwater mitigation requirements.

3.1.2.7 Template Forms

Depending on the specific requirements of the development, additional agreements or forms may be required for submittal. Template forms are provided in Appendix G.

Chapter 4 - Rainfall

4.1 APPLICATION

This chapter provides design storm frequency and precipitation data to be used in the design of stormwater management facilities for City of Billings' contracted projects, residential lot developments, commercial property developments, subdivision developments, and Business District Development/Redevelopment and miscellaneous developments. The information provided for the Water Quality Storm is intended for use in the design of permanent water quality treatment facilities for commercial property, subdivisions, and Business District Development/Redevelopment and miscellaneous developments.

4.2 MINOR AND MAJOR DRAINAGE SYSTEMS

Every urban area has two separate and distinct drainage systems, whether or not they are actually planned or designed. One is the Minor Drainage System and the other is the Major Drainage System, which are combined to form the Total Drainage System.

The Minor Drainage System is designed to transport the runoff from storm events with recurrence intervals from 2-year to 10-year with a minimum of disruption to the urban environment. Minor storm drainage can be conveyed in the curb and gutter area of the street (subject to street classification and capacity as defined herein), a roadside ditch, in the underground storm drain, open channels, or other conveyance facilities.

The Major Drainage System is designed to convey runoff from the 100-year recurrence interval storm to minimize health and life hazards, damage to structures, and interruption to traffic and services. Major storm flows can be carried in the urban street system (within acceptable depth criteria), open channels, storm sewers, and other facilities.

Drainage planning and design shall include consideration for both the Minor and Major Drainage Systems.

4.3 DESIGN STORM FREQUENCY

The design storm frequency varies depending on the development type as well as the street classification as shown in Tables 4.1 and 4.2.

Table 4.1 – Design Storm Frequency by Development Type

Development Type	Design Storm Frequency (Recurrence Interval, Year)	
	Minor	Major
Residential Subdivision	2	100
Commercial Lot Development	50	N/A

Table 4.2 – Design Storm Frequency by Street Classification		
Public Street Classification[2]	Design Storm Frequency (Recurrence Interval, Year)	
	Minor[1]	Major
Local Streets	2	100
Collector / Commercial Subdivision Street	5	100
Industrial / Central Business Streets	10	100
Arterial Streets	10	100

[1] 50-year design storm shall be used for depressed road crossings.

[2] Private streets shall be governed as Commercial Lot Development per Table 4.1.

Drainage systems shall be evaluated for the Major storm to identify potential flood hazards. Drainage systems may need to be designed to convey a portion, or all, of the Major storm flows if Major storm flows cannot be safely conveyed to a suitable receiving system, or if allowable flow depths in streets cannot be maintained (see Section 6.2).

4.4 DESIGN STORM DEPTH AND INTENSITY

Rainfall depths and intensities are provided in Tabled 4.3 and 4.4 for the City of Billings, including durations from 5 minutes up to 24 hours and recurrence intervals from 2 years up to 100 years. This information was derived using precipitation data available from the National Climatic Data Center (NCDC) for Billings Logan International Airport (NCDC Cooperative Station Number 240807 (NCDC, 2014) for the period of record from July 1948 through September 2013.

Table 4.3 – Precipitation Depth – Duration
(Depth In Inches)

Duration	2-year	5-year	10-year	25-year	50-year	100-year
5-min	0.27	0.42	0.51	0.65	0.75	0.85
10-min	0.39	0.58	0.70	0.87	1.00	1.13
15-min	0.47	0.68	0.83	1.03	1.18	1.33
20-min	0.50	0.75	0.91	1.13	1.30	1.46
25-min	0.54	0.80	0.98	1.21	1.39	1.56
30-min	0.56	0.84	1.02	1.28	1.47	1.66
35-min	0.59	0.89	1.08	1.34	1.53	1.72
40-min	0.61	0.92	1.12	1.39	1.59	1.78
45-min	0.63	0.95	1.16	1.43	1.64	1.84
50-min	0.65	0.97	1.19	1.47	1.68	1.89
55-min	0.67	1.00	1.22	1.50	1.72	1.93
1-hr	0.68	1.03	1.26	1.55	1.76	1.97
2-hr	0.76	1.11	1.34	1.63	1.85	2.07
3-hr	0.85	1.18	1.40	1.68	1.88	2.09
6-hr	1.05	1.38	1.60	1.88	2.08	2.28
12-hr	1.29	1.67	1.92	2.23	2.46	2.70
24-hr	1.57	2.05	2.37	2.78	3.08	3.38

Based on DOWL Precipitation Analysis (2015)

Table 4.4 – Precipitation Intensity - Duration (Intensity In Inches per Hour)						
Duration	2-year	5-year	10-year	25-year	50-year	100-year
5-min	3.26	5.02	6.18	7.75	8.96	10.16
10-min	2.33	3.45	4.19	5.20	5.98	6.75
15-min	1.87	2.74	3.31	4.11	4.72	5.32
20-min	1.50	2.24	2.73	3.39	3.89	4.38
25-min	1.29	1.93	2.35	2.91	3.33	3.76
30-min	1.12	1.68	2.05	2.55	2.94	3.33
35-min	1.01	1.52	1.85	2.29	2.62	2.95
40-min	0.92	1.38	1.68	2.08	2.38	2.68
45-min	0.84	1.26	1.54	1.91	2.18	2.45
50-min	0.78	1.17	1.43	1.76	2.02	2.27
55-min	0.73	1.09	1.33	1.64	1.88	2.11
1-hr	0.68	1.03	1.26	1.55	1.76	1.97
2-hr	0.38	0.55	0.67	0.82	0.93	1.03
3-hr	0.28	0.39	0.47	0.56	0.63	0.70
6-hr	0.18	0.23	0.27	0.31	0.35	0.38
12-hr	0.11	0.14	0.16	0.19	0.21	0.22
24-hr	0.07	0.09	0.10	0.12	0.13	0.14

Based on DOWL Precipitation Analysis (2015)

The depth versus duration information in Table 4.3 shall be used together with the SCS (NRCS) Type II rainfall distribution to develop the 24-hour storm hyetograph for runoff hydrograph analyses. The rainfall intensities listed in Table 4.4 for the corresponding durations (times of concentration) shall be used in the Rational Method to determine peak runoff rates. For times of concentration other than those listed in Table 4.4, do not interpolate within Table 4.4 directly; rather, the corresponding intensity shall be estimated using a linear interpolation of precipitation depths. (i.e., the 5-year, 22-minute rainfall depth interpolated from the 5-year, 20-minute and 25-minute depths is 0.77 inches, which translates to an intensity of 2.10 inches per hour).

4.5 WATER QUALITY STORM

The water quality design storm shall be used to size runoff treatment and water quality BMPs. Runoff treatment BMPs should be sized based on either the water quality volume or flow rate in order to achieve the required treatment efficiencies.

The water quality runoff volume and/or flow rate for post-development conditions shall be based on the 0.5-inch rainfall event. This storm was selected by the Montana DEQ and issued in the General Permit and has been adopted by the City of Billings as the water quality design storm. Industry standard for water quality treatment is to capture and treat runoff from at least 90 percent of the storms. Based on analysis of precipitation data for the City of Billings, a 0.5-inch daily precipitation represents the 94 percent non-exceedance value (only 6% of daily storm totals exceed 0.5 inches). Further details on how the Water Quality Design Storm is to be applied is discussed in Chapter 8 – Permanent Water Quality Treatment.

Chapter 5 - Runoff

5.1 APPLICATION

This chapter discusses criteria for drainage basin delineation and for selection of acceptable stormwater runoff calculation methods to be used for drainage design within the City of Billings.

5.2 DRAINAGE BASIN AREA

The total area, including upstream offsite areas, contributing to the point of interest shall be included in the delineation of drainage basins. Runoff from upstream undeveloped land, not part of the proposed project, shall be included in the design calculations. Runoff from upstream developed property must be determined based on existing conditions or approved drainage plans. A detailed contoured map with the best information available shall be used to identify off-site areas.

There are several irrigation ditches within the City of Billings. The impact of these ditches must be considered in evaluating drainage basin boundaries and in analyzing off-site contributing runoff to the site and off-site discharge from the site. The drainage analysis shall include an evaluation of the capacity of the irrigation ditch for carrying stormwater runoff in addition to irrigation flows and shall also include an evaluation of potential flow contributions from irrigation deliveries or waste-way structures. Irrigation ditches should generally, not be considered to be a basin boundary since storm runoff from up-basin may overtop the ditch and flow into the area of development. Irrigation ditches should only be considered drainage divides if it can be demonstrated that adequate surcharge capacity is available in excess of that required to carry irrigation flows.

Large drainage basins will typically need to be divided into sub-basins to effectively evaluate the stormwater runoff conditions. Sub-basin boundaries shall be constructed to represent the contributing area to individual storm drain inlets and shall consider the roadway crown, roadside ditches, or other topographic or drainage features which dictate runoff patterns. Large subdivisions should be divided into sub-basins reflecting post development build-out conditions which will dictate basins boundaries. Drainage sub-basin boundaries for subdivisions shall reflect assumed post-developed topographic drainage boundaries, which typically do not follow legal lot lines. Sub-basins for use with the Rational Method shall be delineated to represent homogenous land uses. Where basins are not homogenous, the Rational Method may result in unrealistically low peak flow rates due to use of low weighted-average runoff coefficients.

5.3 SELECTION OF RUNOFF CALCULATION METHODS

Table 5.1 – Acceptable Runoff Calculation Methods		
Runoff Calculation Method	Applications	Limitations/Notes
Rational Method	- Used for determining peak runoff rates for sizing conveyance systems - Should not be used when routing of runoff hydrographs is required	- Should only be used for developments and basins of 5 acres or less - Should only be used for basins with homogeneous land uses
Modified Rational Method	- A simplified method used to approximate storage requirements for small drainages	- Should only be used for developments and basins of 5 acres or less - The Modified Rational Method spreadsheet developed by the City of Billings shall be used (**https://ci.billings.mt.us/567/Stormwater-Management**)
NRCS (SCS) Method	- Used for determining peak runoff rates and runoff hydrographs for large drainage basins - Used for determining storage requirements for detention or retention facilities	- Should be used for developments and basins larger than 5 acres
EPA SWMM	- Used for complex drainage systems requiring modeling of a network of system components	- Consult with City Engineer for Approval to use this method

5.4 NRCS (SCS) HYDROGRAPH METHOD

The SCS Hydrograph Method shall be employed using the procedures detailed in Section 3.2.4 of the HEC-22 Manual (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**).

5.4.1 Soils Types

Use site-specific soils information for the project site when available, or the Natural Resources Conservation Service (NRCS) Soil Survey of Yellowstone County to identify the soils and corresponding hydrologic soil groups for each drainage basin

5.4.2 Time of Concentration

The time of concentration shall be calculated using the procedures detailed in TR-55 Method (**https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf**). Time of concentration (T_c) should range from five minute to 20 minutes for most basins. To the extent possible, the resulting peak flows shall be verified against observed runoff during historic rainfall events in Billings to ensure reasonableness. The final subdivision build-out shall be considered in determining appropriate T_c flow path. Sheet flow lengths shall be limited to no more than 150' and, unless approved by the City Engineer's Office, flow paths from backyards shall not be considered in the determination of T_c. Multiple flow path scenarios shall be evaluated in selecting the flow path which results in the shortest time of concentration, which will govern determination of the peak flow.

5.4.3 Curve Numbers

Curve numbers (CNs) to be used shall be as set forth in Table 5.2. Depending on basin area, multiple CNs with associated flow properties may be required. A conservative approach shall be used when determining CN values.

Table 5.2 – Runoff Curve Numbers for Urban Areas
(Average Watershed Condition, $I_a = 0.2\ S_R$)

Land Use Description		Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Fully Developed Urban Areas (Vegetation Established)					
Lawns, open spaces, parks, golf courses, cemeteries, etc.					
Good condition; grass cover on 75% or more of the area		39	61	74	80
Fair condition; grass cover on 50 to 75% of the area		49	69	79	84
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads					
Paved with curbs and storm sewers		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
	Average % impervious*				
Commercial and business areas	85	89	92	94	95
Industrial districts	72	81	88	91	93
Residential Lots:	Average % impervious*				
	65	77	85	90	92
	38	61	75	83	87
	30	57	72	81	86
	25	54	70	80	85
*Interpolate as necessary					
Developing Urban Areas (No Vegetation Established)					
Newly graded area		77	86	91	94
Native Ground Cover					
Herbaceous – mixture of grass, weeds and low growing brush, with brush the minor element (30%-70% ground cover)			71	81	89
Herbaceous – mixture of grass, weeds and low growing brush, with brush the minor element (>70% ground cover)			62	74	85
Sagebrush with grass understory			35	47	55
Pasture, grassland or range – continuous forage for grazing		39	61	74	80
Meadow – continuous grass, protected from grazing, mowed for hay		30	58	71	78
Cultivated Agricultural Lands					
Row crops		67	78	85	89
Close-seeded or broadcast legumes or rotation meadow		58	72	81	85
Small grain crops		63	75	83	87

5.5 RATIONAL METHOD

One of the most widely used equations for the calculation of peak runoff from small basins is the Rational formula, given as follows:

$$Q = C_f CIA$$

Where: Q = Flow in cfs,
C_f = correction factor for infrequent storms,
C = a dimensionless runoff coefficient,
I = rainfall intensity in inches per hour, and
A = drainage area in acres

The Rational Method shall be applied using the procedures detailed in Section 3.2.2 of the HEC-22 Manual (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**). To the extent possible, the results shall be verified against observed runoff during historic rainfall events in Billings to ensure reasonableness.

5.5.1 Frequency Correction Factors

Table 5.3 lists the correction factor to be used for infrequent storm events.

Table 5.3 – Frequency Correction Factors for Rational Method

Recurrence Interval (years)	Adjustment Factor C_f
2 and 10-year	1.00
25-Year	1.10
50-Year	1.20
100-Year	1.25
NOTE: $C*C_f$ should not exceed 1.00	

5.5.2 Time of Concentration

The time of concentration shall be calculated using the procedures detailed in Section 3.2.2.3 of the HEC-22 Manual (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**). Time of concentration (T_c) should range from five minutes to 20 minutes for most basins. To the extent possible, the resulting peak flows shall be verified against observed runoff during historic rainfall events in Billings to ensure reasonableness. The final subdivision or site build-out shall be considered in determining appropriate T_c flow path. Sheet flow lengths shall be limited to no more than 150' and, unless approved by the City Engineer's Office, flow paths from backyards shall not be considered in the determination of T_c. Multiple flow path scenarios shall be evaluated in selecting the flow path which results in the shortest time of concentration, which will govern determination of the peak flow.

5.5.3 Runoff Coefficients

Runoff Coefficients to be used shall be as set forth in Table 5.4. Depending on basin area, multiple coefficients with associated flow properties may be required. A conservative approach shall be used when determining coefficient values.

Table 5.4 – Runoff Coefficients ("C") for the Rational Method

Type of Drainage Area	Runoff Coefficient, C*
Residential:	
Neighborhood areas	0.70
Single-family areas	0.50
Multi-units, detached	0.60
Multi-units, attached	0.75
Apartment dwelling areas	0.70
Industrial:	
Light areas	0.80
Heavy areas	0.90
Parks, cemeteries	0.10 – 0.25
Playgrounds	0.20 – 0.40
Railroad yard areas	0.20 – 0.40
Unimproved areas (forest)	0.10 – 0.30
Lawns:	
Sandy soil, flat, 2%	0.10
Sandy soil, average, 2-7%	0.15
Sandy soil, steep, 7%	0.20
Heavy soil, flat, 2%	0.17
Heavy soil, average 2-7%	0.22
Heavy soil, steep, 7%	0.35
Streets, parking lots and other paved areas:	
Asphaltic and concrete	0.95
Brick	0.85
Drives, walks and roofs	0.95
Gravel Areas	0.70-.85

*Higher values are usually appropriate for steeply sloped areas and longer return periods as infiltration and other losses have a proportionally smaller effect on runoff in these cases.

5.6 EPA SWMM RUNOFF METHOD

The EPA SWMM runoff method is widely accepted and is typically used for large complex projects or subdivisions. The results from this method shall be verified for reasonableness through comparison to the results of other accepted methods including the SCS Hydrograph Method and/or the Rational Method. To the extent possible, the results shall also be verified against observed runoff during historic rainfall events in Billings to ensure reasonableness. Check with the City Engineer for approval to use this method.

5.7 MODIFIED RATIONAL METHOD

The Modified Rational Method was developed (Poertner, 1974) with the intent of using the rational method for sizing of storage facilities on small watersheds. The Modified Rational Method approximates the volume of runoff for various storm durations, with peak flows based on the time of concentration for each respective duration and a triangular approximation of the runoff hydrograph for each. The

difference between the volume of runoff into the facility and the outflow from the facility, computed for the various storm durations is used to establish the maximum required detention storage.

This simplified approach is more valid for small basins such as rooftop drainage, parking lots, or other small components of development, with contributing areas less than 5 acres.

The City developed and prefers the use of their Modified Rational Method spreadsheet. This spreadsheet is available on the City's website (**https://ci.billings.mt.us/567/Stormwater-Management**).

5.8 COMPUTER AIDED DESIGN SOFTWARE

The City of Billings will allow the use of other computer aided design software programs for large, complex developments. However, designer shall provide a detailed, written explanation, within the body of the CDP, detailing selection of input parameters, description for how program calculates results, and a detailed explanation of those results. Appurtenant results pages shall be provided in an appendix of the CDP.

Chapter 6 - Hydraulic Analysis and Design

6.1 APPLICATION

This chapter provides criteria to be used in the design of public storm drainage infrastructure including inlets, manholes, storm drain, open channels, culverts, and bridges to safely convey storm runoff for projects within the City of Billings.

6.2 GUTTER FLOW

The primary purpose of streets is for traffic and the use of streets for storm runoff must therefore be restricted. However, streets are an integral part of the urban drainage system and may be used for transporting a limited amount of storm runoff. The City allows the use of streets for drainage within the limitations specified in Tables 6.1 and 6.2. Street classifications are specified on the current Functional Classification Map developed by the City of Billings. This map can be found on the City's website (**http://ci.billings.mt.us/DocumentCenter/View/1998**).

Table 6.1 – Allowable Use Of Streets For Minor Storm Runoff

Street Classification	Maximum Street Encroachment
Local	No curb overtopping. Flow may spread to crown of street.[1]
Collectors	No curb overtopping. Flow spread must leave at least one, 11' lane free of water, five feet either side of the street crown. [1]
Arterials	No curb overtopping. Flow spread must leave at least two, 11' lanes free of water, ten feet each side of the street crown or median. [1]
Arterials (more than 6 lanes)	No curb overtopping. Flow spread must leave at least four, 11' lanes free of water, twenty feet each side of the street crown or median. [1]

[1]Where no curbing exists, encroachment shall not extend beyond property lines, except at drainage easements.

Table 6.2 – Allowable Use Of Streets For Major Storm Runoff

Street Classification	Maximum Depth
Local and Collectors	The depth of water at the gutter flowline shall not exceed 18 inches. Residential dwellings and public, commercial, and industrial buildings shall not be inundated at the ground line unless flood-proofed.
Arterials	To allow for emergency vehicles, the depth of flow at the street crown shall be no more than six inches. Residential dwellings and public, commercial, and industrial buildings shall not be inundated at the ground line unless flood-proofed.

6.2.1 Hydraulics

Gutter flow encroachment and hydraulics shall be evaluated using the methods presented in Section 4.3 of the HEC-22 Manual (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**).

6.2.2 Minimum Gutter Slope

Gutters shall be constructed at slopes no flatter than 0.4 percent for retrofit conditions and 0.6 percent for new construction. For new gutter sections in vertical curves, the k-value shall be less than or equal to 167 to provide for adequate drainage. If the k-value exceeds 167, special consideration shall be given to promote drainage.

6.2.3 Inlet Spacing and Location

6.2.3.1 General

The interception capacity of inlets and required spacing shall be determined in accordance with the procedures described in Sections 4.3 and 4.4 of the HEC-22 Manual.

- Recommended Locations for inlets
  - Prior to pedestrian crossings
  - At low points in the gutter grade
  - Where significant flows from off the right-of-way are expected
  - On horizontal curves where a change from normal crown to super-elevation may cause water to sheet-flow across the road
  - Where lay-down curb (e.g., at approaches) may allow the flow to escape and cause flooding
  - Where necessary to maintain gutter flow widths and depths within the allowable limits set forth in Tables 6.1 and 6.2
  - Mid-block inlets within subdivisions, shall be located along property lines to minimize impacts to future driveways and other development features
  - Where a curbed roadway crosses a bridge, the gutter flow should be intercepted and not permitted to flow onto the bridge.

6.2.3.2 Inlet Types

Allowed storm inlet types include grated and combination (grated with curb opening or grated with curb opening plus slotted drain) inlets. The City of Billings standard inlets include Type II inlets in sag locations and Type III inlets for on-grade installations (See City of Billings Standard Modifications; **https://ci.billings.mt.us/569/Standard-Mods**). For streets without curb and gutter, these inlets may not be appropriate and another inlet may be selected with City approval.

- Inlets in sag locations – inlet capacity in sump locations shall reflect 50 percent plugging by debris (design capacity equals 50 percent of the theoretical capacity).

- Inlets at on-grade locations – inlet capacity on-grade shall reflect 25 percent plugging by debris, (design capacity equals 75 percent of the theoretical capacity).

- Inlets installed within the right-of-way, or are adjacent to trails, sidewalks, and bike lanes must have grates that are designated for pedestrian and bicycle traffic. Approval from the City is required for inlets within the right-of-way that are not designated for pedestrian and bicycle.

- The capacity of an inlet shall be checked against the capacity of the inlet lateral pipe to ensure that the lateral pipe has adequate capacity to convey the inlet(s) capacity.

6.2.3.3 Sediment Filters

Sediment filters may be required by the City in locations with high sediment loads. Sediment filters must be properly maintained, including semiannual replacement schedules. Improper maintenance of sediment filters will be subject to City recourse as outlined in City Code, Chapter 28. Sediment filters may decrease flow capacity of the inlet. The inlet capacity calculations should consider the filter manufacturer's capacity restrictions of the inlet, if filters are required.

6.3 STORM DRAIN

6.3.1 Hydraulics

Use the methods set forth in Chapter 7 of the HEC-22 Manual for the hydraulic design of storm drains, except as modified herein (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**).

6.3.1.1 Freeboard Requirements

Storm drains shall be designed to operate in a non-pressurized (non-surcharged) flow condition during the Minor storm. Storm drains may be designed to surcharge during Major storm events; however, surcharging shall not result in a hydraulic grade line (HGL) elevation higher than the criteria listed in Table 6.2.

6.3.1.2 Diameter, Slope, and Velocity Limits

Minimum slopes for storm drain pipes shall be as required to maintain a full-flow velocity of at least 2.5 feet per second during the Minor Storm Event. Maximum full-flow velocity shall be limited to 12 feet per second in storm drain mains during the Minor Storm Event.

Minimum diameter for storm drain main lines and laterals, which will be part of the public storm drainage system, shall be 12 inches. Minimum diameter for private connections into the public storm drainage system shall be 6 inches as discussed in Section 6.3.5. Pipe sizes shall normally increase in the downstream direction and transitions from smaller pipes to larger pipes shall occur by matching the inside top (crown) of the pipes where practicable. Where it is not possible to match crowns, the 80-percent diameter points of the pipes shall be matched, where practicable; or, upon approval from the City Engineer's Office, inverts may be matched if the HGL does not exceed the street elevation.

6.3.1.3 Maintenance Access

All stormwater pipe and facilities shall be accessible for operation and maintenance by the City of Billings, Homeowners' Association or private business.

When vehicle access is necessary, for facilities constructed outside of the street section, access roads shall be provided in dedicated access easements. The minimum clear driving lane width of access roads is 12 feet. Access roads shall have a maximum grade of nine percent and shall be constructed with gravel, pavement, concrete or an appropriate all-season surface.

Gates and/or bollards are required when necessary to restrict access to stormwater facilities. Cables and/or chains stretched across access roads are not acceptable.

6.3.1.4 Manning "n" Values

The Manning's "n" value used for the design of storm drains shall be as shown in Table 6.3.

Table 6.3 – Manning's Coefficients (n) for Storm Drain Conduits

Pipe Material	Roughness or Corrugation	Manning's n
Concrete Pipe	Smooth	0.013
Concrete Boxes	Smooth	0.015
Spiral Rib Metal Pipe	Smooth	0.013
Corrugated Metal Pipe, Pipe-Arch and Box	2-2/3 by 1/2 in Annular 2-2/3 by 1/2 in Helical 6 by 1 in Helical 5 by 1 in 3 by 1 in 6 by 2 in Structural Plate 9 by 2-1/2 in Structural Plate	0.027 0.023 0.025 0.026 0.028 0.035 0.037
Poly Based Thermoplastic	Smooth Corrugated	0.015 0.025
PVC Based Thermoplastic	Smooth	0.011

*Published values may differ; however, values presented in this table assume long term use of pipe which leads to increased roughness. Manufacturer recommendations shall be used if values are higher than presented above.

6.3.2 Materials

Storm drains shall be constructed and installed as represented by the City of Billings Standard Modifications to the Montana Public Work Standard Specifications (MPWSS) (**https://ci.billings.mt.us/569/Standard-Mods**).

6.3.3 Access Manholes

6.3.3.1 General

Access manholes are required when joining pipes of different types, sizes, at horizontal or vertical bends in the alignment, at lateral connections, and at the upstream terminus of storm drain mains.

6.3.3.2 Required Size

The required minimum manhole size shall be as shown in Table 6.4.

Table 6.4 – Minimum Allowable Manhole Size

Storm Drain Diameter	Manhole Diameter
12" to 24"	4'
27" to 36"	5'
42"	6'
48" and larger	Junction box or Tee Manhole

Larger manhole diameters or a junction box may be required when storm drain alignments are not straight through or where lateral pipes enter the manhole. The number and size of pipes that may be connected to any single manhole is limited in order to maintain the integrity of the structure. For angled connections or those with several pipes on the same plane, a larger manhole than set forth in the Table 6.4 may be required. For structural integrity, minimum undisturbed wall (edge of pipe

opening to edge of pipe opening) shall be 8 inches and for 72-inch and larger diameter structures, the minimum undisturbed wall between openings shall be 12 inches; unless otherwise allowed by the manufacturer's engineer.

6.3.3.3 Required Spacing

The maximum manhole spacing along storm drains is as set forth in Table 6.5.

Table 6.5 – Maximum Allowable Manhole Spacing

Storm Drain Diameter	Maximum Spacing
12" to 36"	400'
42" to 60"	500'
66" and Larger	600'

6.3.3.4 Maximum Manhole Depth

Manhole depths shall not exceed 20 feet without special safety provisions such as intermediate platforms and minimum diameter risers of 48 inches.

6.3.3.5 Drop Manholes

The difference between the highest trunk line pipe invert entering a manhole and the invert leaving shall not exceed 24 inches. Manholes exceeding 24 inches of fall shall be designed as drop manholes. Drop manholes with drop heights exceeding six feet shall be designed with high strength (6,000 psi) concrete.

6.3.4 Clearance from Other Utilities

The following utility clearances shall be maintained where possible. All clearances are based on the outside edge of the storm drain to the outside edge of the other utilities. For additional information, refer to the Infrastructure Layout diagram listed in the City's Standard Modifications Drawings.

- Horizontal clearances from storm main:
  - Cable TV, Gas, Power — 5 feet
  - Sewer — 6feet
  - Telephone, Fiber Optics — 5 feet
  - Water — 12 feet
- Vertical clearances from storm main:
  - Cable TV, Gas, Power — 1 feet
  - Sewer — 1 feet
  - Telephone, Fiber Optics — 1 feet
  - Water — 1.5 feet
  - Misc. Private Utilities — 1 feet
- Water main crossings shall be designed to prevent freezing due to minimal clearance from storm drains.
- Avoid crossing other utilities at highly acute angles. The angle measure between utilities shall be between 45 and 90 degrees.

6.3.5 Private Drainage System Connections

Private drainage system connections to the public storm drain system shall be approved by the City and shall comply with the following criteria. Such connections shall be entirely owned and maintained to the main by development in which the connection was installed and/or services.

- All private stormwater connections shall include backflow prevention to prevent stormwater from the City's storm drain system from surcharging onto private property. Backflow preventer must be installed on-site and not within the public right-of-way.
  - Minimum pipe diameter discharging to the City's storm drain system shall be 6 inches with a minimum slope of 1 percent to provide adequate scour velocity. The maximum pipe diameter allowed will depend on an evaluation of the capacity of the City's storm drain system and approval from the City Engineer's Office.
  - Directly connected pumped connections to the City's storm drain system are not allowed. Developments may install a pump to mitigate stormwater runoff per the requirements of this manual; however, stormwater runoff shall be pumped to a manhole or other feature prior to making a gravity connection to the City's system.
  - Lateral connections within the public right-of-way shall be made at right angles.
- Private connections to the City storm drain shall be made by the following (in order of preference):
  - Core-drill or appropriate fitting directly on the main line; or
  - Connecting to an adjacent catch basin/manhole. Connection shall only be made with approval from the City Engineer's Office if it is deemed such connection is in the best interest of the City.

6.3.6 Outfalls

6.3.6.1 General

- Use the methods set forth in Chapter 7.1.5 of the HEC-22 Manual, as modified herein.
- Invert elevations of outfalls shall be no lower than the bank-full water surface elevation (2-yr flood) in open channels or streams, where practicable.
- Outfalls downstream of detention facilities shall be designed to prevent backwater into those facilities.
- Outfalls within ditches/drains shall be constructed with fire-proof material.

6.3.6.2 Erosion Protection

- Erosion protection is required at the outlet to prevent erosion of the outfall channel bed and bank.

6.3.6.3 Energy Dissipation/Rip-Rap

- Where flow velocities exceed 10 feet-per-second at the outfall, during the Minor Storm (when the outfall conduit is running at design capacity), energy dissipation, in addition to erosion protection may be required to minimize erosion. Design energy dissipation measures in accordance with FHWA HEC-14, "Hydraulic Design of Energy Dissipaters for Culverts and Channels" (**https://www.fhwa.dot.gov/engineering/hydraulics/pubs/06086/hec14.pdf**).

- Rip-Rap size and classification shall be based upon flow rates to be mitigated. Rip-Rap sizing shall follow MDT's guidelines within their Standard Specifications, Division 700:

http://www.mdt.mt.gov/other/webdata/external/const/specifications/2014/division_700.pdf

6.3.6.4 Maintenance Access

- All stormwater pipe and facilities shall be accessible for operation and maintenance by the City of Billings, Homeowners' Association or private business.

  When vehicle access is necessary, for facilities constructed outside of the street section, access roads shall be provided in dedicated access easements. The minimum clear driving lane width of access roads is 12 feet. Access roads shall have a maximum grade of nine percent and shall be constructed with gravel, pavement, concrete or an appropriate all-season surface.

  Gates and/or bollards are required when necessary to restrict access to stormwater facilities. Cables and/or chains stretched across access roads are not acceptable.

6.4 OPEN CHANNEL CONVEYANCES

6.4.1 General

New or altered channels shall be lined with grass, rocks or other erosion resistant materials. Concrete or asphalt shall not be used unless approved by the City Engineer.

Design open channels in accordance with the methods provided in Chapter 5 of HEC-22 except as modified herein. Boulevard swales are considered a category of Open Channel Conveyances and are discussed in more detail in Chapter 7.

6.4.2 Clearance

Channels shall be located no closer than ten feet from any structure foundation as measured horizontally from the edge of the swale at the top of freeboard elevation.

6.4.3 Erosion Control

Channel segments shall be designed according to the permissible tractive force (shear stress) methodology set forth in Section 5.3 of HEC-22 and Hydraulic Engineering Circular 15 (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**, **http://www.fhwa.dot.gov/engineering/hydraulics/pubs/05114/05114.pdf** , respectively)

Both the bare soil condition immediately following construction and the anticipated vegetated conditions of the channel shall be evaluated. If the channel is determined to be unstable during the Minor Storm for either of these conditions, the appropriate long-term, temporary, and transitional linings shall be installed.

Erosion control structures, such as check drops or check dams, may be required to control flow velocities.

The grass species selected for seeding shall conform to requirements set forth in the Montana Public Works Standard Specifications and the City of Billings Standard Modifications.

6.4.4 Freeboard Requirements

A minimum freeboard of one-foot from the water surface during Major Storm event to the top of bank shall be provided for open channel conveyances.

6.4.5 Low-Flow Channels

Low flow channels shall be included in the channel cross section to carry sustained low flows and frequent storm events in a confined sub-section of the larger channel. A pipe may also be used to mitigate sustained low flows.

6.4.6 Friction Factors (n)

Use Manning's roughness factors (n) set forth in Table 5-1 of HEC-22. The design shall consider the channel roughness both immediately after construction and when vegetation is fully established. Roughness factors, which are representative of unmaintained channel conditions, shall be used for the analysis of water surface profiles. Roughness factors, which are representative of well-maintained channel conditions, shall be used to determine maximum velocity.

6.4.7 Side Slopes

Side slopes shall be no steeper than 4H:1V for maintained grass-lined channels, 3H:1V for unmaintained native grass-lined channels and 2H:1V for riprap-lined channels.

6.4.8 Maintenance Access

Provide maintenance access for inspection, mowing operations, and debris removal by conventional equipment along the length of the conveyance channel. The type of equipment needing access is dependent on the size of the channel. Large channels will need access for dump trucks and loaders. For small ditches, foot or pick-up truck access may suffice. Channels may need to be offset within the easement to facility maintenance.

6.4.9 Operation & Maintenance of Private Open Channels

Open channels require periodic maintenance. The degree of maintenance is dependent on the location, the specific type of facility, and the liner material (grass, rock, etc.).

Maintenance of open channels is required to insure the conveyance capacity of the facility is maintained and that channel erosion does not occur. The condition of open channels should be checked on a periodic basis, especially after large storms or extended periods of high flow or immediately following periods of high intensity winds (erosion may occur during high flows, from scour caused by localized debris blockage or from debris blown into the channel). Debris should be removed to prevent channel plugging, channel scour and loss of channel conveyance. Erosion shall be repaired or stabilized.

Vegetated channels shall be maintained to ensure that vegetation does not limit the conveyance capacity of the facility. If conveyance restrictions are apparent, the vegetation should be trimmed to restore capacity.

Emergent vegetation (spirogyra, elodea, watercress, etc.) in conveyance channels may also become a problem if it is allowed to constrict the conveyance capacity of the facility. Vegetation above the ordinary high water mark shall also be monitored primarily for its ability to retain bank stability without reducing channel capacity at maximum design flows.

6.5 CULVERTS

Culverts are used to convey water in irrigation ditches and natural drainage-ways under City Streets and trails. Culverts shall be designed using the methods set forth in the Federal Highway Administration (FHWA) Hydraulic Design Series No. 5 (HDS-5), "Hydraulic Design of Highway Culverts", Publication No. FHWA-NHI-01-020 except as modified herein (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/12026/hif12026.pdf**).

6.5.1 Street Overtopping

Culverts shall be sized such that the depth of street overtopping is limited as set forth in Table 6.6.

Table 6.6 – Allowable Street Overtopping Depths at Culvert Crossings

Street Classification	Minor Storm	Major Storm
Local and Collector	None	Six inches at the street crown. Residential dwellings and public, commercial, and industrial buildings shall not be inundated at the ground line unless flood-proofed.
Arterial	None	No overtopping allowed. Provide 1-ft of clearance between the crown of the culvert and the water surface elevation where practicable, for drainage basins greater than one square miles.

6.5.2 Headwater Depth

The headwater (HW) depth shall be limited according to the following ratios to diameter (D):

- For culverts with a cross sectional area less than or equal to 30 square feet: HW/D ≤1.5
- For culverts with a cross sectional area greater than 30 square feet: HW/D ≤ 1.2

Culverts must also be sized without creating significant flow constriction, such that existing channels upstream are not overtopped during the design flow event.

6.5.3 Allowable Velocities

Culverts shall be designed to maintain a minimum velocity of 2.5 feet-per-second during the Minor Storm to prevent sediment accumulation and shall be designed with a minimum slope of 0.5 percent, where practicable.

Culverts shall be sized to limit velocities in order to minimize erosion potential during the Major Storm Events. For exit velocities in excess of 10 feet-per-second during the Major Storm, energy dissipation, in addition to erosion protection may be required to minimize erosion. Design energy dissipation measures in accordance with FHWA HEC-14, "Hydraulic Design of Energy Dissipaters for Culverts and Channels" (**https://www.fhwa.dot.gov/engineering/hydraulics/pubs/06086/hec14.pdf**).

6.5.4 Materials

Culverts shall be constructed of materials approved by the City as represented by the City of Billings Standard Modifications to the Montana Public Work Standard Specifications (MPWSS) (**https://ci.billings.mt.us/569/Standard-Mods**).

Culvert wall strengths and coatings shall be suitable for the soil conditions, design depths, and trench details. Culvert strength shall be designed assuming HS-20 live load capacity unless unique conditions of the crossing warrant a higher load capacity (i.e., HS-25 or E-80).

When an abrasive bed load is anticipated or when velocities exceed 10 feet per second, protective measures shall be implemented to limit pipe damage. Corrosion, abrasion and other appropriate observations of field conditions shall also be considered in determining appropriate culvert materials and joint types. Corrosion resistance shall be evaluated based on minimum resistivity, pH, sulfate content and chlorine content of the soil and groundwater.

6.5.5 End Treatments

Culverts shall be designed with appropriate end treatments at their inlets and outlets such as flared end sections, headwalls, or wingwalls to provide smooth transitions to/from the drainage channel or ditch and to conform to embankment slopes. In addition to the pipes, end treatments installed within ditches/drains shall be fire-proof. Erosion protection or energy dissipaters shall be provided as necessary to limit erosion due to turbulent flow and high velocities. Depending on the culvert location, a safety grate or trash rack may need to be installed.

6.5.6 Maintenance Access

Provide maintenance access to the upstream and downstream ends of culverts for inspection and debris removal.

6.6 BRIDGES

Hydraulic sizing for bridges across major drainages shall conform to the requirements of the Montana Department of Transportation (MDT).

Chapter 7 - Runoff Control Facilities

7.1 APPLICATION

This chapter provides criteria for design of runoff control facilities including detention basins, retention/infiltration basins, and boulevard swales. These facilities are used to control the quantity of runoff discharged from the project site by storing runoff and slowly releasing water through an outlet structure by evaporation and infiltration or conveyance measures. These runoff control facilities may also be used in conjunction with water quality treatment facilities discussed in Chapter 8. Storage requirements related to runoff control vary with the project classification as discussed in Chapter 2.

7.2 DETENTION BASINS

Detention basins can be designed as a standalone facility, also known as a dry basin, where runoff is routed over time until the basin completely drains out. They can also be designed to "stack" on top of water quality facilities such as retention/infiltration basins or wet basins where temporarily stored runoff will drain down to the original wet basin water surface elevation or to the top of the retention/infiltration basin designed to store the water quality volume (WQV). Further details of these water quality facilities are provided in Chapter 8.

Design of detention basins shall follow the procedures presented in Chapter 8 of the HEC-22 Manual, as modified herein (**http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf**).

7.2.1 Groundwater

Anticipated groundwater levels must be addressed in the design to ensure that sufficient capacity will be available in the basin, above the historic, seasonally-high water table, for storage of stormwater runoff. For standalone detention basins, the historic, seasonally-high water table level shall be a minimum of three feet below the bottom of basin to avoid saturated conditions which interfere with proper maintenance of the facility.

Further details on required groundwater evaluations and suggested sources of information are provided in Appendix D.

7.2.2 Basin Geometry

- Maximum water depth at any time shall not exceed 6 feet for detention basins. The maximum water depth can exceed 6 feet only in those cases where a detention basin is "stacked" on top of a water quality wet basins or wetland. Freeboard above the design storm in the amount of 1 foot is required when designing detention ponds.

- Side slopes shall be no steeper than 4H:1V for maintained grass-lined sections, 3H:1V for unmaintained native grass-lined sections and 2H:1V for riprap-lined sections.

- The slope of the pond bottom shall be no less than 2% to promote drainage across grassed surfaces.

- ❖ The maximum water surface elevation during the Major Storm shall be no less than one foot below the adjacent ground, window well, finished floor, top of foundation or any other entry point vulnerable to flooding for residential dwellings and public, commercial, and industrial buildings.

- ❖ Safety benches should be considered with larger detention basins to provide a shallow area for people and animals that inadvertently enter the open water, to exit the basin.

7.2.3 Maximum Drain-Down Time

Detention basins are used to limit discharge from the site to an allowable runoff rate as discussed in Chapter 2. The water surface in the facility shall return to the pre-storm level within 72-hours after cessation of the major storm.

7.2.4 Low-Flow Channels

Dry detention basins shall be constructed with low-flow channels that have a capacity of 1 to 3 percent of the Minor Storm inflow rate and with a minimum longitudinal slope of 0.5 percent. The bottom of the basins shall be sloped at a 2 percent minimum grade towards the low-flow channel to facilitate drainage. A piped configuration may be used in lieu of a dedicated above-ground low-flow channel.

7.2.5 Multi-Purpose Use

Detention facilities designed for multi-purpose use (sport courts, neighborhood parks, play areas, picnic areas, etc.) are allowed. Multi-use amenities shall be anchored to prevent floatation.

Runoff from more frequent storms shall be stored separately from the multiple use areas. These separate storage areas should, at a minimum, be sized to store the water quality storm volume.

The developer shall make arrangement for maintenance of such amenities unless such responsibility is accepted by the City of Billings.

7.2.6 Set Backs

- ❖ Detention basins shall be located:
  - ➢ Such that the facility does not interfere with underground utilities, utility easements, floodplains, etc.; and,
  - ➢ Such that adequate access, maintenance and operations needs (including construction considerations with full replacement) are met and adjacent facilities are protected. The geotechnical and hydrogeological report, detailed in Appendix D, shall identify subsurface impacts to surrounding soils, groundwater, and adjacent facilities or structures. Guidelines in Appendix D will affect the setback for detention basins.
  - ➢ Designer shall check ARM 17.36.323 and DEQ Circular 8 for additional setback standards.

7.2.7 Water Quality Treatment

Stormwater runoff from the water quality event shall be routed through a sediment trap, sediment forebay, or other appropriate water quality BMP, detailed in Chapter 8, prior to discharging to the

detention basin in order to facilitate removal of transported sediments and debris. If other potential pollutants such as oils, grease, or fuel (gasoline and diesel) could be present in the site runoff, it may also be necessary to provide added measures to remove these contaminants.

The facility shall be protected from high sediment loads during construction and until site vegetation has established.

7.2.8 Outlet Control Structures

Outlet control structures shall be designed using the criteria and methods set forth in Chapter 8 of the HEC-22 Manual, as modified herein.

- Minimum orifice diameter without screening is six inches. Screening shall be provided to prevent blockage for orifices of smaller diameter.

- Where safety or debris is an issue, install removable trash and safety racks at outlet orifices, pipes, and weirs.

- Design the outlet structure to minimize the potential for clogging. Consider using perforated pipes with gravels as a filter to prevent clogging, where appropriate.

- The minimum diameter for outlet conduits shall be 12 inches. Anti-seep collars shall be placed on outlet conduits through embankments.

7.2.9 Emergency Overflow & Spillways

Use the criteria set forth in Chapter 8.4.4.4 of the HEC-22 Manual as modified herein. All detention storage facilities shall include a provision for non-erosive control of overflows. Overflows from the Major Storm event shall be directed to a safe discharge path to protect adjacent and downstream properties from damage.

Discharge leaving the site shall be at the same location and have the same characteristics as pre-developed flows. Offsite easements may be required per Table 2.3.

7.2.10 Vegetation & Landscaping

Detention basins shall be landscaped to provide for slope stability, erosion control, and low maintenance. Landscape materials shall be compatible with use in a stormwater detention facility and associated water quality treatment facility. Utilize plant species native to the Billings area to the maximum extent practicable. In general, basins shall be irrigated and either seeded or installed with sod to provide an amenity to the community.

Floatable or erodible material (i.e., wood chips, straw mulch, etc.) shall not be allowed within the basin. The interiors of the basin shall be stabilized with gravel, rock, and vegetation.

Vegetation on basin embankments shall be limited to shallow rooted varieties. Points of inflow to the basin shall be armored to prevent erosion.

7.2.11 Maintenance and Maintenance Access

- Maintenance shall be performed by the HOA or commercial site owner, unless this responsibility is accepted by the City. Further details are provided in Appendices E and F.

- Maintenance will be required to remove invasive plants and debris accumulated at inlet and outlet structures.

- Stormwater detention basin outlet control structures shall be accessible for maintenance and operation. When vehicle access is necessary, access roads shall be provided in dedicated access easements or right-of-way of at least 20 feet wide. The minimum clear driving width of access roads shall be 12 feet and the minimum turn-around radius shall be 25 feet or hammerhead. Access roads shall have a maximum grade of nine percent and shall be constructed with gravel, pavement, concrete or an appropriate all-season surface.
  - Gates and/or bollards are required when necessary to restrict access to stormwater facilities. Cables and/or chains stretched across access roads are not acceptable.

7.3 RETENTION/INFILTRATION BASINS

Retention basins and infiltration basins are very similar in function and consist of a basin with the only means of emptying being through evapotranspiration and infiltration. Retention and Infiltration basins are used to control runoff, but are also used to provide water quality treatment by filtration into the soil. This section discusses the design criteria for retention/infiltration basins for both runoff control and water quality treatment of the water quality volume (WQV). Further details of the water quality design are discussed in Chapter 8. A subsurface infiltration facility (boulder pit) example is found within Appendix G.

Retention/infiltration basins can either be constructed as open systems or subsurface systems. Open systems typically includes excavation of a basin designed to slowly infiltrate the collected runoff into the underlying soil. Subsurface retention/infiltration basins take the form of boulder pits, vault systems, and injection wells which are typically used on sites with limited available space.

7.3.1 Geotechnical/Hydrogeological Evaluation

A geotechnical/hydrogeological evaluation conducted in accordance with Appendix D is required to support the design of retention/infiltration basins for both runoff control and water quality treatment purposes. The evaluation shall be conducted at and below the bottom elevation to minimum depths specified at the location of the proposed basin to characterize native soils, groundwater conditions, and adjacent facilities and structures. The assessment shall demonstrate the feasibility of infiltration and to assess potential risk of stormwater infiltration. Infiltrated stormwater must not adversely affect groundwater levels or flow at property boundaries. The level of data required will be dependent on the amount of stormwater to be managed, the type of infiltration system proposed, and the surface and subsurface soil conditions at the site. The assessment will be conducted by a professional with experience collecting and analyzing hydrogeological data.

- The Developer shall demonstrate through: 1) infiltration testing; 2) soil logs; and 3) a written opinion of a licensed civil/geotechnical engineer or qualified hydrogeologic professional that

sufficiently permeable soils exist on the site for an infiltration system meeting the requirements herein to function properly with the site-specific conditions. The preferred methods for determining infiltration rates are presented in Appendix H.

- The infiltration rate shall be measured at a depth equal to the proposed bottom grade of the facility. A factor of safety of 2.0 shall be applied to the measured infiltration rate in arriving at the design infiltration rate. Follow procedures in Appendix H for determining infiltration rates.

- Geotechnical/Hydrogeological report shall identify the appropriate proximity of infiltration system in relation to adjacent facilities and structures. Developer shall collect sufficient data to identify hydrogeological conditions that have the potential to allow shallow lateral movement of infiltrated water; (i.e., high permeability soil layer, underlain by a low permeability soil layer). The report will contain sufficient data and detail to demonstrate that proposed infiltration systems will not impact any facilities and that any impacts will be limited to the subject property. Where hydrogeological conditions exist that indicate potential impacts to facilities or structures by infiltrated stormwater, infiltration systems may not be considered as appropriate for stormwater management.

Refer to Appendix D and H for additional requirements.

7.3.2 Limitations

- Retention/Infiltration basins may not be approved for use where hydrogeological conditions exist that indicate the potential for infiltrated stormwater to impact on- or off-site facilities or structures and where potential impacts will not be confined to the property.

- Not appropriate for use with tight clays or other soils with low infiltration rates or in areas with a shallow water table.

7.3.3 Groundwater

The depth to the historic, seasonally-high water table, bedrock, hardpan or other impermeable layer shall be no less than three feet below the bottom of basin to allow for infiltration of the runoff. Where impermeable soils are near the bottom of the retention/infiltration basin, it may be possible to use of a permitted Class V injection well to augment infiltration (See Section 7.3.8).

In some instances it may be appropriate to "key" the bottom of the sub-surface infiltration system into a sand or gravel lens, which may coincide with groundwater, to achieve manageable infiltration rates. In situations such as this, the runoff generated by the water quality storm shall be mitigated in a separate system where direct interaction with groundwater is avoided. See Appendix G for reference.

Further details of required groundwater evaluations are provided in Appendix D.

7.3.4 Basin Geometry

- Maximum water depth at any time shall not exceed 6 feet for an open retention/infiltration basin. Safety benches should be considered with larger retention/infiltration basins to provide a shallow area for people and animals that inadvertently enter the open water, to exit the basin.

- Open retention/infiltration basin side slopes shall be 4H:1V or flatter for maintained grass-lined sections, 3H:1V for unmaintained native grass-lined sections and 2H:1V for riprap-lined sections.

- Embankment fill slopes shall be no steeper than 3H:1V and preferably 4H:1V or flatter.

- Subsurface retention/infiltration basins shall be sized based upon the porosity of the fill material within the facility and not on the void ratio of the fill material.

- The maximum water surface elevation during the Major Storm shall be no less than one foot below the adjacent ground, window well, finished floor, top of foundation or any other entry point vulnerable to flooding for residential dwellings and public, commercial, and industrial buildings.

7.3.5 Maximum Drain-Down Time

- Retention/Infiltration basins are used to treat and control runoff from the site to meet criteria discussed in Chapter 2. The basin shall completely drain the captured runoff from the Major storm within 72-hours after cessation of the storm.

- If the retention/infiltration basin is used in combination with a detention basin to control the quantity of runoff, the total draw-down time for the facility shall not exceed 72-hours.

7.3.6 Multi-Purpose Use

Retention/infiltration facilities designed for multi-purpose use (sport courts, neighborhood parks, play areas, picnic areas, etc.) may be allowed where the hydrogeological conditions are appropriate. Multi-use amenities shall be anchored to prevent floatation.

Runoff from more frequent storms shall be stored separately from the multiple use areas. At a minimum, use the water quality storm to size these separate storage areas.

The developer shall make arrangement for maintenance of such amenities unless such responsibility is accepted by the City of Billings.

7.3.7 Set Backs

- Retention/Infiltration basins shall be located:

  - Such that the facility does not interfere with underground utilities, utility easements, floodplains, etc. ; and,

  - Such that adequate access, maintenance and operations needs (including construction considerations with full replacement) are met and adjacent facilities are protected. The geotechnical and hydrogeological report, detailed in Appendix D, shall identify subsurface impacts to surrounding soils, groundwater, and adjacent facilities or structures. Guidelines in Appendix D will affect the setback for detention basins.

- Designer shall check ARM 17.36.323 and DEQ Circular 8 for additional setback standards.

7.3.8 Injection Wells

- Stormwater injection wells (as classified by EPA) may be considered for use in conjunction with retention/infiltration systems to improve the overall infiltration rate. These wells can be used where shallow low permeability soils overly more permeable soils and prevent direct infiltration of stormwater into the underlying soils which are capable of accepting the volume and rate of stormwater infiltration necessary to meet the requirements of this manual. An example of a stormwater injection well is provided in Appendix G.

- Depending on design of the subsurface retention/ infiltration system, the system may be classified as a Class V EPA injection well. A Class V well by definition is any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system (an infiltration system with piping to enhance infiltration capabilities). Developer is responsible to determine if proposed sub-surface retention/infiltration systems are covered under the EPA Underground Injection Control Program as a Class V well. Developer shall obtain and submit appropriate permit as necessary prior to approval from the City.

7.3.9 Water Quality Treatment

Stormwater runoff from the water quality event shall be routed through a sediment trap, sediment forebay, or other appropriate water quality BMP, listed in Chapter 8, prior to discharging to the retention/infiltration basin in order to facilitate removal of transported sediments and debris. If other potential pollutants such as oils, grease, or fuel (gasoline and diesel) could be present in the site runoff, it may also be necessary to provide added measures to remove these contaminants. More information on these BMPs is discussed in Chapter 8 and/or Appendix A of this manual.

- Retention/Infiltration basins shall have sufficient capacity to store at least the entire WQV (see Chapter 8).

- Retention/Infiltration basin shall be designed to fully drain within 72-hours.

- If the retention/infiltration basin is used in combination with a detention basin to control the quantity of runoff, the total draw-down time for the facility shall not exceed 72-hours.

- The Retention/Infiltration basin shall be protected from high sediment loads during construction and until site vegetation is established.

7.3.10 Maintenance & Maintenance Access

- Maintenance shall be performed by the HOA or commercial site owner, unless this responsibility is accepted by the City. Further details are provided in Appendices E and F.

- Infiltration facilities shall be accessible for operation and maintenance. When vehicle access is necessary, for facilities constructed outside of the street section, access roads shall be

provided in dedicated access easements of 20-foot minimum width. The minimum clear driving width of access roads shall be 12 feet and the minimum turn-around radius shall be 25 feet or hammerhead. Access roads shall have a maximum grade of nine percent and shall be constructed with gravel, pavement, concrete or an appropriate all-season surface.

- Approval of retention/infiltration systems shall obligate the owner to repair, replace, or reconstruct the system if it fails to operate as designed. The maintenance and operation schedule for retention/infiltration systems shall include such a provision. As described in Section 1.2, Developer may be required to mitigate system deficiencies beyond the required warranty period, if the deficiencies were found to be the result of improper design, construction, or maintenance. Additionally, if the system fails to function, during Minor and Major storm events, as described in the analysis required in Section 3.1.2.3, Developer may be required to mitigate deficiencies beyond the warranty period.

- Failure to maintain retention/infiltration systems will be subject to the terms set forth in the agreement for the subdivision or commercial site.

7.4 Boulevard swales

Boulevard swales are primarily used in subdivisions without conventional curb/gutter street sections. Boulevard swales are designed to control runoff by either collecting runoff from the street and adjacent areas, storing the runoff, and then infiltrating into the native soil or conveying runoff to a detention/retention or other approved facility. Boulevard swales typically have contributing drainage areas typically less than 1 acre. Boulevard swales shall be designed to accommodate the worst-case runoff scenario which is typically immediately following initial construction of the development, prior to build-out. Boulevard swales should not be confused with water quality swales discussed in Chapter 8, which are used for water quality treatment designed around a water quality flow (WQF).

7.4.1 Locations

- Boulevard swales are commonly placed along roadways or property lines in a manner that integrates the swale with adjacent infrastructure, landscaping and water quality features.

- Boulevard swales shall be located within the right-of-way or dedicated storm drainage easement.

7.4.2 Geotechnical/Hydrogeological Evaluation

Geotechnical/Hydrogeological investigations for boulevard swales shall follow the same criteria as retention/infiltration basins described in section 7.3.1. The geotechnical/hydrogeological investigation shall be conducted at and below the bottom elevation and location of the proposed swale. See Appendix D and H for additional requirements.

7.4.3 Groundwater

The historic, seasonally-high water table level shall be a minimum of three feet below the bottom of boulevard swale to prevent saturation which hampers proper maintenance of the facility.

Further details required for groundwater evaluations can be found in Appendix D.

7.4.4 Basin Geometry

- The boulevard swale shall use a trapezoidal cross section with side slopes no steeper than 4H:1V for maintained grass-lined sections, 3H:1V for unmaintained native grass-lined sections and 2H:1V for riprap-lined sections.

- The minimum bottom width shall be 1-ft.

- The swale must be designed to control runoff in accordance with the requirements presented in Chapter 2.

- The maximum water surface elevation during the Major Storm shall be no less than one foot below the adjacent ground, window well, finished floor, top of foundation or any other entry point vulnerable to flooding for residential dwellings and public, commercial, and industrial buildings.

7.4.5 Maximum Drain-Down Time

- Boulevard swales used for retention shall be designed to fully drain within 72-hours after cessation of the Major storm.

7.4.6 Culverts

- Culverts installed in boulevard swales shall be designed in accordance with the requirements of Section 6.5 of this manual and the City of Billings' standard drawing for drive approaches.

7.4.7 Landscaping and Vegetation

- The boulevard swales shall be either planted with vegetation sufficient to provide full ground coverage or shall be landscaped with rock.

- Vegetation shall be comprised of drought-tolerant grasses or shall be supplemented with a sprinkler system.

7.4.8 Maintenance & Maintenance Access

- Boulevard swales shall be protected from high sediment loads during construction and until vegetation is established in the swale and on adjacent areas contributing runoff. This may require periodic cleaning of the boulevard swale until vegetation is fully established.

- Maintenance for swales and associated culverts shall be addressed in the HOA or by the adjacent property owner and shall follow the requirements set forth in the SIA and Appendix E and F. Maintenance requirements shall address vegetation heights, mowing, watering, fertilizing and frequency for sediment removal and erosion repairs.

- If access from the adjacent public right-of-way is not available, an access easement to the swale shall be provided to facilitate inspection, monitoring, and maintenance. Appropriate access shall be considered when accounting for maintenance of culverts within the swale.

- Failure to maintain boulevard swales will be subject to the terms set forth in the agreement for the subdivision.

Chapter 8 - Permanent Water Quality Treatment

8.1 APPLICATION

The City of Billings has an active General Permit for Storm Water Discharges with Small MS4's on record with the Montana Department of Environmental Quality. This chapter presents the requirements for the implementation and use of post-construction Best Management Practices to ensure compliance with the City's General Permit requirements. Compliance with this section does not require water quality monitoring, or quantitative estimates of pollutant load removal. However, the use of a performance-based approach whereby the principles and objectives of stormwater pollutant control are addressed and applied is required.

8.2 WATER QUALITY VOLUME

The Water Quality Volume (WQV) is the amount of stormwater runoff from a rainfall event that should be captured and treated to remove the majority of stormwater pollutants on an average annual basis. The WQV is based on the first half inch of rainfall per the City's current General Permit with DEQ. Pollutants typically come from the impervious area and therefore the unified stormwater equation will be used to calculate the water quality volume (WQV):

$$\boldsymbol{WQV = \frac{(P)(Rv)(A)}{12}}$$

Where:

WQV = Water Quality Volume, in acre-feet
P = Water Quality Rainfall Depth, inches (0.5-inches)
Rv = the unitless runoff coefficient, Rv = 0.05 + 0.9(I)
I = the percent impervious cover draining to the facility, in decimal
A = total site area draining to the structure, in acres

8.3 WATER QUALITY FLOW

The Water Quality Flow (WQF) is used to determine a flow rate associated with the WQV, for sizing flow-based treatment systems (e.g. Treatment Swales, Flow-Through Devices, etc…). The WQF is calculated using the WQV and the Natural Resource Conservation Service (NRCS) runoff method as discussed in Chapter 5. The WQF is calculated using the following equation:

$$\boldsymbol{WQF = \frac{12(q_u)(WQV)}{640}}$$

Where:

WQF = Water Quality Flow Rate, in cfs
q_u = unit peak discharge, in cfs/mi^2/inch (see Table 8.3)
WQV = water quality volume, in acre-feet

Table 8.3 – NRCS Unit Peak Discharge	
Time of Concentration (minutes)*	q_u (cfs/mi^2/inch)
6	1010
12	800
18	676
24	592
30	529
45	424
60	357

*Either round down to the nearest time of concentration or interpolate for intermediate times of concentration.

8.4 SELECTION OF PERMANENT WATER QUALITY BMPS

In coordination with the Montana Department of Environmental Quality and Montana's other MS4 Municipalities, the *Montana Post-Construction Storm Water BMP Design Guidance Manual (September, 2017)* was created as a means for the development community to design and construct stormwater features that ensures development meets the water quality requirements of the General Permit.

The BMP's listed in Chapter 5 of the *Guidance Manual* were developed to specifically meet the requirements of the General Permit. It is the City's understanding that if a developer constructs post-construction stormwater features per the methodology in the *Guidance Manual,* the development's site will be compliant with the General Permit. If a stormwater feature is not constructed per the *Guidance Manual*, it is the developer's sole responsibility to ensure their site specific post-construction BMP meets the requirements of the General Permit.

The *Montana Post-Construction Storm Water BMP Design Guidance Manual (September, 2017)* can be viewed on the City's website (**https://ci.billings.mt.us/567/Stormwater-Management**).

Chapter 9 - Erosion and Sediment Control

9.1 APPLICATION

This section provides criteria for selection, design, installation, and maintenance of temporary sediment and erosion control Best Management Practices (BMPs) to reduce impacts from construction activities to surface waters, public rights-of way and adjacent properties.

9.2 SWPPP AND NOI REQUIRED SUBMITTALS

In accordance with City Ordinance 28-100, if a project meets the criteria below, a SWPPP (Stormwater Pollution Prevention Plan) and NOI (Notice of Intent) shall be submitted to both the City of Billings and Montana Department of Environmental Quality (MTDEQ) for acceptance. The SWPPP and NOI shall be submitted to the City prior to any grading on the site and prior to submittal to MTDEQ. The SWPPP and NOI submittal to MTDEQ shall be the same as prepared for the City of Billings.

The MTDEQ, in accordance with federal regulations, requires submittal of a SWPPP and NOI in compliance with the General Permit for public and private projects that:

- Disturb one (1) acre or more of land; or
- Are part of a larger master plan development or subdivision that will ultimately disturb one (1) acre or more of land (including Subdivisions and Master Plan reviews, as required by the Billings Municipal City Code (BMCC))
- Section 28-401(a), BMCC requires a SWPPP and NOI be submitted for any construction activity on properties within 50 feet of any water course. This includes irrigation and drainage ditches identified as state waters.

Forms for the SWPPP and NOI can be found on MTDEQ's website (**http://deq.mt.gov/Water/WPB/mpdes/stormwaterconstruction**). The General Permit requires the SWPPP and NOI permit holder to:

- Be identified within the NOI and match the Owner of the SWPPP. A Certified SWPPP Administrator is required for all construction projects requiring an NOI and SWPPP and shall be identified within the NOI and SWPPP.
- Maintain and update the SWPPP to reflect changes on the construction site.
- Specify the inspection frequency. Inspections of storm water and erosion controls shall be every 7 days or every 14 days and following each storm event of 0.25" or more.
- Maintain inspection records and provide the records upon request by the City and/or MTDEQ.
- Maintain and modify temporary BMPs to reflect current conditions of the job site and update site plans and SWPPP language during inspections.
- Achieve stabilization and remove all temporary BMPs once 70% of the disturbed area is revegetated.
- File a Notice of Termination (NOT) upon stabilization of the site.

9.3 CONSTRUCTION LESS THAN ONE-ACRE

Construction activity disturbing areas less than one acre shall be required to implement BMPs and good housekeeping practices to minimize impacts including, but not limited to, erosion and sediment transport into public right-of-way or onto adjoining property. Homebuilders/contractors are responsible for managing BMPs on individual lots within a subdivision and/or master plan area and are required to follow the requirements in the NOI and SWPPP for the property.

9.4 BEST MANGAGEMENT PRACTICES (BMP)

Temporary erosion and sediment control best management practices (BMPs) for construction sites in the City of Billings may be selected, designed, and installed using the methodology discussed in the most current edition of the Montana Department of Transportation Erosion and Sediment Control Best Management Practices Manual. This manual provides guidelines for applications, limitations, effectiveness, materials, design & installation, inspection & maintenance, and removal of temporary BMPs. These manuals are available on MDT's website (**https://www.mdt.mt.gov/publications/docs/manuals/env/bmp-manual-jan15.PDF**).

In addition, the Montana Department of Environmental Quality developed the *Storm Water Management During Construction Field Guide for Best Management Practices* reference document which may help in developing a BMP plan. Please contact their office for a copy of this document.

9.5 CONSTRUCTION ADJACENT TO WATERWAYS

In addition to a SWPPP and NOI application, if construction activities are planned on or near a waterway in Montana, one or several permits may be required. For the purpose of this manual, a waterway is defined as a ditch, drain, creek, stream, river or wetland. Conservation districts, along with participating resource agencies, developed a joint application form that includes the requirements of the following agencies and their required permits:

1. Conservation Districts (local government) - 310 permits
2. MT Fish, Wildlife and Parks (state government) - SP 124 permits
3. Floodplain Administrators (Building Department) - floodplain permits
4. US Army Corps of Engineers (federal government) - Section 404/Section 10 permits
5. MT Department of Environmental Quality (state government) - 318 (turbidity) Authorizations
6. MT Department of Natural Resource and Conservation (state government) - Navigable river land use licenses and easements.

The joint application can be found on DNRC's website (**http://dnrc.mt.gov/licenses-and-permits/stream-permitting**).

Chapter 10 - Bibliography

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Montana's MS4 Municipalities (September, 2017) Montana Post-Construction Storm Water BMP Design Guidance Manual, Missoula, Montana.

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Stormwaterassociation.com, March, 2015.

The Ohio State University. Stormwater Management Program Post Construction BMP Operation and Maintenance Guidance Manual. December 1, 2009.

Georgia Stormwater Management Manual –Volume 1 Stormwater Policy Guidebook. First Edition. August, 2001

Appendix A
Additional Requirements for Commercial Site Developments

Per Section 2.1.4, some commercial sites require additional stormwater runoff treatment. The table and text below identifies such facilities and the pollutant removal criteria.

Oil Treatment Required if:	Nutrient Treatment Required if:	Metals Treatment Required if:
1. Fueling Stations and similar type facilities	1. Nurseries	1. Fueling Stations and similar type facilities
2. Commercial or industrial properties storing or transferring 1,500 gallons or more of petroleum chemicals	2. Lawn care/ fertilizer facilities	2. Properties zoned control heavy industrial
3. Properties zoned control heavy industrial	3. Agricultural facilities	3. Vehicle maintenance/ equipment repair facilities
4. Vehicle maintenance/ equipment repair facilities	4. Animal Care facilities	4. Hydraulic equipment storage areas
5. Hydraulic equipment storage areas	5. City determined necessary	5. City determined necessary
6. City determined necessary		

Oil Treatment*

Oil treatment is required for all high use and high traffic areas regardless of the impervious area. Oil treatment facilities need only be located to treat stormwater which may contain oil and grease. Oil treatment facilities are not required to treat runoff from clean roofs, landscaped areas, or other areas which are separated from or not subject to surfaces which may contain oil or grease. Some high traffic areas may generate sufficient quantities of oil to threaten water quality, but the quantities may be insufficient for many oil control BMPs to be effective; therefore these properties may employ different BMPs than are recommended for high-use areas.

The oil control facilities are intended to achieve the goals of no ongoing or recurring visible sheen, and to have a Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l.

Nutrient Treatment*

Nutrient, typically nitrogen and phosphorus, treatment is required at all nurseries, lawn care/fertilizer, agriculture, and animal care facilities over 1 acre in size. Nutrient treatment BMP facilities shall be sized to treat all stormwater discharging to the BMP. Nutrient treatment is not required for runoff which does not come in contact with chemical storage and application areas or areas inaccessible to animals. Treatment should achieve 50% reduction of total phosphorus and 35% reduction of total nitrogen, depending on influent concentrations and design.

Metals Treatment*

Metals are typically in the form of particles, and are generally removed with basic treatment requirements which remove total suspended solids. Therefore, properties requiring metals treatment should already be treated through TSS treatment. In the event that dissolved metals are reaching water bodies through stormwater runoff, additional control measures, such as filters may be required at such facilities. Metals removal should be from 20 to 85% depending on design, metal state (i.e., dissolved), influent concentration, etc.

*It is the responsibility of the developer to ensure site complies with DEQ, EPA or other agencies which may have regulations not specified in this manual.

Appendix B
Preliminary Drainage Report

The purpose of the preliminary drainage report is to describe and illustrate the preliminary solutions to the drainage problems which may occur on-site and off-site as a result of the development or any phase of the development. The drainage report shall be submitted during the subdivision process with the application for Preliminary Plat.

Preliminary drainage reports shall provide an appropriate level of detail to address drainage issues and present the overall plan for the property. The report shall be based on the following outline and include appropriate background information, supporting data, calculations and plan drawing(s).

TITLE PAGE

1. Type of Report (Concept)
2. Project Name
3. Prepared for/by
4. Date
5. P.E. Seal and Signature

INTRODUCTION

1. Location
    a. City, County, State Highway and local streets within and adjacent to the site, or the area to be served by the drainage improvements.
    b. Names of surrounding developments, properties or landmarks.
2. Description of Property
    a. Area in acres
    b. Ground cover (type of ground cover and vegetation)
    c. Existing land uses and known and foreseeable future land uses
    d. Topographic features, steepness of slopes
    e. Major drainage ways and receiving channels
    f. Existing drainage facilities
    g. Flood Hazard Zones
    h. Geologic Features (if applicable)
    i. Previous drainage studies for the property (if any)
3. Proposed Project Description
    a. Land uses
    b. Changes to existing facilities
    c. Changes to floodplains
    d. Proposed system improvements
4. Drainage Criteria
    a. Minor and Major Storm Analysis
    b. Geotechnical/Hydrogeological Analysis
    c. Hydrologic Methods
        i. Rainfall
        ii. Design Storms
        iii. Runoff methods and computer models
    d. Hydraulic Methods
        i. Design standards
        ii. Hydraulic models

iii. Detention Pond sizing

e. State or Federal Regulations (if applicable).

HISTORIC DRAINAGE SYSTEM

1. Major Basin Description
    a. Reference to major drainage way planning studies such as flood hazard delineation report, major drainage way planning reports, and flood insurance rate maps.
    b. Major basin drainage characteristics and structures, existing and planned land uses within the basin.
    c. Summary of off-site and on-site basin characteristics and runoff rates.

PROPOSED DRAINAGE SYSTEM

1. Design Concepts
    a. Discussion of concept and typical drainage patterns.
    b. Discussion of compliance with off-site runoff considerations.
    c. Discussion of proposed drainage patterns and improvements including streets, storm sewer, culverts, open channels and detention storage.
    d. Discussion of the content of tables, charts, figures, plates, or drawings presented in the report.
    e. Discussion of geotechnical and hydrogeological impacts of development.

SUMMARY

1. Relation to off-site drainage features.
2. Summary of proposed improvements.
    a. Storm sewer
    b. Culverts
    c. Open channels
    d. Detention Storage
    e. On-site and off-site impact and mitigation measures
3. Floodplain impacts.
4. State or Federal regulations.
5. Compliance with applicable regulations and standards.

REFERENCES

Reference all criteria, master plans, and technical information used in support of concepts and calculations.

APPENDICES Background Data

1. Floodplain maps
2. Applicable reports or report excerpts.
3. Key correspondence with adjacent property owners or utilities.

PRELIMINARY REPORT DRAWING CONTENTS

All drawings shall be submitted as back-up materials with the Preliminary Plat. A map shall be provided in sufficient detail to identify drainage flows entering and leaving the development and general drainage patterns. The map shall identify any major facilities from the property (i.e., development, existing detention facilities, culverts, storm sewers) along the flow path to the nearest major drainage way.

Floodplain Information: The location of the subject property shall be included with the report. All major drainage ways shall have the floodplain defined and shown on the report drawings.

Drainage Plan shall show the following:

1. Existing topographic contours at two (2) feet maximum intervals. The contours shall extend a minimum of one-hundred (100) feet beyond the property lines.
2. All existing drainage facilities.
3. Approximate flooding limits based on available information.
4. Conceptual major drainage facilities including detention basins, storm sewers, swales, riprap, and outlet structures in the detail consistent with the proposed development plan.
5. Major drainage boundaries and sub-basin boundaries.
6. Any off-site features influencing development.
7. Proposed flow directions and, if available, proposed contours.

Appendix C
Final Drainage Report

The purpose of the Final Drainage Report is to present the final design details for the drainage facilities discussed in the Preliminary Drainage Plan. Any changes to the preliminary concept must be presented and fully explained.

Drainage plan shall provide an appropriate level of detail to address the drainage issues and present sizing and locations for all proposed improvements. The report shall be based on the following outline and include appropriate background information and supporting data and calculations and plan drawing(s).

TITLE PAGE

1. Type of Report (Final)
2. Project Name
3. Prepared for/by
4. Date

CERTIFICATION PAGE (found in Appendix G)

1. Project Name
2. P.E., P.G., P.H. Seal and Signature

INTRODUCTION

1. Location
    a. City, County, State Highway and local streets within and adjacent to the site, or the area to be served by the drainage improvements.
    b. Names of surrounding developments, properties or landmarks.
2. Description of Property
    a. Area in acres
    b. Ground cover (type of ground cover and vegetation)
    c. Existing land uses and known and foreseeable future land uses
    d. Topographic features, steepness of slopes
    e. Major drainage ways and receiving channels
    f. Major drainage ways and receiving channels
    g. Existing drainage facilities
    h. Flood Hazard Zones
    i. Geologic Features (if applicable)
3. Previous drainage studies for the property (if any)
    a. Proposed Project Description
    b. Land uses
    c. Changes to existing facilities
    d. Changes to floodplains
    e. Proposed system improvements
    f. Right-of-way conveyance or acquisition required
4. Drainage Criteria
    a. Application Standards or exceptions
    b. Minor and Major Storm Frequencies
    c. Hydrologic Methods

i. Rainfall
ii. Design Storms
iii. Runoff methods and computer models
iv. Geotechnical/Hydrogeological Analysis (Attach Reports)

d. Hydraulic Methods
i. Design standards
ii. Hydraulic models
iii. Detention Pond sizing

e. State or Federal Regulations (if applicable)

HISTORIC DRAINAGE SYSTEM

1. Major Basin Description
   a. Reference to major drainage way planning studies such as flood hazard delineation report, major drainage way planning reports, and flood insurance rate maps.
   b. Major basin drainage characteristics and structures, existing and planned land uses within the basin.
   c. Summary of off-site and on-site basin characteristics and runoff rates.
2. Sub-Basin Description
   a. Discussions of historic drainage patterns of the property.
   b. Discussion of off-site drainage flows and flow patterns and impact on development under existing and fully developed basin conditions.
   c. Summary of off-site and on-site basin characteristics and runoff rates.

PROPOSED DRAINAGE SYSTEM

1. Design Concepts
   a. Discussion of minor and major drainage patterns, impacts, flows and volumes.
   b. Discussion of compliance with off-site runoff considerations.
   c. Discussion of proposed drainage patterns and improvements including streets, storm sewer, culverts, open channels and detention storage.
   d. Discussion of the tables, charts, figures, drawings, etc. presented in the report.
2. Design Details
   a. Discussion of problems encountered and solutions at specific design points.
   b. Discussion of detention storage and outlet design.
   c. Discussion of maintenance and access aspects of the design.
   d. Discussion of impacts of concentrating the flow on the downstream properties.
   e. Summary of basin characteristics and runoff rates.
   f. Discussion of geotechnical and hydrogeological impacts of development.
   g. Discuss flooding hazards and describe minimum building elevations.

SUMMARY

1. Relation to off-site drainage features.
2. Summary of proposed improvements.
   a. Storm sewer

b. Culverts
c. Open channels
d. Detention Storage
e. Geotechnical/Hydrologic impacts
f. On-site and off-site impacts and mitigation measures

3. Floodplain impacts.
4. State or Federal regulations.
5. Compliance with applicable regulations and standards.

REFERENCES

Reference all criteria, master plans, and technical information used in support of concepts and calculations.

APPENDICES

1. Background Data
    a. Floodplain maps.
    b. Applicable reports or report excerpts.
    c. Key correspondence with adjacent property owners or utilities.
2. Hydrologic Computations
    a. Land uses regarding adjacent properties.
    b. Soil types, coverage and loss coefficients
    c. Proposed land uses for project by basin.
    d. Time of concentration and runoff coefficients for each basin.
    e. Basin parameters used for modeling including basin area, length, slope, distance to centroid and routing elements.
    f. Initial and major storm runoff at specific design points for off-site and on-site flows.
    g. Off-site, historic and fully developed runoff computations at specific design points.
    h. Hydrographs at critical design points.
    i. Schematic diagram of hydrology model showing basins and routing elements and combination elements.
3. Hydraulic Computations
    a. Culvert Capacities and inlet and outlet protection.
    b. Storm sewer capacity, including energy grade line (EGL) and hydraulic grade line (HGL) elevations.
    c. Gutter capacity as compared to allowable.
    d. Storm inlet capacity including roughness coefficients, trickle channels, freeboard, hydraulic grade line, and slope protection.
    e. Check and/or channel drop placement.
    f. Detention area volume capacity and outlet capacity calculations; depths of detention basins, outlet configuration.
    g. Downstream/outfall capacity to the Major Drainage way system.
4. Miscellaneous Information
    a. Other documents relating to drainage conditions on the property.
    b. Agreements with property owners or other agencies.
    C. Permits, etc.

Appendix D
Geotechnical/Hydrogeological Report

1. The evaluation shall include at a minimum:
    a. A review of available geologic, hydrogeological, and topographic conditions to identify any site conditions that could impact the use of the storm drainage systems or the construction of sub-level structures. This review shall include all available previous geotechnical engineering reports for the development. Citations to possibly useful references are provided at the end of this appendix.
    b. Where access to adjacent properties is unavailable, the project owner shall rely upon the best known information for the area, supplemented with available information, including any existing engineering reports or studies for sites in the vicinity.
    c. A surface and subsurface reconnaissance of the site and an inspection of adjacent properties to assess potential impacts from the proposed stormwater system and to verify that the conditions are consistent with the mapped information.
    d. The level of data for the hydrogeological assessment required will be dependent on the amount of stormwater to be managed, the type of infiltration system proposed, and the surface and subsurface soil conditions at the site. The assessment will be conducted by a professional with experience collecting and analyzing hydrogeological data.
    e. An assessment of hydrogeological conditions that indicate the potential for infiltrated stormwater to impact on- or off-site, facilities or structures. The assessment will also demonstrate that impacts to groundwater elevation or flow, resulting from the proposed infiltration system will be confined to the property. **A groundwater mounding calculation shall be provided to identify the impacts of infiltrated stormwater runoff.** An example calculation method and spreadsheet is made available from the United States Geological Survey (USGS); however, other approved, similar calculation methods may be accepted. This information can be found at the following link: **https://pubs.usgs.gov/sir/2010/5102/**
    f. The Geotechnical/Hydrogeological report will contain the signed project certification cover sheet found in Appendix G.
2. The Report Narrative shall include:
    a. A brief project description including size, number of lots proposed, project location (section, township and range), and background information relevant for drainage design;
    b. A discussion of the study investigations including methods and results of field assessments, testing and analyses performed;
    c. A description of the soil units and subsurface geologic conditions on the site and in the vicinity of the site;
    d. A description of the site including surface, soil, and groundwater conditions, etc.
3. Test Method Documentation shall include:
    a. A map with the location of all subsurface field explorations, sampling locations and any in- place field tests;
    b. A description of the field test and any difficulties encountered during excavation and testing;
    c. A description of the equipment used to perform the field explorations or tests. When applicable, describe the type of fabric lining and gravel backfill used;
    d. Logs of subsurface borings shall identify the depth to groundwater, the presence of any limiting layers and the target soil layer; include test pit or excavation dimensions. Borings intended to characterize hydrogeologic conditions for infiltrations systems should extend a minimum of 10-feet below the base of the proposed

infiltration system, or a minimum of 25-feet below the ground surface, whichever is deeper;

e. Report test data documenting any infiltration testing, calculations, results problems encountered; and,
f. A description of the condition of any existing facilities being tested, noting any silt build-up, water level, connections to other structures (including distance to inverts of any interconnecting pipes), measured depths and dimensions, etc.

4. Results of field and laboratory testing conducted, including the grain size analysis represented both graphically and in tabular format;
5. A summary of field testing conducted and the measured and proposed design infiltration rates for infiltration systems. **Approved test methods for infiltration testing are found in Appendix H**;
6. Results of the sub-level structure feasibility study and a summary of the property boundary and down-gradient analysis as applicable; and,
7. A geologic cross-section of the stormwater disposal area drawn to scale, with the proposed stormwater disposal facilities superimposed on the cross-section. All relevant geologic units shall be clearly identified including the target disposal layer and limiting layers.
8. Conclusions and recommendations.
    a. The Site Plan shall include:
    b. Project boundaries (including all existing and proposed property lines);
    c. Labeled topographic contours, extending beyond the project and drainage basin. Projects in an urban area shall use a maximum contour spacing of 1 foot;
    d. Location of the soil and geologic units identified;
    e. Location of significant structures, properties or geologic features on site and in the project vicinity;
    f. Location of existing natural or constructed drainage features on site and in the project vicinity; and,
    g. Location of proposed site infrastructure including roadways and drainage features such as ponds, drywells, etc.

SUGGESTED SOURCES:

- Montana Ground Water Information Center Database: http://mbmggwic.mtech.edu/
- Lopez, D.A., and Sims, M., 2003, Areas of potential swelling-clay hazard in the Billings area, Yellowstone County, Montana: Montana Bureau of Mines and Geology Geologic Map 61D, 1 sheet, scale 1:48,000.
- Lopez, D.A., 2002, Geologic map of the Billings area, Yellowstone County, Montana: Montana Bureau of Mines and Geology Geologic Map 61A, 1 sheet, scale 1:48,000.
- Lopez, D.A., 2000, Geologic map of the Billings 30' x 60' quadrangle, Montana: Montana Bureau of Mines and Geology Geologic Map 59, 1 sheet, scale 1:100,000.
- Olson, J.L., and Reiten, J.C., 2002, Hydrogeology of the west Billings area: Impacts of land-use changes on water resources: Montana Bureau of Mines and Geology Report of Investigation 10, 32 p., 2 sheets.
- Olson, J.L., and Reiten, J.C., 2001, Basic hydrogeologic data for the West-Billings area (1999-2000), Yellowstone County, Montana: Montana Bureau of Mines and Geology Open-File Report 436, 110 p. United States Geological Survey (USGS). Scientific Investigations Report 2010-5102. Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins. Glen B. Carleton. http://pubs.usgs.gov/sir/2010/5102.

Appendix E
Operations and Maintenance Requirements

OPERATION AND MAINTENANCE

An Operations and Maintenance Manual is required for Subdivision and Commercial Property development. The O&M Manual summarizes the tasks required for perpetual maintenance to ensure the proper operation of stormwater facilities. The O&M manual shall include at a minimum:

- Contact information for the party responsible for O&M.
- Description of the maintenance tasks to be performed and their frequency.
- An inspection checklist to be used for annual maintenance. Template forms found in Appendix G.
- List of the expected design life and replacement schedule of each component.
- Site plan showing the overall layout of the development.
- Copy of recorded HOA Agreement and SIA, if applicable.
- Other information as necessary.

The O&M Manual shall first be submitted to the City's Environmental Affairs Division for review and comment. After acceptance by the Environmental Affairs Division, the O&M Manual shall be recorded at the Yellowstone Clerk and Recorders Office in a format acceptable to them.

Appendix F
HOA Agreement Requirements

HOMEOWNERS' ASSOCIATIONS REQUIREMENTS

For stormwater systems within subdivisions, a homeowner's association (HOA) shall be formed to maintain and operate the facilities.

A draft copy of the SIA and/or CC&Rs for the HOA in charge of operating and maintaining the facilities associated with the stormwater system shall be submitted at the time of Preliminary Plat submittal. Final copies are required at the time of initial Private Contract Submittal. The SIA/CC&Rs shall summarize the maintenance and fiscal responsibilities of the HOA. In addition, the SIA/CC&R's shall state that any proposed changes to the stormwater system/facilities shall first be approved by the City Engineer's Office. The O&M manual shall also be submitted at this time. A financial plan is required in order to provide the entity responsible for maintenance with guidance in regard to financial planning for maintenance and replacement costs. The financial plan shall include the following items:

- A list of all stormwater-related facilities and their expected date of replacement and associated replacement costs.
- Sinking fund calculations that take into consideration probable inflation over the life of the infrastructure and estimates the funds that need to be set aside annually.
- A mechanism for initiating and sustaining the sinking fund account demonstrating that perpetual maintenance of all facilities associated with the stormwater system will be sustained.

Homeowners' associations are to be non-profit organizations. A standard business license is not acceptable for this purpose. The HOA shall remain in good standing with the requirements of the State of Montana. Developer shall sign HOA Agreement stating ownership and responsibilities prior to approval of development. A template agreement is found in Appendix G.

Appendix G
Template Forms

- **STORMWATER FACILITY MAINTENANCE AGREEMENT**
- **BMP INSPECTION FORM**
- **REPORT CERTIFICATION FORM**
- **INJECTION WELL EXAMPLE**
- **BOULDER PIT EXAMPLES**

STORMWATER FACILITY
MAINTENACE AGREEMENT

The following agreement shall be used for sample purposes only. The document shall not be used directly for recording. A template document can be downloaded off the City's website (http://ci.billings.mt.us/567/Stormwater-Management).

Stormwater Facility Maintenance Agreement

THIS Agreement is made by and between the City of Billings, a municipal corporation of the State of Montana, hereinafter referred to as the "City" and _____, a Developer, as owner (including successors and assignee's of the City as may become applicable including the heirs, executors, administrators, successors and assigns of above owner(s) as may be or may become applicable), hereinafter called "Grantor," (if more than one grantor is listed above, said language herein referring thereto shall be interpreted in the plural and refer jointly and severally to such grantors).

WHEREAS, the undersigned is proceeding to build on and develop the property; and has submitted the Site Plan/Subdivision Plan know as _____ (Name of Plan/Development), located on _____ (Lot/Block/Subdivision) hereinafter called the "Plan", which is expressly made a part hereof, as approved or to be approved by the City, provides for detention of stormwater within the confines of the property; and

WHEREAS, the City and the undersigned, its successors and assigns, including any homeowners association, (hereinafter the "Landowner") agree that the health, safety, and welfare of the residents of the City, requires that on-site stormwater management facilities be constructed and maintained on the Property; and

WHEREAS, the City requires that on-site stormwater management facilities as shown on the Plan (the "Facilities") be constructed and adequately maintained by the Landowner.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The Facilities shall be constructed by the Landowner, in accordance with the plans and specifications identified in the Plan.
2. The Landowner shall at all time, adequately maintain the Facilities. Such maintenance obligation shall include the obligation to properly maintain all surface and subsurface inlets, pipes, channels, structures, rock pits, vegetation, and all other improvements provided to control the quantity and quality of the stormwater within the facility. Adequate maintenance is herein defined as keeping the Facilities and all components thereof in good working condition so that these Facilities continue to perform their design functions.

3. In the event the Landowner fails to maintain the Facilities in good working condition acceptable to the City, the City may enter upon the Property and take such steps as are necessary to correct deficiencies identified in the inspection report and to charge the costs of such repairs to the Landowner. This provision shall not be construed to allow the City to erect any structure of permanent nature on the land of the Landowner outside of the easement for the stormwater management facilities. It is expressly understood and agreed that the City is under no obligation to routinely maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the

City. The Landowner grants to the City, its authorized agents and employees, a non-exclusive, perpetual easement over, across, under and through the Property for such purposes.

4. The Landowner shall perform all work necessary to keep the Facilities in good working order. In the event a maintenance schedule for the stormwater management facilities (including sediment removal) is outlined on the approved plans, the Landowner shall comply with such schedule.

5. In the event the City performs work of any nature on the Facilities in accordance with this Agreement, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the City upon demand, within thirty (30) days of receipt thereof for all actual costs incurred by the City hereunder.

6. This Agreement imposes no liability of any kind whatsoever on the City and the Landowner agrees to hold the City harmless from any liability in the event the stormwater management facilities fail to operate properly.

7. This Agreement shall be recorded among the deed records of Yellowstone County, Montana, and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests, including any homeowners association.

**** Note to Reviewer: Attached to this agreement shall be required information listed in Appendix F of the City's Stormwater Management Manual. Remove this text for final document****

IN WITNESS THEREOF, the parties hereto acting through their duly authorized agents have caused this Agreement to be signed, sealed and delivered:

(Insert Company/Corporation/Partnership Name) [SEAL] Date

_____ _____

By: (Name and Title)

State of Montana
County of _____
This instrument was signed and sworn to before me
on _____ by _____
(Name of signer)

_____
(Notary Signature)
[Affix seal/stamp to the left or below]

ACKNOWLEDGMENT AND ACCEPTANCE OF CONVEYANCE

The City of Billings acknowledges receipt of this HOA Stormwater Facility Maintenance Agreement and hereby accepts the property interest conveyed through this instrument.

_____

_____,
City Administrator, City of Billings

ATTEST:

_____
(name), City Clerk

State of Montana
County of _____
This instrument was signed and sworn to before me
on _____ by _____
(Name of signer)

_____
(Notary Signature)
[Affix seal/stamp to the left or below]

POST CONSTRUCTION
BMP INSPECTION CHECKLIST

Example Inspection Forms for Post-Construction BMP's can be found in Appendix F of the Montana Post-Construction Storm Water BMP Design Guidance Manual; September 2017. The table below suppliments the Inspection Forms by indicating inspection activities and frequencies.

POST CONSTRUCTION BMP INSPECTION CHECKLIST

Activity	Schedule/Frequency
Inspect pond area for oil sheens or trash	Monthly
Inspect exterior of catch basins	Monthly and after storm events
Inspect pond area, sidewalls, and shoreline for erosion, settlement, and rodent damage	Quarterly
Inspect fences, gates and locks	Quarterly
Inspect bioswales for vegetation cover and bare areas	Quarterly
Inspect ditches, check dams, and all visible pipes and culverts for trash, obstructions and other problems	Quarterly and after storm events
Inspect inlets and outlets for trash, obstructions, and vegetation	Quarterly, and after storm events
Inspect trash racks, debris barriers, and energy dissipaters	Quarterly and after storm events
Inspect water levels in the pond	After storm events
Inspect pond area for undesirable or poisonous vegetation and noxious weeds	Semi-annually, during growing season
Pond area sediment accumulation (pond bottom)	Annually
Inspect interior of catch basins for debris and sediment	Annually
Inspect spillway for vegetation overgrowth and ease of heavy equipment access	Annually
Inspect inside catch basins, including flow restrictor/orifice plate	Annually
Inspect access ramps for ease of heavy equipment access	Annually

Prepared by RESources for Sustainable Communities for the Birch Bay Watershed & Aquatic Resources Management (BBWARM) District. This project was been funded wholly or in part by the U.S. Environmental Protection Agency under assistance agreement WS-96073401 to Whatcom County. The content of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

REPORT CERTIFICATION FORM

(Project Title)

FINAL DRAINAGE, GEOTECHNICAL OR HYDROGEOLOGICAL REPORT (List one)

(LOCATION)

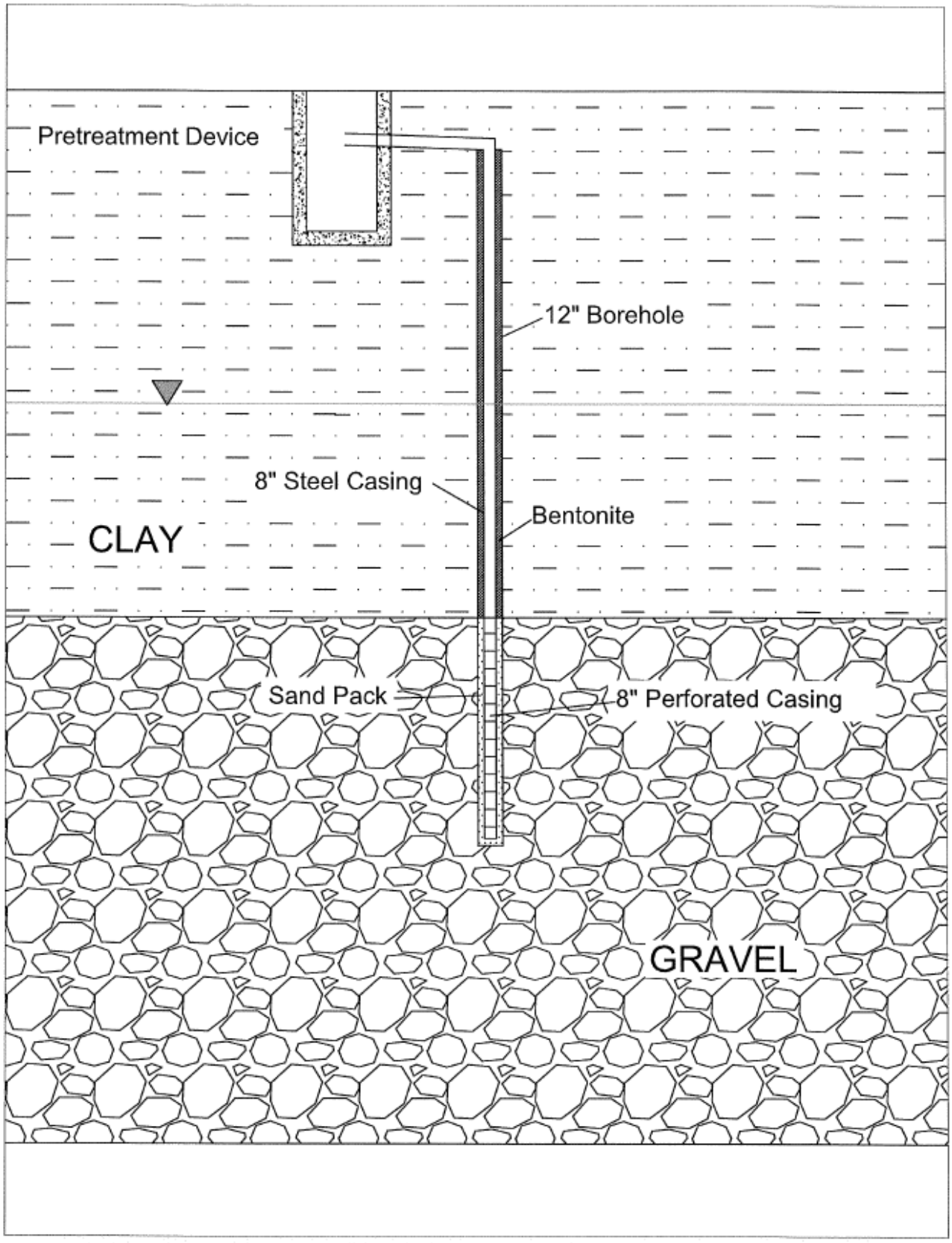
CERTIFICATION

I hereby state that this Final Drainage, Geotechnical or Hydrogeological Report (pick one) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community of professional engineers, geologists or hydrogeologists (pick one). The analysis has been prepared utilizing procedures and practices specified by the City of Billings and within the standard accepted practices.

PE, PG or PH STAMP OR SEAL

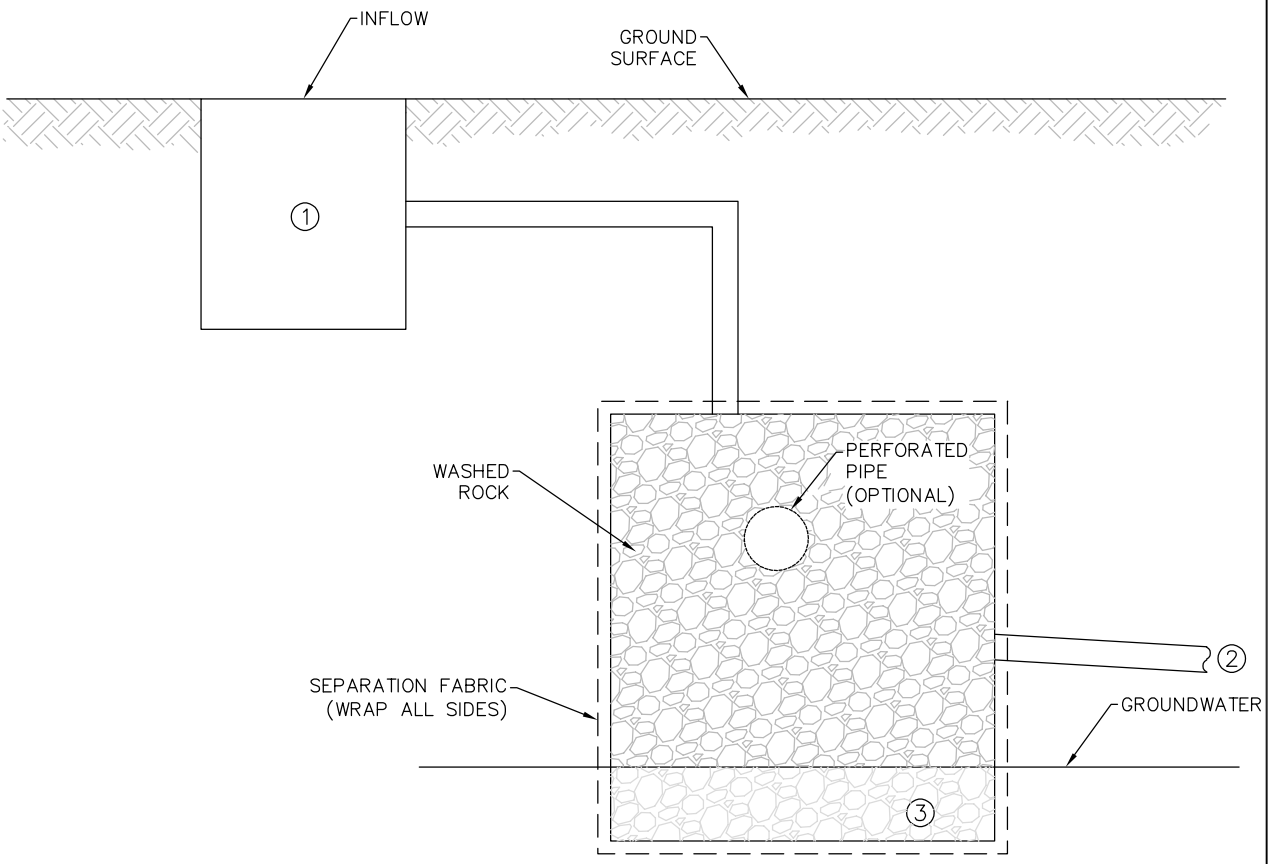
John Doe, P.E.; P.G.; P.H. Date

INJECTION WELL EXAMPLE


Pretreatment Device
12" Borehole
8" Steel Casing
Bentonite
CLAY
Sand Pack
8" Perforated Casing
GRAVEL

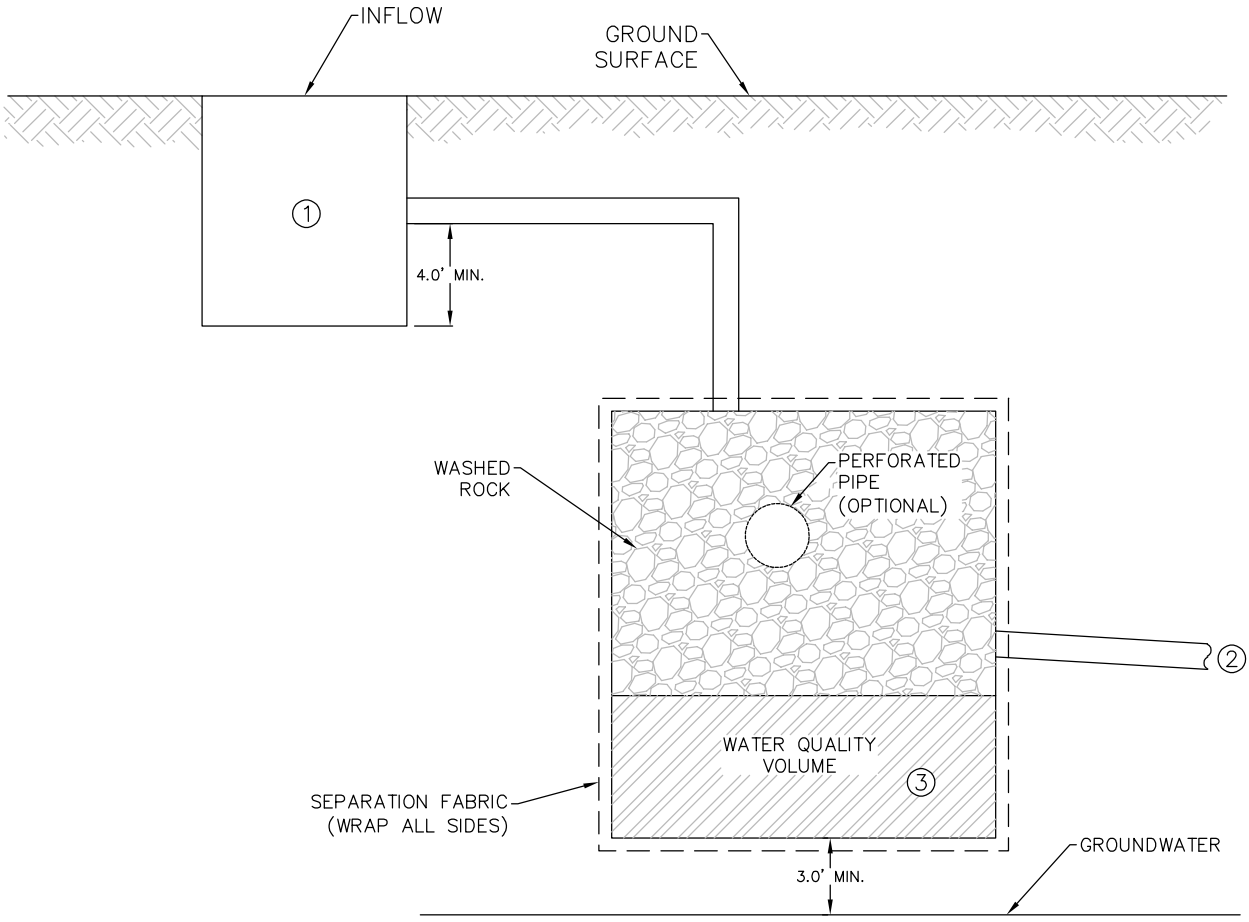
BOULDER PIT EXAMPLES

WHERE BOULDER PIT INTERACTS WITH GROUNDWATER



1. WATER QUALITY TREATMENT PER THE REQUIREMENTS OF THE MONTANA POST-CONSTRUCTION STORM WATER BMP DESIGN GUIDANCE MANUAL.
2. OUTFALL IF PERMITTED BY CITY'S SWMM.
3. VOLUME BELOW GROUNDWATER DOES NOT COUNT TOWARD OVERALL BOULDER PIT REQUIRED VOLUME STORAGE.

WHERE BOULDER PIT DOES NOT INTERACT WITH GROUNDWATER



1. PRE-TREATMENT REQUIRED TO MIMIC SEDIMENTATION FOREBAY. SHALL CONTAIN 10% OF THE WATER QUALITY VOLUME; MAY BE ACCOMPLISHED BY MORE THAN ONE DEVICE.

2. OUTFALL IF PERMITTED BY CITY'S SWMM.

3. WATER QUALITY VOLUME SHALL REMAIN BELOW INVERT OF OUTFALL PIPE.

Appendix H
Soil Infiltration
Testing Requirement

This Section adds to the infiltration testing section of the Montana Post-Construction Storm Water BMP Design Guidance Manual; however, this section shall take precedence over any discrepancies with the practices or results of the water quality Guidance Manual.

One of the following methods should be used to determine the design infiltration rate.

- Design Infiltration Rate Using the USCS Classification (non-field measured – This method is only applicable to proposed infiltration systems with less than 5,000 square feet of infiltration area)
- Encased Falling Head Test (field measured)
- Pilot Infiltration Test (field measured)
- Borehole Infiltration Test (field measured)

Design Infiltration Rate Using the USCS Classification

For infiltration systems with less than 5,000 square feet, a design infiltration rate can be selected from Table 1: Infiltration Rate Ranges for USCS Soils based on the least-permeable soil layer encountered within 10 feet of the base of the proposed infiltration system. The design infiltration rates presented in Table 1: Infiltration Rate Ranges for USCS Soils represent the ranges of infiltration rates for each soil classification. The minimum infiltration rate shall be selected as the design infiltration rate.

Table 1: Infiltration Rate Ranges for USCS Soils

Soil Description	USCS	Range of Typical Infiltration Rates (inches/hour)	
		min	max*
Well graded gravel, sandy gravel	GW	1.30	137.00
Poorly graded gravel, sandy gravel	GP	6.80	137.00
Well graded sand, gravelly sand	SW	0.80	68.00
Poorly graded sand, gravelly sand	SP	0.50	68.00
Silty gravel, silty sandy gravel	GM	1.63	13.50
Clayey sands	SC	0.05	0.78
Silty Sand	SM	0.24	0.70
Clayey gravel, clayey sandy gravel	GC	0.04	0.50
Inorganic Silts of low plasticity	ML	0.04	0.14
Clay	CL	0.00	0.01
Inorganic Silts of high plasticity	MH	0.00	0.01
Inorganic clays of high plasticity	CH	0.00	0.01

*If proposing to use maximum rates, a detailed explanation shall be provided why the maximum rates apply to development.

Encased Falling Head Test

The encased falling head test is performed with a 6-inch casing that is embedded approximately 24 inches into the native soil. The goal of this field test is to evaluate the vertical infiltration rate through a 24-inch plug of soil, without allowing any lateral infiltration. The test is not appropriate in gravelly soils or in other soils where a good seal with the casing cannot be established.

A minimum of three encased falling head tests must be conducted within the footprint of each infiltration system. For proposed infiltration systems with more than 10,000 square feet of infiltration area, one additional encased falling head test is required for each additional 10,000 square feet. Different soil types may be encountered during the soil infiltration testing; a minimum of two encased falling head tests per soil type are required. The encased falling head test locations should be evenly spaced throughout the proposed infiltration system. The results of the infiltration tests will be averaged to determine the measured infiltration rate for the infiltration system. The measured infiltration will be divided by a safety factor of 2.0 to arrive at the design infiltration rate.

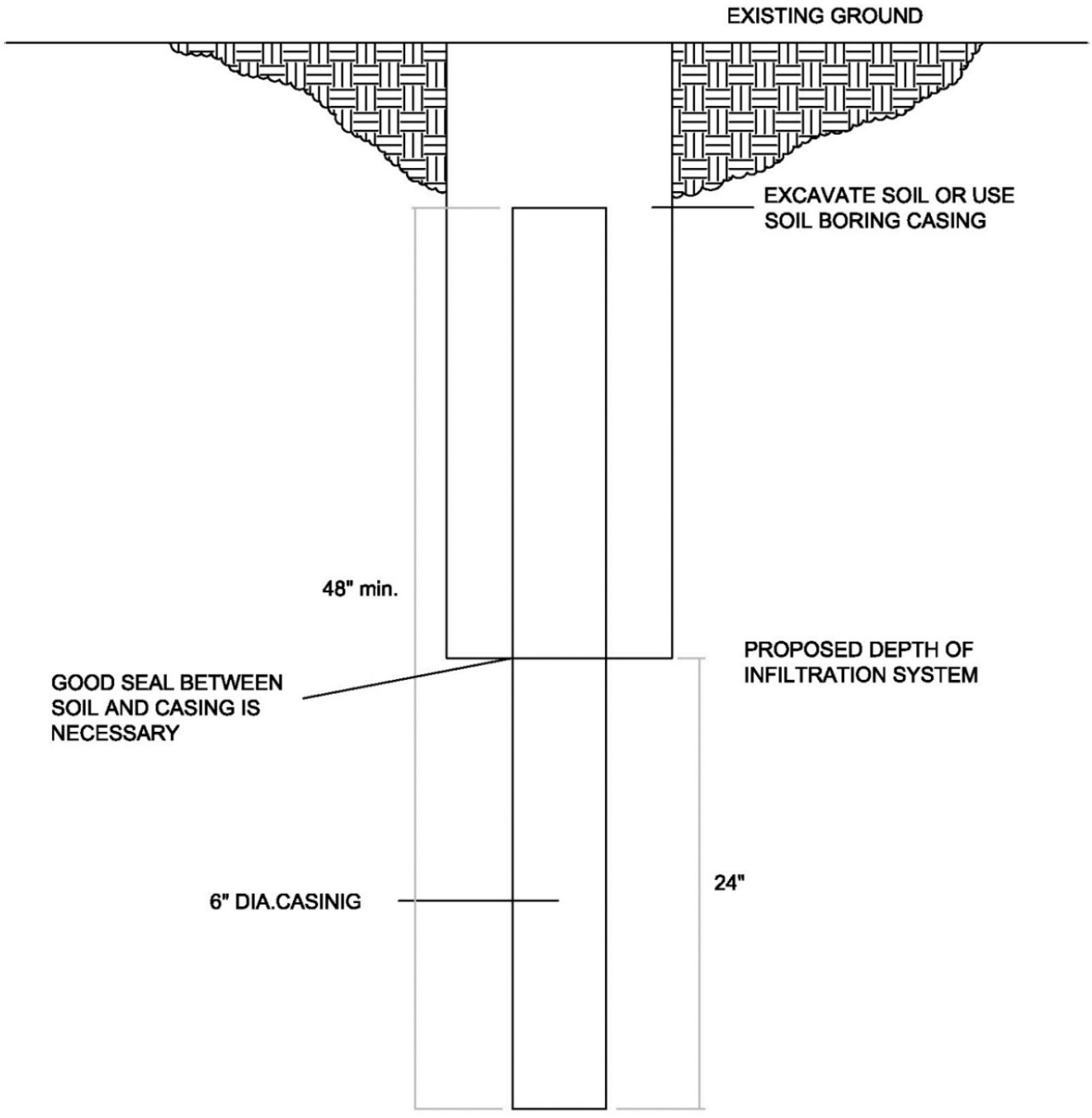
Encased Falling Head Test Procedure:

- Embed a solid 6-inch diameter casing into the native soil at the elevation of the proposed facility bottom. Ensure that the embedment provides a good seal around the pipe casing so that percolation will be limited to the 24-inch plug of the material within the casing. The minimum casing length must be 48 inches; longer casings can be used.
- Fill the 6-inch diameter casing with clean water a minimum of 24 inches above the soil to be tested, and maintain this depth for at least 4 hours (or overnight if clay soils are present) to presoak the native material. In sandy soils with little or no clay or silt, soaking is not necessary. If after filling the hole twice with 24 inches of water, if the water infiltrates completely in less than 10 minutes, the test can proceed immediately.
- To conduct the first trial of the test, fill the 6-inch diameter casing to approximately 24 inches above the soil and measure the water level to the nearest 0.01 foot (⅛ inch). The head used in the test can be greater than 24 inches, provided the head is not greater than 50 percent of the maximum head in the proposed infiltration system. The pre-saturation head must be the same as the infiltration testing. The level should be measured with a tape or other device with reference to a fixed point. The top of the pipe is often a convenient reference point. Record the exact time.
- Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all of the water has infiltrated. In faster draining soils (sands and gravels), it may be necessary to shorten the measurement interval in order to obtain a well-defined infiltration rate curve. Constant head tests may be substituted for falling head tests at the discretion of the professional overseeing the infiltration testing. Successive trials should be run until the percent change in measured infiltration rate between two successive trials is minimal. The trial should be discounted if the infiltration rate between successive trials increases. At least three trials must be conducted. After each trial, the water level is readjusted to the 24 inch level. Enter results into the data table.
- Measure the depth and approximate volume of any water that accumulates in the borehole or trench around the test casing, indicating a bad seal around the pipe or short circuiting through the soil being tested.
- The average infiltration rate over the last trial should be used to calculate the measured infiltration rate
- The measured infiltration rate must be within the rates given in Table 1: Infiltration Rate Ranges for USCS Soils, provided in this appendix, for the native soil tested. If the measured infiltration rate is greater than the

maximum listed rate, additional information may be required by the City, up to and including repeating the test procedure under observation by personnel designated by the City

- The location of the test shall correspond to the infiltration system location.

Figure 1: Encased Falling Head Test Diagram:



Pilot Infiltration Test

Large-scale infiltration testing using the Pilot Infiltration Test described below is the preferred method for estimating the measured infiltration rate of the soil profile beneath proposed infiltration systems. The Pilot Infiltration Test is not a standard test but rather a practical field procedure recommended by the City of Billings.

A minimum number of two pilot infiltration tests must be conducted within the footprint of each proposed infiltration system. For proposed infiltration systems with more than 10,000 square feet of infiltration area, one additional pilot infiltration test is required for each additional 10,000 SF. The pilot infiltration test locations should be evenly spaced throughout the proposed infiltration system. The results of the infiltration tests will be averaged to determine the measured infiltration rate for the infiltration system. The pilot infiltration test will produce a measured infiltration rate in inches per hour. The measured infiltration will be divided by a factor of safety of 2.0 to arrive at the design infiltration rate.

Pilot Infiltration Test Procedure:

- Excavate the test pit to the estimated surface elevation of the proposed infiltration system. Lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.
- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. Accurately document the size and geometry of the test pit.
- Install a vertical measuring rod (minimum 5-ft. long) marked in 1/8" increments in the center of the pit bottom
- Use a rigid pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 6 and 12 inches above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.
  Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point on the measuring rod. Keep adding water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate; a goal of 5% variation or less variation in the total flow) while maintaining the same pond water level. The total of the pre-soak time plus one hour after the flow rate has stabilized should be no less than 6 hours.
- After the flow rate has stabilized for at least one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the water has infiltrated completely. Calculate and record the measured infiltration rate in inches per hour in 30 minutes or one-hour increments.
- The measured infiltration rate must be within the ranges given in Table 1: Infiltration Rate Ranges for USCS Soils, provided in this appendix, for the native soil tested. If the measured infiltration rate is greater than the maximum listed rate, additional information may be required by the City, up to and including repeating the test procedure under observation by personnel designated by the City.
- The location of the test shall correspond to the infiltration system location.

Borehole Injection Test

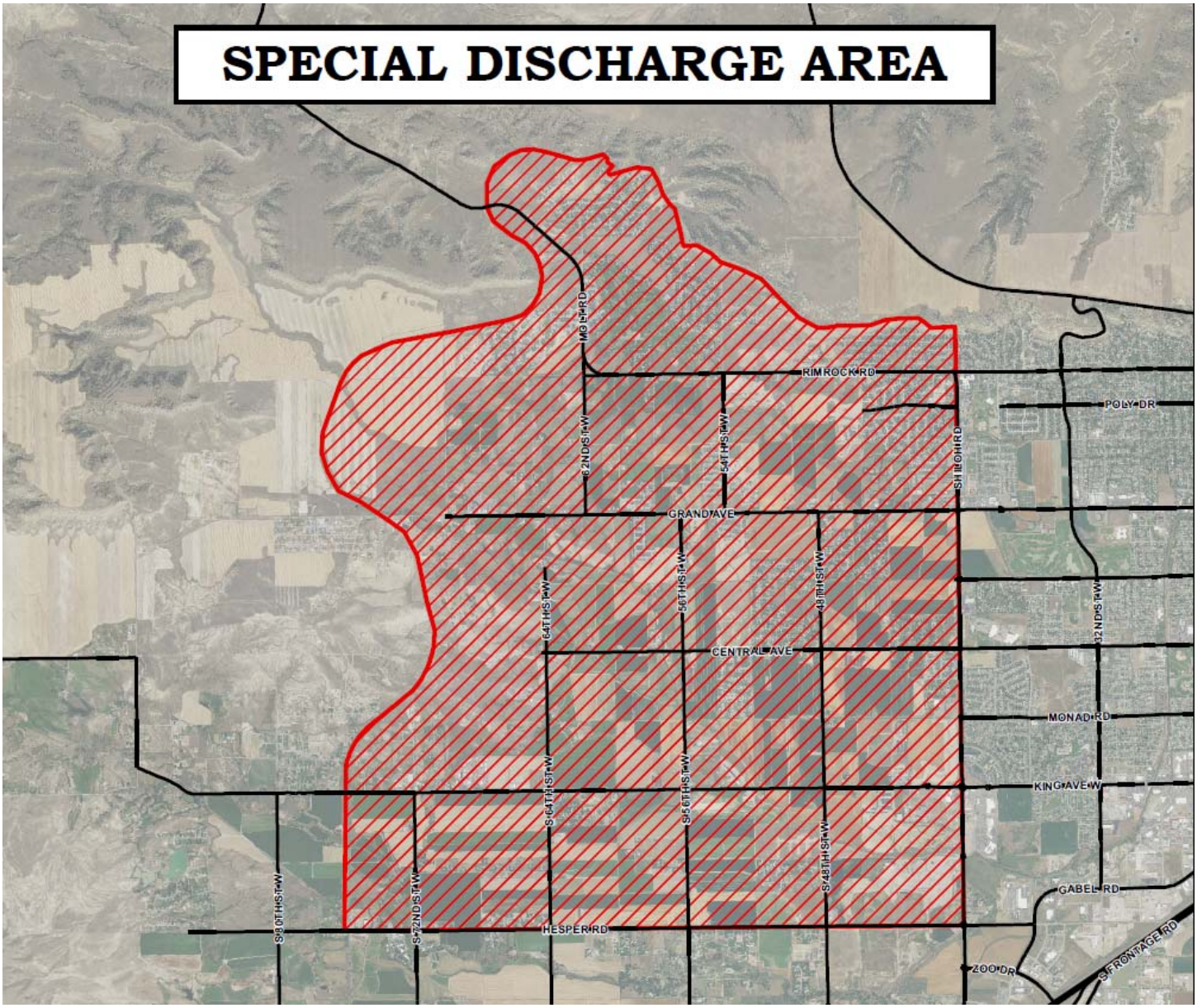
The borehole injection test will produce a measured injection rate in gallons per hour for a stormwater injection well. The measured injection rate will be divided by a factor of safety of 2.0 to arrive at the design injection rate. In-situ injection measurements, using the borehole injection test described below is the preferred method for estimating the measured injection rate for disposal of stormwater to higher permeability soils located at a minimum depth of 20 feet bgs. The borehole injection test is not a standard test but rather a practical field procedure recommended by the City of Billings.

Borehole Injection Test Procedure:

- The location of the test must be within 20 feet of the proposed location of the stormwater injection well.
- Drill borehole to target injection depth, a minimum of 20 feet.
- Install steel casing, a minimum of 4 inches diameter, by pushing or driving it to 24 inches below the drill bit. Casing must extend to the ground surface.
- Add water to the casing at a rate determined by the tester, based on the average volume to be discharged to the well over 72 hours. A rotameter can be used to measure the flow rate into the casing. Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute.
- The casing must remain under atmospheric pressure throughout the duration of the test. A pump may be used to convey water to the casing, but the pump discharge cannot pressurize the casing.
- Water must be supplied to the casing for a minimum of one hour. Tests may be terminated after water has been supplied to the casing for a total of four hours. Document the time water is supplied to the casing and the duration of any interruptions (e.g. changing the water supply source).
- The test may be terminated any time after one hour if the volume discharged during the test exceeds 5% of the estimated 72-hour discharge volume of the proposed stormwater injection well.
- Calculate and record the average infiltration rate in gallons per minute over the final hour of the test. The average injection rate over the final hour of the test will be the measured injection rate used for the stormwater injection well. The measured injection rate will be divided by a factor of safety of 2.0 to arrive at the design injection rate.
- The location of the test shall correspond to the infiltration system location.

Appendix I
Special Discharge Area

The map below identifies the City's West Billings *Special Discharge Area*, which identifies that the allowable stormwater discharge rate within this area from all types of development and for all durations of storms, up to and including the Major Storm, shall be limited to a prorated value of 1 cfs per 10 acres of development. For example, a 100-acre subdivision would be allowed a discharge rate of 10 cfs, while a 0.5-acre commercial site would be allowed a discharge rate of 0.05 cfs (approximately 22.4 gpm). The map below indicates the properties located within the *Special Discharge Area*.



Appendix J
Project Submittal Checklist

The following information is intended to provide a framework for required documents to be submitted based upon development activity. This list may not be all inclusive and additional information or forms shall be submitted upon request.

Residential Lot Development

- SSP
- Lot Grading Plan

Commercial Property Development

- CDP
- Geotechnical/Hydrogeologic Report
- Project Plans
- Operations and Maintenance Manual – Recorded Copy
- Plat and SIA

Subdivision Development

- CDP
- Geotechnical/Hydrogeologic Report
- Project Plans
- Operations and Maintenance Manual – Recorded Copy
- Plat and SIA
- HOA Maintenance Agreement – Recorded Copy
- Materials Submittals (Shop Drawings)
- Final Acceptance Submittal after construction