400.1 INTRODUCTION

A. **Objectives:** The objectives of the standards in this Chapter are to help maintain an effective City-wide stormwater program that will:

1. Implement a stormwater treatment program reflecting the requirements associated with the City's National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, the Oregon Department of Environmental Quality (DEQ) Total Maximum Daily Load Program (TMDL), the DEQ Water Pollution Control Facilities Permit issued to the City of Keizer (WPCF), the City of Keizer Underground Injection Control Management Plan (UICMP), and the water quality needs of the City's urban watershed and waterways.

2. Safely convey all stormwater from sources upslope to approved storm system facilities downslope, thus preventing the uncontrolled or irresponsible discharge of stormwater onto adjoining public or private property and protecting the safety and security of persons and property.

3. Maintain and even improve the water quality in, and the beneficial uses of, the City's waterways, lakes, ponds, wetlands, and other natural drainage resources.

4. Protect the City's natural resources by preserving water quality and reducing the transport of soil and other pollutants.

5. Reduce surface runoff volumes by prioritizing stormwater interception, evapotranspiration, and infiltration.

6. Permit and construct facilities which are safe and economical to maintain, meet reasonable service levels, and minimize life-cycle replacement costs.

7. Provide guidance for orderly development by controlling and minimizing the discharge of stormwater and providing adequate capacity for future development.

8. Substantially maintain the pre-existing runoff characteristics of development sites or drainage basin(s).

Alternative materials and methods to these Standards will be considered by the Director for approval based on consideration of the above objectives.

B. **Applicability:** These Standards provide the framework to ensure compliance with key elements of the City's NPDES permit, WPCF permit, and TMDL program. They shall govern all design, construction, and modification of the City-managed stormwater infrastructure, including the collection, treatment, retention, infiltration, evapotranspiration, and conveyance of stormwater generated from property owned and/or maintained by the City. The concepts and criteria contained within will also be used to evaluate private property stormwater connections to the City-managed stormwater infrastructure.

These Standards cannot provide for all situations. They are designed to assist and not substitute for competent work by Engineers.

C. **Additional Referenced Standards:** The requirements presented in these Standards do not exclude or replace the requirements of other applicable federal, state, or local regulations or permits. They are intended to work concurrently with the Keizer Development Code, the City's Stormwater Utility Ordinance and Stormwater Discharge Ordinance, the UICMP, the City Standard Details, and the City Standard Construction Specifications.

D. **How to use this Chapter:** When designing a stormwater system in conformance with these Standards, the following key elements should be considered and addressed:

1. **Assess the existing site and the proposed development:** It is critical to perform a site assessment early in the planning and design process to evaluate zoning and other land use restrictions, soil types, infiltration rates, topography, flow paths onto and leaving the site, existing vegetation, etc.

2. **Determine the type of stormwater project and associated threshold(s):** Stormwater requirements are dependent on physical characteristics of the surface of the property, including consideration of pre-existing conditions, activities occurring during construction, and the resulting site surface conditions once construction is complete. This Chapter defines thresholds based on size and type of project, and associated requirements for these thresholds.

3. **Perform hydrologic analyses for the project design:** Projects are required to perform hydrologic analyses to determine the flows and intensities expected of the project. Approved methods for performing these analyses are discussed later in this Chapter.

4. **Select and design stormwater facilities:** The designer shall use the information gathered to determine the most effective stormwater facility(ies) for the project.

a. **Utilize GSI facilities:** The City requires all projects to utilize Green Stormwater Infrastructure to the MEF as part of the project.

b. **Incorporate stormwater treatment facilities.** All projects shall treat the WQE storm design event runoff. These may be stand-alone or incorporated with other storm facilities, but shall include GSI to the MEF.

c. **Utilize Infiltration:** The City requires that all new projects provide infiltration into existing soils and substrates to the MEF, in compliance with the UICMP and State UIC guidelines.

d. **Design stormwater retention facilities.** All projects shall provide retention of all stormwater runoff from the site to the MEF, unless otherwise approved by the Director due to specific site characteristics.

e. **Consider flow control facilities:** To meet the requirement to retain all stormwater runoff to the MEF, certain sites may need to include flow control to be implemented as part of the design. In other situations, it simply benefits the overall system to provide flow control prior to treatment or retention facilities.

f. **Consider combined stormwater facilities.** Projects are encouraged to utilize combined treatment and retention facilities where possible.

5. **Design the conveyance system:** The conveyance system must be designed to carry offsite and onsite stormwater from the stormwater facility(ies) to an approved point of disposal. It shall also provide for the future development of up-gradient property, to be located within either the public right-of-way or easements.

400.2 GENERAL DESIGN REQUIREMENTS AND CONSIDERATIONS

This section provides the criteria for stormwater project thresholds, sizing methodologies, hydrologic analyses, infiltration testing, and other general requirements for stormwater projects.

A. **<u>Specific Project Types, Thresholds, and Facility Requirements</u>:** Threshold levels and the associated requirements for stormwater facility design are as follows:

1. **Small Projects.** Projects consisting of less than 5,000 square feet of new or replaced impervious surface are defined as a Small Project and are allowed to meet lesser hydrologic analysis requirements for treatment, flow control, and retention of stormwater.

2. **All Other Projects.** All public stormwater facilities and projects with 5,000 square feet or more of new or replaced impervious surface are required to meet the full requirements for treatment, flow control, and retention of stormwater.

B. **Approved Point of Disposal:** The Point of Disposal for all stormwater generated within a development shall be approved by the Director.

C. **Overflow Route**: In addition to the Approved Point of Disposal, all projects must identify an overflow route for stormwater in the event a stormwater component or facility fails, or if rainfall exceeds the facility's design capacity. This overflow route must be shown on the site plan. Director approval is required for all proposed overflow routes.

D. **Stormwater Treatment**. Stormwater pollutants are generally separated into the following categories: suspended solids/sediment, oxygen-demanding pollutants, temperature, organic carbon, organic matter (i.e., leaves, flowers, twigs, pollen), hydrocarbons, metals (i.e., lead, copper, zinc, and cadmium), nutrients (i.e., nitrogen and phosphorous), pathogens (i.e., bacteria, viruses, and protozoa from sources such as animal feces, leaking sewers, etc.) and toxins (i.e., pesticides, chemical toxins). The treatment requirements in these Standards are intended to conform with the MS4 permit requirements and to reduce the discharge of the above pollutants to waters of the State. All treatment facilities shall be designed to utilize GSI to the MEF.

E. **Stormwater Retention.** All developments and stormwater projects are required to provide retention of stormwater runoff, without release into the existing stormwater conveyance system(s). The soil infiltration rates on some sites may necessitate adjustment to this retention requirement. Also, certain watersheds and areas within the City limits have specific characteristics that modify retention requirements. The hierarchy to be followed in determining project-specific applicable facility retention requirements is based the Design Infiltration Rate (see Definitions) for the site or the Point of Disposal (see Definitions), as follows:

1. **Design Infiltration Rate greater than 2 inches per hour** - The project facility shall retain and treat the entire WQE. The project facility shall retain all stormwater runoff up to, and including, the 100-year design storm event with no release allowed.

2. **Point of Disposal is in an Unserved Stormwater Area (regardless of design infiltration rate)** - The project facility shall retain and treat the entire WQE. The project facility shall retain all stormwater runoff from design storm events up to, and including, the 100-year design storm event with no release allowed.

3. **Design Infiltration Rate between 0.5 inches and 2 inches per hour** – The facility shall retain and treat the entire WQE. In addition, the facility shall retain stormwater runoff from all design storm events up to and including the 100-year design storm, but with an allowable release rate up to the predeveloped 5-year design storm event. All stormwater released shall also be treated to remove a minimum of 80% of the total suspended solids (TSS) entering the facility.

4. **Design Infiltration Rate less than 0.5 inches per hour** – The facility shall retain and treat the entire WQE. The facility shall also retain stormwater runoff for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year design storm events, with an allowable release rate up to the equivalent pre-developed design storm events. All stormwater released shall also be treated to remove a minimum of 80% of the total suspended solids (TSS) entering the facility.

5. **"Critical Basin" Point of Discharge (regardless of design infiltration rate)** – The facility shall retain and treat the entire WQE. The facility shall also retain stormwater runoff for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year design storm events, with an allowable release rate up to the equivalent pre-developed design storm events. All stormwater released shall also be treated to remove a minimum of 80% of the total suspended solids (TSS) entering the facility.

In all situations these adjustment criteria, and the extent practicable in meeting them, shall be approved by the Director case-by-case, based on site-specific conditions. If the characteristics of a site or project require an alternative design or other mitigation in lieu of meeting the above criteria, the Engineer may propose an alternative design for review and approval by the Director.

F. **Infiltration Facilities, including UIC**: Subsurface discharge infiltration facilities that are defined by DEQ and the City UICMP as Underground Injection Control Structures (UICs) shall be designed to include approved

pretreatment devices and be registered with the City as required under the UICMP.

These facilities will not be allowed (or required) whenever the following site conditions are encountered in the proposed facility location, except as discussed below or otherwise approved by the Director**:**

1. **Sites with slope stability concerns.** These sites require a geotechnical evaluation by a Geotechnical Engineer or Certified Engineering Geologists to determine the suitability for infiltration and other facility recommendations.

2. **Sites with a high groundwater table.** These sites require a geotechnical evaluation by a Geotechnical Engineer or Certified Engineering Geologists to confirm the seasonal high groundwater levels determine the suitability for infiltration and other facility recommendations.

3. **Sites with contaminated soils.**

4. **Locations near building foundations.** Infiltration facilities shall be located at least ten feet from building foundations and shall not be located immediately upslope of building structures. If the side and a portion of the infiltration facility is lined, this setback may be reduced as authorized by the Building Official.

5. **Locations near property lines.** Infiltration facilities shall be located at least five feet from adjoining property lines and easements where the adjoining property is downslope of the facility.

G. **Flow Control**. As described in Subsection 3.2.B. above, certain Design Infiltration Rates and certain basins in the City require that a flow control stormwater facility be included, to control the flow of stormwater leaving the site. These facilities shall be designed using one of the Approved Analytical Methods for hydrologic analysis.

A designer may also choose to incorporate flow control facilities onsite, in advance of the retention facility, to detain larger storm events and reduce the rate of flow entering the retention facility. The Engineer is encouraged to size this facility using one of the Approved Analysis Methods but may utilize other methodology or design storms that allow the systems to function properly.

H. **Manufactured Alternative Treatment Technology:** There are many types of manufactured treatment, retention, and flow control products available for use today. Some of these alternative systems are stand-alone and meet the requirements for stormwater treatment. Other systems

must be used in conjunction with pre-treatment systems to meet stormwater quality standards.

1. **Design Requirements**. In addition to design calculations, the following must be submitted with each manufactured stormwater treatment technology project:

    a. The pollution reduction capacity of the facility.

    b. The flow-through conveyance capacity (i.e., maximum flow rate through the facility that will not cause agitation and release of previously trapped pollutants).

    c. An Operations and Maintenance Plan must also be submitted to the City in accordance with the manufacturer's recommendations.

    d. Manufactured stormwater treatment technologies must be designed, constructed, and installed in accordance with the manufacturer's recommendations.

    e. The maximum depth of any sump pump for any stormwater facility is twenty feet.

These technologies shall be reviewed and approved by the Director on a case-by-case basis. The City reserves the right to approve, deny, or condition the use of Alternative Treatment Technologies.

I. <u>Stormwater Facility Selection Criteria</u>.

a. **Public Stormwater Facilities**: For the design of facilities for the treatment, retention, and flow control of runoff from areas designated as public infrastructure (streets, sidewalks, developed rights-of-way, public parks or open space, etc.), the Director requires that facilities are utilized to the MEF and be considered in the following order:

    i. **GSI Facilities**, designed to treat stormwater runoff to the MEF before entering any downstream facilities or points of disposal.

    ii. **UIC facilities**, as defined by the Oregon DEQ and as managed under the City's UICMP. Depending on site- and project-specific characteristics, pre-treatment of the stormwater runoff may be required to protect groundwater affected by the UIC facility.

iii. **ROW planter or swale facilities**, located within planter strips or similar areas within the public right-of-way.

iv. **Proprietary stormwater treatment and retention devices**, such as manufactured technologies used to address the stormwater quality impacts of development through a combination of physical, chemical, and/or biological treatment processes.

b. **Private Stormwater Facility:** While City treatment, flow control, and retention requirements also apply to stormwater runoff from areas owned and operated by private entities, the Standards do not specify a preference regarding the options considered. The facilities must be designed to provide these mechanisms to the MEF and be in general conformance with these Standards. Any private UIC facilities must be registered with DEQ as per their requirements.

c. **Gravity Flow:** Where possible, all public and private storm systems shall be designed to flow by gravity into an existing or new storm conveyance system. Lift stations will only be approved on a case-by-case basis if no other options are available.

d. **Self-cleaning:** Except for pollution control or water quality structures, all storm drain system components shall be designed to be self-cleaning to the MEF.

e. **All-Weather Access:** All-weather maintenance vehicle access shall be provided to all stormwater facilities maintained by the City. The type of surface treatment (i.e., asphalt, concrete, or compacted gravel) shall be approved by the Director and will be designed in accordance with the location, slope and expected operation and maintenance vehicle types. If this all-weather access crosses property other than the public ROW, legal easements for operation and maintenance access shall be provided to the City.

K. **Infiltration Testing:** All stormwater facilities designed to utilize infiltration are required to perform infiltration testing to determine the existing soil permeability and infiltration capacity before design of the facilities. The test location should be at or very near the location and depth of the proposed facility(ies). Small Projects may utilize simplified infiltration testing for evaluation. All other projects shall provide infiltration testing performed by a qualified professional following one of these methods:

1. The **Professional Method Infiltration Testing** described in the *City of Salem Public Works Design Standards*.

2. One of the professional **Infiltration Testing Methods** described in the *Marion County Stormwater Quality Treatment Engineering Standards.*

3. One of the professional **Infiltration Tests** described in the *Portland Stormwater Management Manual*.

4. Another professional testing method as approved by the Director in advance of the testing.

The infiltration test results shall be used to determine the Design Infiltration Rate for the stormwater facility design. Results of the infiltration testing, Design Infiltration Rate calculations, and associated data shall be submitted with the stormwater facility design and construction drawings.

L. **Design Sizing Methodologies**: There are two methods for sizing stormwater facilities – commonly known as the Simplified Method and the Engineered Method.

1. The **Simplified Method** uses a surface area ratio calculation to size the stormwater facilities. The amount of new or replaced impervious area is calculated and multiplied by a sizing factor that varies by facility type. This Method is allowed for Small Projects. Method calculations must be submitted to the City with the construction plans when applying for a development permit, but are not required to be stamped by an Engineer.

2. The **Engineered Method** shall be used to design all other projects with new replaced impervious surface, and all public stormwater facilities. It may also be applied to design facilities on smaller projects where the more detailed hydrologic calculations allow the facility to be sized more accurately than with the Simplified Method. This methodology shall be performed by an Engineer.

   The Engineered Method consists of sizing stormwater facilities by applying hydraulic and hydrologic engineering calculations to determine runoff, flow, volume, storage, conveyance capacity, etc. This Chapter provides the requirements for the various necessary hydrologic and hydraulic calculations in the next section.

   The Engineered Method analysis and supporting documentation shall be submitted to the City as part of the Stormwater Management Report submitted with a land use application and/or construction drawings.

M. **Hydrologic Analysis:** Stormwater facility design flows and volumes shall be determined using the methods described in this section. For every

project, the impervious area shall include the total impervious (replaced and proposed) area on the site.

1. **Drainage Areas**. All hydrologic analyses must include the drainage area of the site being evaluated and all the upstream contributing basin area including those areas outside the proposed development site. Drainage calculations for flow control analysis shall include both the pre-developed and the post-developed drainage conditions.

2. **Acceptable Analytical Methods**. Calculation of stormwater runoff for stormwater treatment and flow control shall be analyzed using the Santa Barbara Urban Hydrograph (SBUH) method, Natural Resource Conservation Service (NRCS) Technical Release (TR)-55 procedures, or the Environmental Protection Agency (EPA) Stormwater Management Model (SWMM). These are typical standards of practice; however, the Director may approve other methods as proposed by the design Engineer.

3. **Design Storm Events:** The physical characteristics of the site and the appropriate design storm shall be used to determine the magnitude, volume, and duration of the runoff hydrographs generated using one of the Acceptable Analytical Methods listed. The Soil Conservation Service Type 1-A, 24-hour rainfall distribution, shall be used in all applications unless otherwise approved by the Director. The following 24-hour rainfall totals, based on recurrence interval, shall be used in determining the runoff hydrograph for various-sized storm events:

a.	Water Quality Event:	1.38 inches
b.	2-year Event:	2.20 inches
c.	5-year Event:	2.70 inches
d.	10-year Event:	3.20 inches
e.	25-year Event:	3.60 inches
f.	50-year Event:	4.10 inches
g.	100-year Event:	4.40 inches

4. **Design Storm Peak Discharge.** The peak discharge from each design storm evaluated for the project may not be increased from conditions existing prior to the proposed development, except where it can be satisfactorily demonstrated by the design Engineer that there is no adverse impact to downstream properties or systems, and that the remaining available downstream capacity for the site being developed is not being exceeded.

5. **Site Conditions**. The following basin characteristics shall be evaluated when using a hydrograph method.

a. Existing Basin Conditions**.** A homogeneous basin area will be assumed, regardless of the current conditions, when determining the peak runoff for pre-development conditions. The runoff characteristics for calculating allowable outflow are based on the combination of woods and grassland. The curve numbers utilized shall be in accordance with industry standards and shall always be used for determining pre-development flow condition selected for the predominate soil type where the project is located.

b. Post-development Conditions. A runoff hydrograph shall be created from an accurate characterization of the post-development site conditions. The runoff hydrograph shall include the contributing pervious and impervious areas along with their associated runoff curve numbers. Sub-basins shall be delineated and routed together when appropriate. A separate analysis of just the impervious area shall also be performed. The larger of the two hydrographs shall be used for design.

5. **Rational Method (Only for Conveyance Design)**. The Rational Method may only be used to determine the peak flow for sizing proposed conveyance facilities and for determining the peak flow capacity of existing conveyance facilities with contributing drainage areas less than ten acres. The minimum Time of Concentration allowed using this Method is 5 minutes.

N. Downstream Capacity Analysis: When the City is aware of conveyance system capacity issues downstream of a large development or project, City may require the design engineer to provide an analysis of the existing system downstream, to evaluate if additional onsite facilities or downstream system improvements are required to mitigate the downstream impacts.

The downstream capacity analysis shall:

1. Be based on peak flows at the approved point of disposal.

2. Evaluate the system's conveyance capacity from the point of disposal, one-quarter of a mile downstream or to a distance where the project site contributes less than 15 percent of the upstream drainage basin area, whichever is greater.

3. Use the Rational Method and the Manning's Formula to evaluate the capacity of existing pipes, ditches, and waterways. "Backwater effect" shall be included in determining capacity for waterways with

drainage areas greater than 250 acres, using HEC-RAS or an equivalent computer modeling software.

If the downstream analysis crosses the jurisdictional boundary of another agency with the authority to manage surface water, that agency shall be notified by the design engineer and given an opportunity to review and comment on the analysis.

O. **Plant Material Landscaping Requirements**: Stormwater facilities utilizing GSI or other above-ground vegetation in the design, as required in these Standards, shall include landscaping with approved plant selection, soil amendments, fertilizers, etc., conforming to one of the following documents (see Appendices):

1. The **Landscape Requirements and Plant Lists for Stormwater Facilities** per Appendix 004B of the *City of Salem Public Works Design Standards*, dated January 2014.

2. The **Planting Requirements** per Appendix A of the *Clean Water Services Design & Construction Standards: R&O 19-5 as Amended by R&O 19-22*, adopted November 12, 2019.

3. Another local jurisdiction's list of landscaping materials as approved by the Director, in advance of planting the materials.

P. **City Standard Details**: Additional design information on the type, layout, and requirements for the installation of public stormwater facilities and conveyance systems is provided in **Section 400** of the City's Standard Details.

Q. **Sensitive Areas.** Projects that are adjacent to wetlands, riparian areas, an existing open-channel waterway, or within the 100-year floodplain of any waterway must meet Federal, State, and local requirements governing those areas – in addition to the requirements of these Standards.

R. **Preserving Existing Trees and Vegetation:** Existing trees and native vegetation should be preserved as much as possible to enhance the pervious areas and natural treatment on a site. The plans should identify all existing trees and native vegetation on the site, documenting those to be removed and those to be retained. For the purposes of this section, "tree" means any living, woody plant which has a diameter at breast height (dbh) of 6 inches or greater.

S. **Ground Disturbing Activity Requirements:** Site design layout and construction practices should be utilized to minimize ground disturbing activities and retain the undisturbed state of the duff layer, topsoil, and

native vegetation where feasible. Limiting the amount of impervious area on a site will reduce the size of required stormwater facilities.

T. **Source Control:** All development and redevelopment projects, regardless of size, which have a potential for discharging a Pollutant(s) (see Definitions, Chapter 100) into the stormwater system shall utilize BMPs to prevent or reduce the discharge of Pollutants from the site.

U. **Site Disturbance During Construction:** Soil compaction or disturbance, where the footprint of facilities designed for full or partial infiltration are to be located, shall be avoided during construction. The location of these facilities shall be clearly marked on the plans. These areas must be protected with barriers or other means during construction. No vehicle or construction equipment traffic, except that specifically used to construct the stormwater facility, shall be allowed within ten feet of infiltration area. Also, equipment should be selected to impact the area as little as possible.

V. **As-Builts:** All facilities shall be field-verified after construction to demonstrate they meet all design parameters including, but not limited to, storage volume, slope, overflow elevation, rock storage, growing medium depths, pipe and structure sizes, etc. As-built drawings shall be submitted in accordance with the general City design standard requirements prior to City acceptance of the facility.

W. **Operations and Maintenance Requirements (Public and Private Facilities)**: Operations and Maintenance (O&M) requirements apply to all stormwater treatment, retention, flow control, conveyance facilities and related components, whether publicly or privately owned.

1. **Public Systems.** Developers of public stormwater systems shall provide Operations and Maintenance documentation, manuals, and other supporting information, specific to the facility and facility components, to the Director prior to City acceptance of the facility(ies).

2. **Private Systems.** Owners of sites which have stormwater facilities are required to provide regular operation and maintenance of these facilities to ensure that they to operate in accordance with these Standards and the City's MS4 permit requirements. In addition, the owners must complete and submit a signed and sworn *Private Stormwater Maintenance Agreement*, in a City-approved format, to the Director prior to City approval of recorded land division or occupancy of private development sites. The Director can provide the template for this *Agreement* upon request.

400.3 PUBLIC STORMWATER CONVEYANCE SYSTEMS

A. General Design Considerations:

1. The Rational Method may be used to determine the peak flow for sizing proposed conveyance facilities and for determining the peak flow capacity of existing conveyance facilities with contributing drainage areas less than ten acres. The minimum Time of Concentration (Tc) allowed using this method is 5 minutes.

2. Other, more conservative calculation methods for sizing the conveyance facilities may be approved by the Director on a case-by-case basis.

Conveyance systems shall be designed and constructed in compliance with all applicable Federal, State, and local agencies. Work within, or near, open waterways will normally require permit authorization from other agencies.

3. Existing waterways shall be retained except where culverts, bridges, or other closed systems are proposed and approved by the Director.

4. The design of waterway conveyance systems shall include the planting of trees and other vegetation in the riparian corridor to provide bank stabilization, temperature control, and wildlife habitat, in accordance with Oregon Natural Resources Conservation Service (NCRS) guidelines.

5. The stormwater conveyance system shall be designed and constructed in accordance with floodplain management policies and regulations.

B. Capacity: A given conveyance system shall be designed to convey the design storm flowing full as described in Table 400-1. The design storm selected shall be based on either the size of the drainage area or the street classification, whichever is larger.

Conveyance System Design Capacity		
System Element		**Design Storm Recurrence Interval**
Local Streets	Streets, curbs, gutters, inlets, catch basins, collector drains	10 years
Local Storm Drains	Drainage area <50 acres	10 years

Collector Streets	Streets, curbs, gutters, inlets, catch basins, collector drains	25 years
Collector Storm Drains	Drainage area 50 acres or greater	25 years
Arterial Streets	Streets, curbs, gutters, inlets, catch basins, collector drains	50 years
Ditches and Culverts	Local Streets	25 years
	Arterial and Collector Streets	50 years
Waterways	Without designated floodplain	50 years
	With designated floodplain	100 years
Bridges		100 years

Table 400-1. Conveyance System Design Capacity for System Elements

C. Piped Systems

1. **Minimum Size** – Storm drainage pipes shall have an inside diameter of ten inches or larger.

   Slope Requirements for New Mains - All storm drain pipes shall be laid on a grade which will produce a mean velocity (when flowing full) of at least 2.5 feet per second, designed using Manning's pipe friction formula with a roughness coefficient of 0.013. The minimum acceptable grade for various pipe sizes with a Manning's Roughness Coefficient of 0.013 is shown in Table 400-2. The minimum grade may be reduced from these values if an absolute minimum velocity of 2.0 fps can be demonstrated. The maximum grade for a storm pipe shall be 20 percent.

Inside Diameter (in)	Grade (Feet per 100 feet)
8 (private)	0.52
10	0.39
12	0.30
15	0.23
18	0.18
21	0.14
24	0.12
27	0.10
30 (and larger)	0.09

Table 400-2. Minimum Pipe Grade for 2.5 feet/second

Engineers may specify a larger storm pipe size in order to achieve a flatter minimum slope, provided it is no more than one size category larger than needed for the carrying capacity; i.e., a 12-inch pipe instead of a 10-inch pipe.

2. **Existing Storm Mains** - The Manning's "n" value for existing pipes varies based on material, condition, and interior wall configuration as shown in Table 400-3, and shall be used for evaluating flow in existing pipes unless a lower value can be justified by inspection.

Manning's Roughness Coefficients	
Pipe Material	**Range of "n" Values ***
Plastic (PVC, HDPE)	0.009 – 0.013
Concrete	0.013 – 0.015
Ductile Iron	0.013 – 0.015
Cast Iron	0.013 – 0.015
Corrugated Metal	0.032

Table 400-3. Roughness Coefficients for Various Types of Pipes

*The lower range represents new pipe and pipe in good condition and the upper range represents pipe in fair condition. Pipes in less than fair condition will require greater "n" values as approved by the Director.

3. **Pipe Materials** - Pipe materials for storm mains and connections shall conform to City of Keizer Specifications, Chapter 400. Acceptable pipe materials and abbreviations are as follows:

   a. CONC—Concrete
   b. DI—Ductile Iron
   c. HDPE—High Density Polyethylene
   d. PVC—Polyvinyl Chloride
   e. ABS – Acrylonitrile-Butadiene-Styrene

4. **Alignment/Location**

   a. Storm pipes shall be laid on a straight alignment between junctions.

   b. The angle of crossings with other utilities shall be nominally 90 degrees, and no less than 70 degrees.

   c. The minimum separation for crossing other utilities shall be six (6) inches. If a crossing of less than six inches of vertical separation is necessary, the storm and utility lines shall be backfilled with controlled density backfill or other approved

material, to a distance of at least three (3) feet outside the utility walls in all directions.

d. Where storm drains parallel other utility pipe or conduit lines, the vertical and horizontal alignment shall permit lateral storm drain connections without abrupt changes in vertical grade of the main or the connecting storm drains.

e. Storm drain alignments shall accommodate future planned projects such as street widening, changes in horizontal or vertical street alignment, and master-planned water, sewer, or other stormwater facilities.

5. **Cover Requirements**

a. Pipe depth is measured from top of pipe to finish grade at the center of the storm drain alignment.

b. All storm drains shall be laid at a depth sufficient to protect against damage by vehicle traffic. Minimum cover for all storm drainage pipes shall be 30 inches above the top of the pipe. Ductile iron pipes, or other pressure-rated material as approved by the Director, shall be used where 30 inches of cover cannot be achieved.

c. All storm drains shall be laid at a depth sufficient to drain neighboring properties and systems where feasible. It must also be demonstrated that the storm drain is at sufficient depth to properly drain the remainder of the upstream contributing basin.

6. **Junctions**

a. Junctions are required for the stormwater conveyance system wherever there is a change in grade, direction, or pipe size. Piped storm drain systems shall also have junctions located at intervals of 500 feet or less.

b. Storm pipe junctions shall be round cleanouts (including beehive structures), manholes, or other approved junctions as shown on the Keizer Standard Details.

c. Cleanouts and beehive structures may be used as junctions only with pipes less than 18 inches in diameter and for maximum depths of five feet from rim to invert.

d. Junctions located outside the public right-of-way shall be a 48-inch diameter or larger manhole. These junctions accessible through an all-weather maintenance road within an access easement dedicated to the City, or equivalent, as approved by the Director.

7. **Catch Basins**

a. Catch basin systems and other stormwater inlets shall be designed to accommodate the appropriately-sized design storm flow from the area served by the inlet.

b. Inlet “spread and capture” calculations are required for all arterial and collector streets. Either the ODOT Hydraulics Manual, Chapter 13, Appendix D, or the FHWA HEC-22 Urban Drainage Design Manual may be used in these calculations, and the results submitted with the project design.

c. On local streets and smaller, inlets may be spaced at no greater than 400 feet apart.

d. Regardless of these two requirements, no more than 0.1 cubic feet per second of non-captured flow is allowed downstream of the catch basin and must still be captured before leaving the project limits.

e. Street stormwater flow paths shall not cross above-ground through intersections.

f. Type 2 catch basins shall be used on curbed portions of streets. Type 1 catch basins should be used where the inlet must be installed at driveways. Catch basins of any type shall not be placed in front of accessible pedestrian ramps or within any accessible route.

g. Catch basin inlets shall be located along the street gutter line or within an open channel flowline. When streets are widened or otherwise modified, causing an inlet to be located outside a flowline, the catch basin shall be replaced with a cleanout, manhole, or other acceptable junction.

h. An overflow to an approved point of disposal must be determined to account for flows exceeding design capacity or inlet failure.

8. **Subsurface Drainage.** On City projects, subsurface drains are required for all excavations and fills, with or without retaining walls, which exceed four feet vertically. These drains shall be constructed with adequate erosion protection and shall discharge into an approved point of disposal.

D. **Culverts** Criteria provided in this section for culvert design for open channel flow shall also apply to culverts placed in drainage ways and roadside ditches.

1. **Culverts in Waterways**

   a. New culverts shall be sized in conformance with the design storm requirements found in Table 400-1.

   b. Culverts placed in rivers, creeks, streams, or open-channel waterways determined to be “waters of the State” require approval from DSL and the USACE, at a minimum.

   c. All culverts on fish-bearing waterways shall be designed for fish passage in accordance with ODFW guidance unless otherwise exempted by ODFW.

   d. Waterway crossing structures shall be designed with a foundation and three sides, or otherwise oversized and buried in the open channel, to maintain the natural channel bottom.

2. **Culverts in Ditches/Open Channels**

   a. Headwater Elevation

      i. For new culverts 18 inches in diameter or less, the maximum allowable design storm headwater elevation (measured from the inlet invert) shall not exceed 2.0 times the pipe diameter or three times the pipe diameter with a seepage collar.

      ii. For new culverts larger than 18 inches in diameter, the maximum allowable design storm headwater elevation (measured from the inlet invert) shall not exceed 1.5 times the pipe diameter.

   b. Inlet Embankment – For culverts 18 inches through 42 inches in diameter, the embankment around the culvert inlet shall be protected from erosion by armoring around the inlet with rock or other hardscape protection. The armoring shall

extend upstream from the culvert a minimum of five feet and shall extend up the sides at least as high as the designed headwater elevation

c. Headwalls and Endwalls. Pipe headwalls, endwalls, or other approved end protection shall be required for:

i. Culverts installed under public streets to serve as a crossing.

ii. Where culvert pipe materials, other than concrete or ductile iron, is exposed at an outlet or inlet.

iii. Where required to provide additional slope stability.

Details for the headwalls, endwalls, and other end protection shall be included in the construction drawings.

d. Outlets

i. For culverts 10 inches in diameter and larger, the receiving channel downstream of the outlet shall be protected from erosion by a rock lining, bioengineering, or by some other approved type of energy dissipater.

ii. Runoff exiting a development site shall be discharged with adequate energy dissipaters to prevent downstream erosion or other damage.

e. Inlet and Outlet Control Analysis. The headwater depth for pipes under inlet or outlet control shall be determined using hydraulics software such as the FHWA program HY-8 or the nomographs contained in the ODOT Hydraulics Manual.

E. Other Conveyance Systems

All conveyance system designs not addressed above shall be designed in accordance with standard engineering practices and be approved by the Director before construction.