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Fanno and Tryon Watersheds

▪

Street Drainage Overview

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2012

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
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INTRODUCTION

The purpose of this report is to provide an overview of streets and drainage characteristics, policies, regulations, and management responsibilities, and impacts to watershed health. Drainage management objectives and potential strategies are provided as guidance for the implementation of future drainage improvement projects in the Fanno and Tryon Creek watersheds.

EXECUTIVE SUMMARY

The Fanno Tryon Watershed Management Plan 2005 (Plan) identified impervious surface runoff as a watershed problem because increased stormwater runoff and greater velocities degrade downstream habitat in Fanno and Tryon Creeks. Unmanaged urban stormwater from streets also carries pollutants from vehicles and other sources to neighborhood streams.

The Street Drainage Overview is a supplement to the Plan and provides additional detail to characterize the street drainage system. It describes management responsibilities for streets, characterizes watershed impacts, and summarizes regulatory requirements. The overview also describes current stormwater facilities, their design criteria and presents goals for reducing the impacts to Fanno and Tryon Creeks and tributaries from street runoff.

Quick Facts

- Fanno Creek Watershed is 33% impervious and Tryon Creek is 24% impervious. Impervious area is 40% in some commercial corridors.
- Fanno Creek Watershed has 131 miles of streets.
- Tryon Creek Watershed has 74 miles of streets.
- Most stormwater from streets flows untreated directly to creeks.

Street Drainage Characteristics

There are three types of streets in SW Portland:

- Curbed streets with developed storm sewer systems (42%)
- Uncurbed streets with varying levels of developed storm sewer systems which may include pipes, roadside ditches, or undefined sheet flow (50%)
- Unimproved streets which typically have no storm sewer system (8%)

Street drainage problems are typically local and watershed health impacts (e.g., increased flows, pollutants) are more prevalent at the watershed scale. Absent or substandard storm sewer systems result in local drainage issues predominantly on uncurbed and unimproved streets.

Drainage is comprised of the natural stream network (27%) and the publicly owned and maintained Municipal Separate Storm Sewer System (MS4) (73%). The MS4 system and urban development have replaced many of the small headwater streams and natural drainage courses. The MS4 system is comprised of 690 individual basins; 75% of the basins are less than 10 acres.

Management Responsibilities

Approximately 72% of streets are City maintained and the City is responsible for the operations and maintenance of their storm drainage systems. The City is generally not responsible for the upgrade of non-standard storm drainage systems. Upgrades are the responsibility of adjacent property owners and typically occur through the city's local improvement district (LID) process.

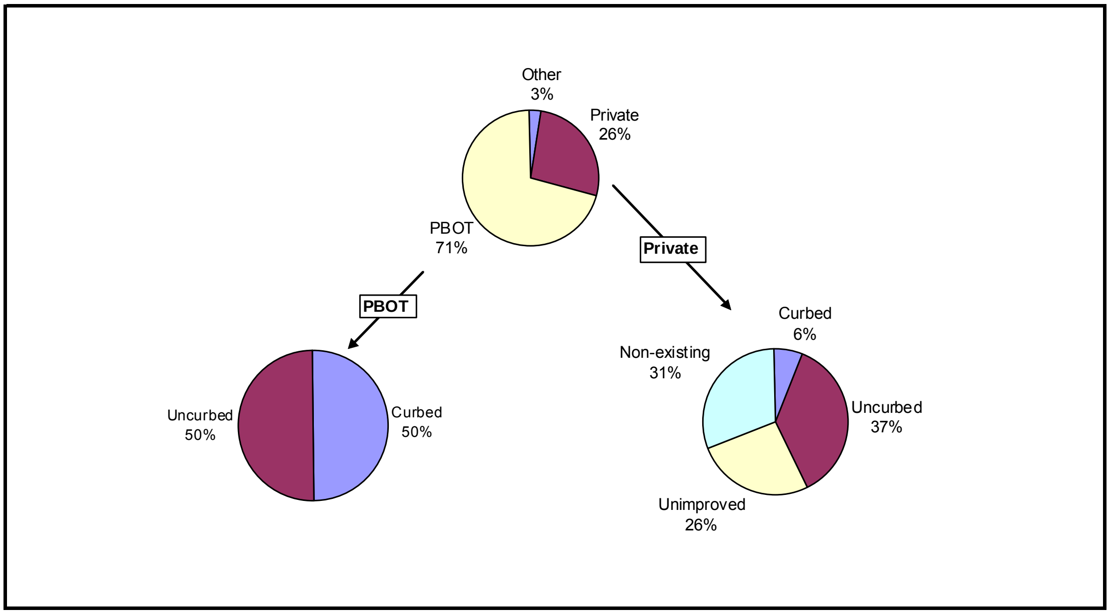


Figure 1: Street Maintenance Responsibilities (upper circle) and Street Type (lower circles).

The remaining 26% of streets are public right of way, but privately maintained. All maintenance and improvements to unimproved streets and drainage are the responsibility of adjacent property owners.

Watershed Impacts

Flow (Hydromodification) – Impervious area (e.g., street pavement) and piped storm systems concentrate runoff and convey it directly to the natural stream system which results in hydromodification or changes to the natural stream hydrology. This includes increased peak flow rates and runoff volumes. Curbed streets which are completely paved and contain piped storm drainage systems which discharge directly to streams have the greatest effect. Uncurbed streets have varying levels of effects depending on the extent of impervious area and any associated drainage system present.

Pollutants – Pollutants in stormwater runoff from street surfaces are conveyed to the natural stream system where they negatively affect water quality. The source of many of these pollutants are automobile related (metals, petroleum products, etc.). Pollutant loadings generally increase with increasing vehicular traffic. Curbed streets provide control of the stormwater runoff and the MS4 system conveys it to the stream, therefore, these tend to have a direct impact on the stream. Uncurbed streets and unimproved streets have varying direct impacts depending on traffic volumes and the routing of the runoff to the stream system.

Fine Sediment – Erosion from unimproved street surfaces can result in the delivery of fine sediments to the natural stream system affecting stream morphology (form and structure) and biological habitats in the streams.

Biological Communities - Federally listed steelhead and Lower Columbia River coho are present in Tryon Creek. Modeling results indicate that fine sediment loading and changes to the hydrologic regime are limiting factors for the health of these fish species. Both of these measures are impacted by discharges from street drainage. Macroinvertebrate communities (aquatic insects) are highly degraded in these watersheds. Analysis indicates that impervious area, piped streams, and roads are negatively correlated to macroinvertebrate community health.

Regulatory Requirements

MS4 Discharge Permit - The street drainage system is the major component of the City's MS4 system. The MS4 discharge permit requires the City to have an approved Stormwater Management Plan (SWMP). The SWMP plan describes measures the City will implement to reduce the discharge of pollutants in stormwater to the "maximum extent practicable" and to protect water quality and watershed health.

Total Maximum Daily Loads (TMDLs) - Fanno Creek and its tributaries have established TMDLs for temperature, bacteria, dissolved oxygen and total phosphorus. Waste Load allocations for bacteria, dissolved oxygen and total phosphorus apply to discharges from the MS4 system. Tryon Creek has TMDLs for temperature and bacteria. Waste Load allocations for bacteria would apply to discharges from the MS4 system. Compliance with the MS4 permit fulfills requirements of the TMDL waste load allocations.

Endangered Species Act - Federally listed steelhead and Lower Columbia River coho salmon are present in Tryon Creek.

Stormwater Management Facility Design Criteria

The design of storm drainage facilities must meet the requirements of the BES Sewer Design Manual. All drainage facilities must convey the 10-yr storm without overflow and have a means to convey a 25-yr storm without damage to property, endangering human life or public health, or significant environmental impact.

All new development and redevelopment must meet the requirements of the City Stormwater Management Manual (SWMM). The SWMM requires:

- Stormwater discharges to pipes, ditches, and streams are only approved if those facilities have the capacity to convey flows from all up-stream development.
- Flow control: Post-development peak flow rates must be equal to the pre-development levels for the 2-yr, 5-yr, and 10-yr 24-hour storm events. Two-year

post-development discharges to streams must be reduced to one-half of the 2-yr pre-development peak flow.
- Pollution reduction: Stormwater management facilities must remove 70% of total suspended solids from 90% of the average annual runoff. In watersheds with TMDLs, additional requirements may apply.

Street drainage improvements must address design constraints including: Site constraints such as existing development, soils with limited infiltration capacity, steep slopes, inadequate disposal points and other public values such as pedestrian requirements.

Strategies for Reducing Impact

1. Provide adequate storm system infrastructure by conducting required operations and maintenance of the existing street drainage system and constructing new street drainage systems as required.

2. Manage storm system discharges to natural streams to normalize flow by reducing the effective impervious area of existing street surfaces to reduce hydromodification and impacts on stream hydrology.

3. Meet MS4 permit requirements (and TMDLs) by reducing pollutant loadings from street surfaces to the natural stream system to improve watershed health.

4. Support protection and recovery of federally listed species by reducing fine sediment loading to the natural stream system from street surfaces including unimproved public right of way.

BACKGROUND

Fanno and Tryon Watersheds

Fanno Creek flows southwest about 15 miles from its headwaters in Portland to the Tualatin River near Durham. The Fanno Creek watershed covers 20,259 acres, or 32 square miles. About 4,530 acres are within the City of Portland (*Map 1*). More than 80% of the Fanno Creek watershed in Portland is zoned for single-family residential use. Multi-family residential (8%) and commercial (4%) zoned lands are located primarily along major transportation routes, particularly Beaverton Hillsdale Highway. Parks and open space total about 6% of the watershed. Impervious surfaces, such as streets, roofs, and driveways, cover over 30% of the watershed.

Tryon Creek flows south about 7 miles from its headwaters near Multnomah Village to the Willamette River near Lake Oswego. The Tryon Creek Watershed covers 4,142 acres, or 6.5 square miles. About 3,060 acres (nearly 80 percent) are within the City of Portland. Fourteen percent of the watershed is covered by parks and open space. More than 50% of the watershed is zoned for single-family residential use. Multi-family residential (5%) and commercial (3%) zoned lands are located primarily along major transportation routes such as Barbur Boulevard in upper Tryon Creek. Impervious surfaces cover about 24% of the watershed.

Both watersheds are characterized by steep slopes, steep stream gradients, and soils that are slow to infiltrate rain. These physical characteristics along with impervious surfaces, loss of vegetation, and altered hydrologic conditions result in a "flashy" urban stormwater system that influences the morphology and stability of streams. Stream channel erosion and incision, streambank instability, and loss of aquatic habitat complexity are common. Development and urban stormwater runoff also effects water quality, which is impaired for temperature, dissolved oxygen, bacteria and nutrients.

Management Responsibility
The Bureau of Environmental Services (BES) is responsible for the management of the public storm drainage system within the City of Portland.

The Federal Clean Water Act, Safe Drinking Water Act, and the Endangered Species Act require the City to manage stormwater runoff to protect water quality in rivers and streams, protect watershed health, and protect groundwater as a drinking water source. The City's National Pollutant Discharge Elimination System (NPDES) Stormwater Permit requires Portland to reduce stormwater pollution from the Municipal Separate Storm Sewer System (referred to as the MS4) and manage other programs that respond to water quality requirements. The MS4 is defined by regulation (40 CFR 122.26(b)(8)) as "a conveyance or system of conveyances **(including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches**, **man-made channels, or storm drains**)" owned or operated by the City. BES coordinates the City's response to the MS4 permit.

In summary, management of the City street system is the responsibility of PBOT and management of the public storm drainage system (MS4) is the responsibility of BES. There are also multiple City and BES policies, programs and codes along with legal and regulatory requirements that relate to street drainage. All of these factors result in a very complex set of issues that must be considered when addressing street drainage.

Existing Street Drainage System
The public street system in the Fanno and Tryon watersheds has been constructed over time to meet the transportation needs of the predominately residential developments in these watersheds. Development policies including street improvement and design standards have varied over time resulting in existing streets constructed to different standards and of varying condition. Older development in these watersheds occurred under the jurisdiction of Multnomah County. Later, these areas were incorporated into the City with the City assuming responsibility for the former county roads. As a result, many streets are not constructed to current City standards although they may have some street improvements.

The existing street drainage system to provide for the management of stormwater runoff from streets mirrors the development of the street system and as a result, exhibits the same mix of systems with both private and public infrastructure components of varying standards and condition. Due to the topography in these watersheds, the existing drainage systems are typically small and discharge locally to small streams or water courses. In addition, the design of most of the existing drainage systems was for conveyance and did not consider water quality or stream habitat impacts. Water quality and stream habitat were not a major consideration prior to development of state and federal stormwater regulations and establishment of total maximum daily loads (TMDLs) to address water quality impairments in the Tualatin River basin in the 1980s.

STORMWATER SYSTEM PLAN

The Bureau of Environmental Services is currently preparing a Stormwater System Plan to develop recommended projects required for stormwater management within the City of Portland. The Stormwater System Plan is being developed in partnership with BES watershed planning efforts. The Project Goals for the Stormwater System Plan are given below:

> ***Project Goal:***
> *Develop a Stormwater System Plan as a subset of the Portland Watershed Plan that provides capital and operational recommendations to address storm system capacity, stormwater quality, surface water drainage, and condition problems in natural and manmade conveyance systems. Work is to be accomplished using an asset management framework that integrates watershed/sub-watershed objectives in the characterization, evaluation and recommendations. The Plan must integrate and/or further refine stormwater activities recommended by MS4 and UIC permit, Portland Harbor/Superfund, and ESA Program.* (Stormwater System Plan – Project Approach, BES, April 20, 2009)

An important early decision in the stormwater system planning effort was to include streams in the planning process since stormwater from the City storm system impacts the streams. This decision was made while acknowledging that "*BES does not have ownership, right of access, or direct control over the natural stream system, nor responsibility for storm drainage on private property.*" (BES 2006). This approach is also consistent with the development of the Portland Watershed Plan.

To initiate the work on the overall City-wide storm system plan, the Stephens Creek Stormwater System Plan was selected as a pilot project in 2009. One of the first products of the pilot project was the identification of Fundamental Services to be provided by the storm system to meet Functions tied to the watershed goals of the Portland Watershed Plan. These are summarized in Table 1.

Table 1: Summary of Services Provided by the Stormwater System*

Fundamental Service Category	Fundamental Service	Functions Met by this Service
Services have been grouped into three categories.	*A fundamental Service is a publicly desired function performed by the City which has a consequence on assets (owned and stewarded)*	*Functions met by the service are tied to the Watershed Goals.*
Stormwater Runoff Management & Stormwater Collection and Conveyance	Reduce risk to life, property and the natural environment through management of stormwater runoff and by providing and maintaining safe drainage collection and conveyance systems.	Hydrology/Hydraulics Human Health Habitat Water Quality Biological Communities
Discharge & Treatment	Ensure appropriate water quality and flow discharge to water bodies (stream, river, groundwater) to protect, enhance, and restore habitat and biological communities, protect human health and safety, and comply with regulatory permits and programs.	Water Quality Hydrology Habitat Biological Communities
Stream Corridor	Protect high quality habitat and improve stormwater assets to promote healthier habitat conditions for biological communities; reduce risk to property and the natural environment from flooding.	Habitat Biological Communities Hydrology / Hydraulics Water Quality

* Stephens Creek Stormwater Plan; Technical Memorandum 2.2.A

Levels of Service (LOS)

The next step in the storm system planning process is the development of Levels of Service (LOS) for the services identified above. This includes development of stormwater system goals, levels of service (performance measures), metrics and targets. This step has not been completed yet, however, draft levels of service for each Fundamental Service have been developed (Appendix).

Draft levels of service that have special relevance to street drainage were excerpted from the overall list and are shown below:

Fundamental Service Category:
<u>Stormwater Runoff Management & Stormwater Collection and Conveyance</u>

A1. Provide adequate infrastructure for stormwater runoff for existing development with no current stormwater system, as well as new development and redevelopment, both public and private.

A2. Manage ditches, stormwater pipes, and publicly managed culverts (road drainage only- not streams) to convey the 25-year design storm without overtopping or surcharge as per the Sewer and Drainage Facilities Design Manual.

A3. Provide vegetative linings for ditches where practical as per the Sewer and Drainage Facilities Design Manual.

B1. Discharges to natural streams are managed to normalize stream flows.

B3. Meet requirements of the MS4 Retrofit Plan: reduce effective impervious surface in existing development.

C1.Inspect and maintain publicly owned stormwater facilities (culverts, catch basins, vegetated facilities, sumps, ditches, stormwater pipes).

When completed the Stormwater System Plan will be the primary mechanism to provide capital and operational recommendations for stormwater system improvements. In the interim, the draft levels of service can be utilized as guidance for development of street drainage improvements.

STREET CHARACTERIZATION

The street drainage system by definition is linked closely to the surface street system; therefore, an understanding of the existing street system is necessary. There are 205 miles (1,082,481 feet) of mapped streets within the public right-of-way in the Fanno and Tryon watersheds. To characterize the existing streets within these watersheds, streets were divided into four categories based on the level of street improvement as described below:

1. **Curbed** – These streets have hard surface pavement with curbs. In these watersheds, the existing pavement type is predominately asphalt although there are some oiled gravel and concrete paved streets segments. Streets in this category typically have some existing storm drainage infrastructure present since the drainage is controlled within the curbed area.
2. **Uncurbed** – These streets have hard surface pavement without any curbs. The existing pavement type is predominately asphalt. Street drainage is typically either conveyed through roadside ditches or dispersed as sheet flow onto adjacent properties.
3. **Unimproved** – These streets have not been graded or improved to City standards. Street surfaces may include some hard surfaces (asphalt or oiled gravel), however, they usually have surfaces of gravel or bare earth. Typically, there is no developed street drainage infrastructure present and drainage is by ditches, undefined sheet flow, or eroded channels within the roadway.
4. **Non-Existing** – Streets in this category have been platted, however, are not currently improved or utilized for vehicular transportation.

The street characteristics based on these categories for individual street segments are shown on *Map 2*.

City policy is to only maintain the following street improvements subject to budgeting and policy constraints (Binding City Policy – BCP-TRN-1.08):

1. Streets and alley improvements constructed under a Street Improvement Permit, through the Local Improvement District process, or as a Capital Improvement Project, that have been accepted by the City Engineer subsequent to construction. Acceptance for maintenance by the City Engineer occurs where streets have been designed and constructed to City standard construction specifications.
2. Street Improvements financed by the Works Progress Administration (WPA) program.
3. Street annexed by the City from another jurisdiction with whom the City has entered into an intergovernmental agreement for the jurisdictional transfer of streets and the annexed streets were previously designated as maintained roads and regularly maintained by the previous jurisdiction prior to annexation.
4. Streets lying within the Portland City limits prior to May 1984 located west of the Willamette River, east of the Washington County line, south of N.W. Cornell Rd. and north of the Clackamas County line, at that time, designated by Multnomah County as County roads.
5. Street accepted for maintenance through written agreements reached by the City Engineer and/or City Council with individuals, agencies or jurisdictions.

All other unimproved streets including undeveloped land in public street right-of-ways are not maintained by the City (PBOT) and are the responsibility of the adjacent property owners.

Based on the City policy described above, 72 percent of the streets in the Fanno and Tryon watersheds are maintained by the City (PBOT) with 26 percent of the streets privately maintained (Figure 1). Two percent of the streets remain the responsibility of other agencies: the Oregon Department of Transportation (1%) maintains SW Barbur Boulevard and Multnomah County (1%) retains maintenance responsibility for a few local service streets in the Tryon Creek watershed.

The street maintenance responsibilities for individual street segments are shown on *Map 3*.

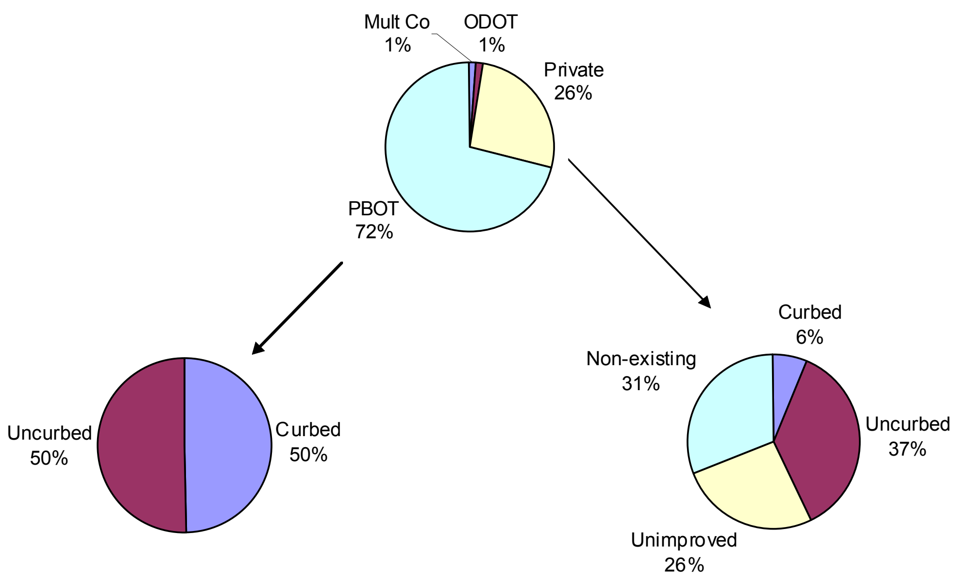
A further analysis of the maintenance responsibilities by the four street improvement categories described above shows that the City maintained streets are divided evenly between curbed (50%) and uncurbed (50%) streets (Figure 1).

The privately maintained streets are divided into three main street categories – uncurbed (37%), unimproved (26%), and non-existing (31%) (Figure 1). The major difference in the privately maintained streets is the very small percentage of curbed streets (6%) and the inclusion of the unimproved streets. The non-existing streets by definition have little impact on current operating or maintenance activities.

Table 2: Street Maintenance Responsibility by Street Type

Maintenance Responsibility	Street Types								Total
	Curbed		Uncurbed		Unimproved		Non-existing		
	Length (ft)	%	Length (ft)	%	Length (ft)	%	Length (ft)	%	Length (ft)
City of Portland	381,022	92	386,028	77	0	0	0	0	767,051
Private	18,206	4	103,824	21	75,223	99	88,557	94	285,810
ODOT	14,355	3	664	0	0	0	0	0	15,019
Multnomah Co.	0	0	8,490	2	488	1	5,623	6	14,601
Totals	413,584	100	499,007	100	75,711	100	94,180	100	1,082,481

Figure 1: Street Maintenance Responsibilities



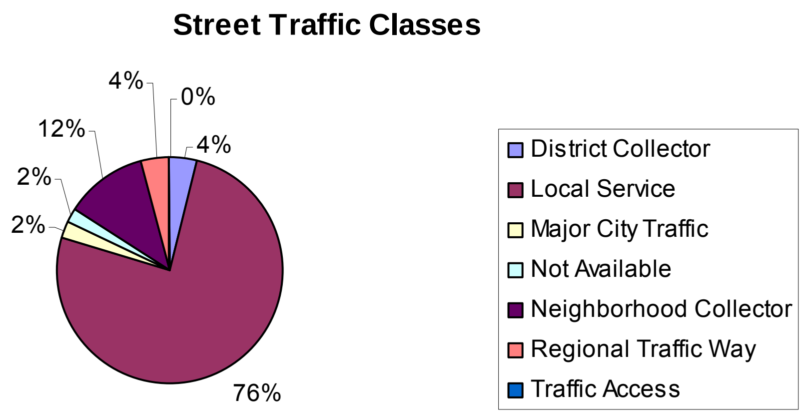
Streets can also be categorized based on traffic volumes and automobile usage. This is often useful when evaluating automobile related pollutant loadings as well as public safety considerations.

The City of Portland Comprehensive Plan describes traffic classes for City streets. The City's Transportation System Plan also designates streets according to these traffic classes. Traffic classes range from major city traffic streets (e.g. Beaverton Hillsdale Highway) to local service streets.

The street classifications for individual street segments in these watersheds are shown on *Map 4*.

Seventy-six percent of streets in the Fanno and Tryon Creek watersheds are classified as local service streets (Figure 2). These are residential streets that provide local circulation for traffic, pedestrians, and bicyclists. About 12% of streets are designated as neighborhood collector streets. These streets connect neighborhoods to nearby centers and corridors and may provide a regional traffic function. These are streets such as SW Hamilton, SW Vermont, and SW Lancaster. About 4% of streets are designated as district collectors, such as SW Boones Ferry Road, SW Multnomah Boulevard, and SW Dosch Road. These streets typically connect town centers, corridors, and neighborhoods to nearby regional centers and other destinations. The only major traffic streets in these watersheds are Beaverton Hillsdale Highway and SW Barbur Boulevard; these streets serve as primary connections to regional traffic ways and serve major activity centers. The only regional traffic way is Interstate 5.

Figure 2: Street Traffic Class Summary



Portland's Bureau of Transportation has gathered traffic data at over 240 locations on 32 streets in the Fanno and Tryon Creek watersheds. Results for a few selected streets are summarized below (Table 3). Generally, traffic volume tends to be highest on major traffic streets such as Beaverton Hillsdale Highway and Barbur Boulevard. District collectors can have daily traffic volumes near 10,000 vehicles per day. Neighborhood collector and local service streets generally have the least.

Table 3: Typical Traffic Volumes by Street Classification

Street	TSP Street Classification	Average Two-way Daily Traffic Volume	Study Year
SW Beaverton Hillsdale Highway east of 62nd Avenue	Major City Traffic	26,386	2009
SW Barbur Boulevard north of Luridly Street	Major City Traffic	16,671	2008
SW Boones Ferry Road south of Arnold Street	District Collector	9,849	2006
SW Capitol Highway north of 41st Avenue/Dolph Court	District Collector	9,285	2006
SW 45th Avenue north of Illinois Street	Neighborhood Collector	3,554	2006
SW Garden Home Road east of 56th Avenue	Neighborhood Collector	3,379	2006
SW Hamilton Street east of 45th Avenue	Neighborhood Collector	2,097	2007
SW 62nd Avenue south of Beaverton Hillsdale Highway	Local Service	1,549	2009
SW Maplewood Road east of 51st Avenue	Local Service	1,502	2007

Summary of Findings

- 72% of the streets are maintained by the City.
- City maintained streets are evenly divided between curbed (50%) and uncurbed (50%) streets.
- 26% of the streets are privately maintained.
- Privately maintained streets are divided between 37% uncurbed, 31% non-existing (platted but un-built), 26% unimproved, and 6% curbed streets.
- Streets comprise nearly half of all impervious surfaces.
- Residential development predominates with 75% of the streets classified as local service streets with similar volumes of automobile traffic.

DRAINAGE SYSTEM CHARACTERIZATION

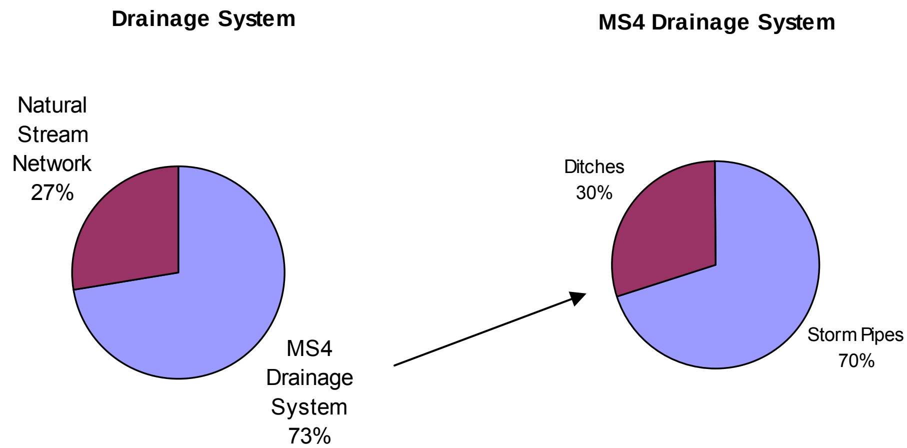
The storm drainage system in the Fanno and Tryon watersheds is a combination of interconnected natural and constructed systems with both publicly and privately owned components. The street drainage system is an integral component of the overall drainage system.

The street drainage system provides for the collection and conveyance of stormwater runoff from the impervious street surfaces along with any runoff that flows on to the street from adjacent properties. Due to topography, soil conditions, and the lack of other stormwater disposal options, stormwater runoff form private property is often directed to the street (e.g. roof runoff piped to the street through curbs where they exist). These street drainage systems may be comprised of curbside flow, storm sewer pipes, roadside ditches, piped outfalls to streams, or undefined flow discharged to land adjacent to streets. The publicly owned components of the street drainage system comprise the City's Municipal Separate Storm Sewer System (MS4). Overall, the MS4 conveyance system is comprised of 62% pipes, 30% ditches, and 8% culverts (Figure 3).

The availability of stormwater disposal options for private properties in these watersheds was evaluated based on existing street drainage systems, topography and the proximity of natural drainage systems. The results of this analysis are shown on *Map 5*. Areas shown without an identified offsite stormwater disposal option may indicate the lack of public stormwater infrastructure and the potential for localized drainage problems.

The stormwater runoff that is collected and conveyed through the MS4 is typically discharged to the natural stream system. Streets and the street drainage systems have at many locations replaced the small natural drainage channels that preceded urbanization. The street drainage system, therefore both manages the stormwater runoff generated from street areas and also serves as an intermediate link in the overall drainage system conveying runoff generated from adjacent properties back to the natural stream system. This placement of the street drainage systems in the overall storm drainage system and the loss of the small natural drainage system are clearly shown on *Map 6*. Overall, 27% of the storm drainage system in these watersheds remains part of the natural stream system with the remaining 73% replaced by the MS4 system. The MS4 system consists of 70% piped systems and 30% roadside ditches and open channels (Figure 3). This does not include the myriad of small open drainage systems lost due to development outside of the public street right of way.

Figure 3: Drainage Street Drainage Responsibilities



City code and policy governing the maintenance of street drainage systems and construction of drainage improvements closely follows the previously described City code and policy related to street improvements.

Chapter 17.42.010 Property owner Responsibilities for Streets of the Portland City Code contains policy regarding responsibility for street maintenance. The policy states:

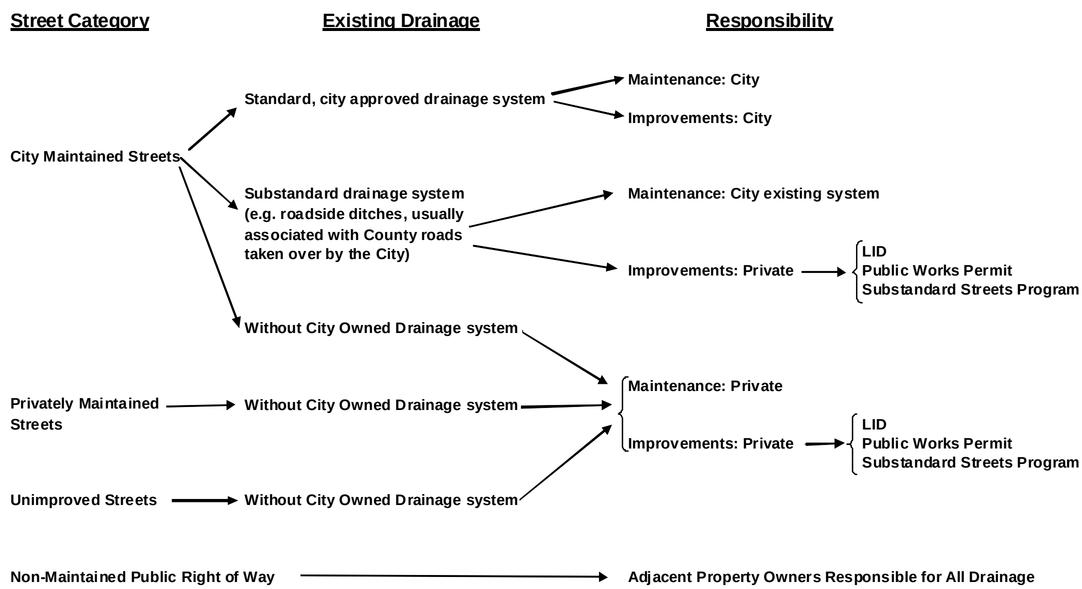
> *It has been and remains the policy of the City of Portland that streets are constructed at the expense of abutting property owners and are maintained by abutting property owners until street improvements are constructed to the standards of, and accepted for maintenance by, the City. Until a street improvement has been constructed to City standards and the City has expressly assumed responsibility for street maintenance, it is the exclusive duty of the abutting property owners to construct, reconstruct, repair and maintain the unimproved street in a condition reasonably safe for the uses that are made of the street and adjoining properties. Streets that have not been improved to City standards are not and will not be maintained or improved at City expense, except at the discretion of the City and as provided in this Code and the City Charter.*

The following is a summary of City of Portland Bureau of Environmental Services (BES) drainage practices as it relates to street drainage (Figure 4).

BES is responsible for the operation and maintenance of City owned drainage conveyance and discharge systems in City maintained streets. This includes storm pipes, crossing culverts, and ditches. The City is not responsible for upgrading substandard drainage systems (e.g. roadside ditches); local drainage improvements are the responsibility of the adjacent property owner through a City permitted process. The City is not responsible for drainage systems beyond the public right of way unless they are City owned. Stormwater runoff from the street onto private property is the responsibility of the private property owner unless the City concentrates water and disposes of it outside of a natural or historically established location (BES 2007).

Maintenance of privately owned drainage systems in both City maintained and non-City maintained streets is the responsibility of adjacent property owners. The City is not responsible for upgrading substandard drainage systems; local drainage improvements are the responsibility of the adjacent property owner through a City permitted process. BES will not make any drainage improvements except in response to an emergency public health and safety issue.

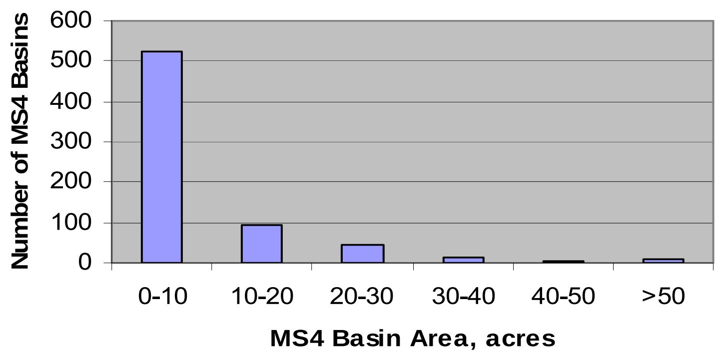
Figure 4: Street Drainage Responsibilities



MS4 Stormwater System

The City owned and maintained components of the street drainage system constitute the City's municipal separate storm sewer system (MS4) in the Fanno and Tryon watersheds. The City's MS4 stormwater system in these watersheds includes 690 individual drainage basins encompassing 5,413 acres (*Map 7*). Due to the topography and the geographic location of these watersheds at the headwaters of the natural stream systems, the individual MS4 basins are generally small in size ranging from 0.1 to 135 acres. . Seventy-five percent (524 basins) of the MS4 basins are less than 10 acres (Figure 5).

Figure 5: Size Distribution of MS4 Basins



The size and distribution of the MS4 basins across these watersheds has major implications for both the management of the MS4 system and associated impacts on the natural stream system. Since the individual MS4 basins are small, the MS4 systems are also small in scale and address localized storm drainage requirements. Therefore, storm system infrastructure requirements are generally independent of other MS4 basins. Impacts are generally related to changes to the local drainage patterns (i.e. conveyance capacity, rerouting and discharge of storm flows, erosion, etc.).

Conversely, watershed scale impacts resulting from increased runoff volumes, peak flow rates and pollutant loads from the stormwater runoff (including street drainage) discharged from the MS4 system are to the natural stream system. The natural stream system in this case serves as the major collection system for conveyance of stormwater flows, analogous to the trunk sewers in a larger completely piped system.

The infrastructure components of MS4 system in these watersheds vary widely in terms of age, materials, methods of construction and current condition. As previously described, storm drainage systems were constructed over time as needed to support development in these watersheds. Since the primary function of the systems is to manage stormwater runoff from the street right-of-way, the type and condition of stormwater infrastructure is strongly correlated with the type of street improvements present.

Curbed streets generally have more highly developed stormwater infrastructure consisting of storm inlets and pipes to collect and convey the stormwater runoff to a disposal point. However, even for this category, there can be a wide variation in storm systems present. For example, Beaverton Hillsdale Highway, classified as a major city traffic street, has curbs and frequent inlets connected by storm pipes with many outfalls to Fanno Creek (photo 1). However, some curbed local service streets such as SW Pendleton Street have minimal storm sewer systems with stormwater flows conveyed on the surface along curbs for long distances before entering an inlet usually located near an open drainageway (photo 3).

Stormwater drainage on uncurbed streets is even more varied and can include roadside ditches, storm pipes and field inlets, or undefined sheet flow. These streets include district collectors (e.g. SW Dosch Road. Photo 5), neighborhood collectors (e.g. SW Vermont Street, photo 2), and many of the local service streets (e.g. SW 17$^{th\ Avenue}$, photo 4). Drainage infrastructure in unimproved streets is minimal to non-existent (e.g. SW Orchid Street, photo 6; SW 19th Avenue, photo 7).

PHOTOS

Photo 1: 3541 SW Beaverton Hillsdale Highway
looking west
(Curbed, Inlets, Storm Pipes)


Photo 2: 4820 SW Vermont Street
looking west
(Uncurbed, Sheetflow)


Photo 3: SW Pendleton at SW 46th Avenue
looking west
(Curbed, Surface Flow, Infrequent Inlets, Storm Pipes)

Photo 4: SW 17th Avenue at SW Orchid
looking north
(Uncurbed, Ditches, Inlets, Berms, Sheetflow)

Photo 5: 4828 SW Dosch looking south
(Uncurbed, Field Inlets, Ditches, Sheetflow, Storm Pipes)

Photo 6: SW Orchid and SW 17^{th} looking west
(Unimproved, Ditches, Sheetflow)

Photo 7: SW 19^{th} Avenue at SW Orchid St looking north
(Unimproved, sheetflow)

Photo 8: SW Vermont St at SW 45^{th} Ave. Looking east
(Curbed, inlets, pipes)

Information on the MS4 system is maintained by BES through its Hansen database system. Information included in the database includes location, physical attributes and condition of system components. The database is currently incomplete for many components of the storm systems in the Fanno and Tryon watersheds. Through the BES Stormwater System Planning effort, the physical attributes (location, size, material type, etc .) of the stormwater system have been collected and updated for many areas in the Fanno and Tryon watersheds, however, condition assessments and capacity analyses are generally missing.

The maintenance of the MS4 system, as previously described, is the responsibility of BES and is performed by the Bureau of Maintenance through an interbureau agreement. The Hansen database is also used to log the maintenance activities. These maintenance activities have historically been complaint or problem-driven. Since condition assessments are generally unavailable from the Hansen database, the database was queried for street-related drainage activities in the Fanno and Tryon watersheds as a method to evaluate overall system conditions.

Drainage complaints within one hundred feet of streets were grouped based on street type and problem type (Table 4). The majority of problems on curbed and surfaced streets were related to catch basins. A cursory review of the call records indicate that most of these are related to clogged catch basins and inlets. Many of the flooding calls also were related to catch basin problems. Storm system capacity is generally not a problem for curbed streets in these watersheds.

Problems with catch basins (such as clogging) on uncurbed surfaced streets were also numerous, however, overall problems on uncurbed streets were more diverse reflecting the more diverse drainage system components on these streets. Over half of the total calls were related to culverts, ditches, general drainage problems, and flooding.

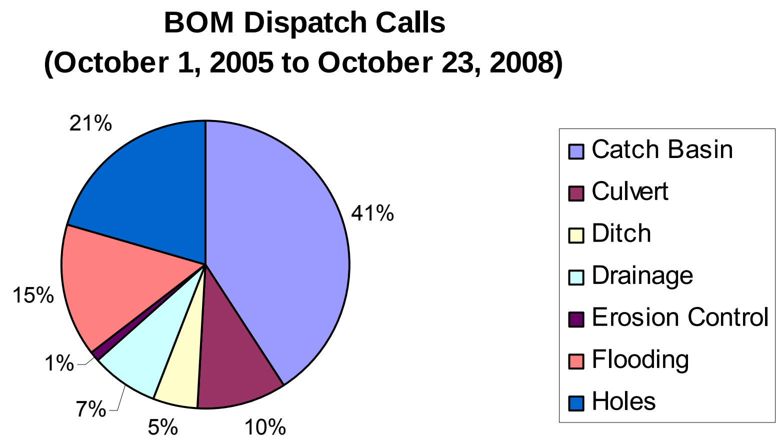
Few calls were received in the selected time period on unimproved streets. This does not necessarily mean that few drainage problems exist on these streets. More likely, since these streets are privately maintained, the City has not received many drainage related calls or did not address them.

Table 4: Street Drainage System Maintenance Calls

Maintenace Bureau Calls in the Fanno and Tryon Watersheds								
	Calls Received by BOM Dispatch Center Sorted by Problem Code							
Within 100 feet of	**Catch Basin**	**Culvert**	**Ditch**	**Drainage**	**Erosion Control**	**Flooding**	**Holes**	**Total**
Curbed Streets	126	8	1	6	0	27	56	224
Uncurbed Streets	88	40	24	31	6	48	49	286
Unimproved Streets	6	6	1	3	0	6	6	28
Total Calls	214	48	25	37	6	75	105	510

A summary of all the Bureau of Maintenance street drainage related calls is shown in Figure 6. Overall reported drainage problems were mostly in four categories: catch basins (41%), Holes (21%), Flooding (15%) and Erosion Control (10%). These results reflect both the nature of the complaint/problem driven maintenance program as well as the predominance of small individual MS4 drainage basins as previously described which tend to focus drainage issues at the local scale.

Figure 6: Summary of Drainage Problem Calls Problem Code



Natural Stream System

The natural stream system serves as the main collection and conveyance system for stormwater runoff discharged from the MS4 system. The natural stream system in the Fanno and Tryon watersheds includes 46 miles of open channels, compared to 140 miles of MS4 drainage system.

The stream system exhibits the effects of the modified hydrologic and hydraulic conditions that have resulted from urbanization and development including infrastructure placement (culverts), increased flows, frequent downcutting of the streambed, erosion and unstable streambanks.

Flooding damage to private property and structures in the Fanno and Tryon watersheds is not common. Due to the topography in these watersheds and the location of the streams in confined channels, there is little existing development within the 100 year flood plain (*Map 8*). The only major exception to this is along the mainstem of Fanno Creek from approximately SW 59th Avenue west to the City limits where existing multifamily residential and commercial developments have encroached within the 100 year flood plain. There is also frequent flooding immediately downstream on Fanno Creek from this location outside the City limits.

Summary of Findings

- Drainage System Responsibilities
  - The City is responsible for operations/maintenance of approved storm drainage systems City maintained streets.
  - Improvements to the City owned storm drainage system are typically problem driven.
  - The City is not responsible for the upgrade of non-standard City maintained storm drainage systems. Upgrades are the responsibility of adjacent property owners.
  - Maintenance and improvements to unimproved streets including drainage are the responsibility of adjacent property owners.

- Street Drainage System
  - The overall drainage system is comprised of the publicly owned and maintained MS4 storm sewer system (73%) and the remaining natural stream network (27%).
  - The MS4 system is comprised of 690 individual basins; 75% of the basins are less than 10 acres.
  - Absent or substandard storm sewer systems result in drainage issues which are most prevalent on uncurbed and unimproved streets.
  - Street drainage infrastructure and conveyance problems are typically local and watershed health impacts (e.g. increased flows, pollutant loadings) are more prevalent on a watershed scale.
  - The MS4 system and urban development have replaced many of the small headwater streams and natural drainage courses.
  - Typical street drainage systems include:
    - Curbed streets with developed storm sewer systems.
    - Uncurbed street with varying levels of developed storm sewer systems which may include pipes, roadside ditches, or undefined sheet flow.
    - Unimproved streets which typically have no defined storm sewer system.

WATERSHED IMPACTS OF STORMWATER RUNOFF

Impervious Area and Hydromodification

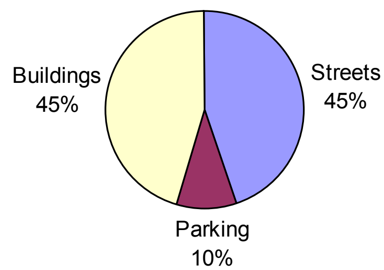
The construction of the urban stormwater system typically results in the loss of small headwater streams that provided natural flood control and groundwater recharge (Moyers et al. 2003). Urban stormwater drainage systems invariably increase the drainage density of sub catchments and reduce the time necessary for overland flow to reach streams, resulting in faster runoff, higher stream velocities and higher and "flashier" flood flows (Hollis 1975).

Research on urban streams has shown that significant impairment of stream ecosystems (including hydrologic factors) begins when total impervious area in a watershed reaches a threshold of approximately 10 percent. Booth (1991) found that impervious cover greater than 10 percent reduces urban stream stability, resulting in unstable and eroding stream channels. These changes can degrade in-stream habitat and affect fish communities. A second threshold appears at about 25-30 percent total impervious area, when most indicators of stream health shift to a poor condition (Schueler 1994; SMRC 2004).

The streams in the Fanno and Tryon watersheds exhibit many of the above effects of development and urbanization. As previously described, construction of storm drainage systems primarily managing street runoff has resulted in the loss of small natural drainage systems and has also resulted in changes to the natural hydrology of the streams. Impervious surfaces cover about 25 percent of the Fanno and Tryon Creek watersheds exceeding the thresholds for significant stream impairment (*Map 9*). In these watersheds, about 45% of the total impervious area is street surfaces (Figure7). These street surfaces are directly connected in most cases to the street drainage system and since infiltration in ditches is minimal, they are nearly 100% effective impervious area.

Figure 7

Impervious Area Compostion
Fanno & Tryon Watersheds



Stream flow monitoring results indicate that winter peak flows can be 30 to 40 times greater than winter base flows (BES 2005). It is estimated that the peak flows are twice pre-development peak flows (MGS 2001). Most streams also exhibit physical characteristics resulting from urbanization and altered hydrology and hydraulics: channels are rectangular and incised in many areas, lack of channel complexity, deposition of fine sediment covering critical gravel and filling deep pools, and stream bank erosion and instability beyond natural ranges (BES 2005). These conditions degrade the biological productivity of streams.

Stormwater Pollutants

Typical Urban Pollutants
The EPA's Preliminary *Data Summary of Urban Stormwater Best Management Practices (BMPs): 4.0* contains typical pollutant loadings from runoff by urban land use (Tables 5 and 6); Table 2 lists typical loadings for medium density residential (MDR) and low density residential (LDR) areas while Table 3 summarizes water quality parameters typical of urban residential runoff.

Table 5 Typical Pollutant Loadings from Runoff by Urban Land Use (lbs/acre-yr)

Land Use	TSS	TP	TKN	NH_3-N	NO_2+NO_3-N	BOD	COD	Pb	Zn	Cu
MDR	190	0.5	2.5	0.5	1.4	13	72	0.2	0.2	0.14
LDR	10	0.04	0.03	0.02	0.1	NA	NA	0.01	0.04	0.01

Table 6 Water Quality Parameters in Urban Residential Runoff (mg/L)

Constituent	COD	TSS	TP	TN	Pb	Cu	Zn	Fecal Coliform
Range	200-275	20-2,890	0.02-4.30	0.4-20.0	0.01-1.20	0.01-0.40	0.01-2.90	400-50,000
Typical	75	150	0.36	2	0.18	0.05	0.02	

Street Stormwater Runoff Water Quality Monitoring

The City of Portland's Bureau of Environmental Services (BES) has sampled and analyzed stormwater runoff from some City streets for the past 5 years as required by the Water Pollution Control Facilities (WPCF) permit issued to the City in June 2005 by the Oregon Department of Environmental Quality (DEQ). The City is required to monitor stormwater entering City-owned underground injection control (UIC) systems throughout the life of the Water Pollution Control Facilities (WPCF) permit and to submit this annual monitoring report. Although this sampling was done outside of the Fanno and Tryon watersheds, the land uses, street traffic classes and climatic factors are the same, therefore the pollutant loading rates should be similar.

Stormwater quality results are classified into two classes: streets with less than 1,000 vehicle trips per day (TPD) and streets with more than 1,000 TPD. Streets with less than 1,000 TPD are primarily located in residential areas. Streets with more than 1,000 TPD are generally commercial, industrial, or transportation corridors that include residential feeder streets. Key findings from monitoring conducted from October 2009 to September 2010 are as follows:

- Pollutants that were detected at the highest frequencies (>50 percent) during the individual sampling events are PAHs: chrysene, phenanthrene, napthalene, pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, and fluoranthene. The detection of PAH compounds was an expected result because of the presence of numerous sources in an urban environment. PAH sources include, but are not limited to, fresh and used petroleum products (e.g., gasoline, diesel, motor oil, used oil), petroleum and coal combustion, motor vehicle exhaust, tire wear, wood ash, asphalt, insecticides, wood preservatives, used cigarette filters, and air deposition. PAHs tend to adhere to sediment particles rather than dissolve in water.
- Dissolved copper, lead, mercury, and zinc were detected in most samples. The ratios of dissolved to total metal concentrations for streets with more than 1,000 TPD traffic category ranged from 5 percent (lead) to 39 percent (zinc) and from 9 percent (lead) to 51 percent (copper and zinc) for streets with less than 1,000 TPD. For individual metals, the ratio of dissolved to total metal concentrations is generally lower for the high traffic category.
- TSS concentrations ranged from 2 milligrams per liter (mg/L) (both < and ≥1,000 TPD) to a maximum concentration of 484 (≥1,000 TPD) mg/L. The mean TSS concentration for UICs with less than 1,000 TPD was 21 mg/L, and the mean concentration for UICs with greater than 1,000 TPD was 51 mg/L.

In general, over the past 5 years of monitoring streets with more than 1,000 vehicle TPD have higher geometric mean and median concentrations than streets with less than 1,000 TPD for the compounds evaluated (COP BES, 2010).

Copper Loadings and Impacts

Copper is a common pollutant in urban stormwater runoff. A significant source is the abrasion of automobile brake pads (Malmqvist 1983; Hewitt and Rashed 1990). City of Portland BES monitoring indicates that on streets with less than 1,000 trips per day (TPDP, dissolved copper averaged 3.01 ug/L and total copper averaged 5.87 ug/L; on streets with more than 1,000 TPD, dissolved copper averaged 4.06 ug/L and total copper averaged 12.13 ug/L (BES 2010).

Copper is a neurobehavioral toxicant in fish that disrupts the fish olfactory system (Hara et. al. 1976). Chemosensory deprivation has important implications for salmon, as these migratory animals rely on their sense of smell to find food, avoid predators, form social dominance hierarchies, navigate from the ocean to freshwater spawning habitats, and assess the reproductive status of prospective mates (Sandahl et. al 2007).

Hansen et al (1999) found that the number of olfactory receptors was significantly reduced in Chinook salmon exposed to copper concentrations of 50 ug Cu/L or greater and rainbow trout exposed to 200 ug Cu/L or more. The number of receptors was significantly reduced in both species following exposure to 25 μg Cu/L for 4 h. Olfactory bulb electroencephalogram (EEG) responses to 10(-3) M L-serine were initially reduced by all Cu concentrations but were virtually eliminated in Chinook salmon exposed to greater than or equal to 50 μg Cu/L and in rainbow trout exposed to greater than or equal to 200 μg Cu/L within 1 h of exposure.

Baldwin et. al (2003) evaluated the sublethal effects of copper on the sensory physiology of juvenile coho salmon. Measuring the impacts of copper on the responses of olfactory receptor neurons to natural odorants (L-serine and taurocholic acid) and an odorant mixture (L-arginine, L-aspartic acid, L-leucine, and L-serine). Increases in copper impaired the neurophysiological response to all odorants within 10 min of exposure. The inhibitory effects of copper (1.0–20.0 mg/L) were dose dependent and they were not influenced by water hardness. Toxicity thresholds for the different receptor pathways were determined by using the benchmark dose method and found to be similar (a 2.3–3.0 mg/L increase in total dissolved copper over background). Short-term influxes of copper to surface waters may interfere with olfactory-mediated behaviors that are critical for the survival and migratory success of wild salmonids.

Sandahl et. al (2007) used neurophysiological recordings to investigate the impact of copper exposures (0-20 μg/L for 3 h) on the olfactory system of juvenile coho salmon (O. kisutch). These recordings were combined with computer-assisted video analyses of behavior to evaluate the sensitivity and responsiveness of copper-exposed coho to a chemical predation cue (conspecific alarm pheromone). The sensory physiology and predator avoidance behaviors of juvenile coho were both significantly impaired by copper at concentrations as low as 2 μg/L. Therefore, copper-containing stormwater runoff from urban landscapes has the potential to cause chemosensory deprivation and increased predation mortality in exposed salmon.

Macroinvertebrate Monitoring

BES has been monitoring macroinvertebrates in the Fanno and Tryon watershed since 2006. Macroinvertebrates monitoring is often utilized as a method to evaluate stream health because they are sensitive to a wide range of pollutants and other stressors and can serve as an integrating measure for many of these. Results of the monitoring to date indicate that macroinvertebrate communities in Fanno and Tryon creeks are highly degraded and dominated by urban-tolerant species. While all the locations sampled were highly degraded, there were important differences among the subwatershed habitats and communities. The differences among subwatersheds were correlated with patterns of land use. Subwatersheds with higher percentages of impervious surfaces, piped streams and roads had more degraded communities, with piped streams and roads having the strongest relationship with community health (*Macroinvertebrate Community Composition in Fanno and Tryon Creeks: 2006-2008).*.

The water quality in Fanno Creek is currently impaired and DEQ has established Total Maximum Daily Loads (TMDL) under the federal Clean Water Act for total phosphorus, temperature, bacteria and dissolved oxygen. Tryon Creek also has established TMDLs for bacteria and temperature.

Fine Sediment Impacts

Excessive fine sediment deposition has degraded aquatic habitat in Tryon Creek. About 85 percent of riffle habitat downstream of Boones Ferry Road is marginal or undesirable due to the high composition of fine sediment (BES 2005).

Fine sediments limit biological productivity. Cobbles and gravels covered with fine sediment have reduced interstitial spaces that are used by aquatic invertebrates, the primary food organism for native fish. Sediment deposition can smother salmon redds and reduce embryo survival by limiting gravel permeability and restricting the flow of water and oxygen to developing embryos. Many studies conclude that sedimentation in redds is one of the most important factors that limit natural salmonid reproduction. Even if eggs survive to emergency, entrapment of fry in redds due to deposition is common. High suspended sediment concentrations can clog fish gills and a thickening of the gill epithelium, affecting a fish's ability to absorb oxygen (Bell 1973). Suspended sediment can affect a fishes' visual capability, leading to reduced feeding and depressed growth rate. Suspended sediment can decrease tolerance to disease and toxicants (Redding et al 1987; Goldes et al 1988) and may induce physiological stress, affecting the ability of fish to perform vital functions (Servizi and Martens 1992).

To further assess potential sources of fine sediment in stormwater runoff from streets in the Fanno and Tryon watersheds, stormwater runoff samples were collected over three days in December 2010 and January 2011 and analyzed for turbidity. Six samples were taken at curbed streets, 8 samples at uncurbed streets, and 7 at unimproved streets. Turbidity was chosen a parameter for analysis because it could be easily measured in the field and could serve as an initial screening measured for fine sediment loadings.

The results are summarized in Figure 8 below. The median turbidity is indicated by the red triangle. Turbidity results are lowest and least variable for curbed streets, with a mean value of 10 NTUs. Uncurbed and unimproved streets results are both highly variable; however, median turbidity for unimproved streets is 180 NTUs, much higher than the median of 28 NTUs for uncurbed streets. The two highest samples gathered for uncurbed streets were gathered in catchments that received a small portion of stormwater from unimproved streets; during sampling at these sites, turbid water could be seen flowing from the unimproved streets.

Substantial research has been done to correlate turbidity to TSS concentration (Gippel, 1995; Sidle and Campbell, 1985). Typically this requires concurrently measuring turbidity and TSS to develop a calibration curve. To estimate TSS concentrations from the turbidity sampling, TSS and turbidity measurements from various Portland area streams collected as part of the BES Portland Area Watershed Monitoring and Assessment Program (PAWMAP) were correlated. The results (Figure 9) show that TSS and turbidity were positively correlated.

Figure 8

Stormwater Turbidity Values for Curbed, Uncurbed and Unimproved Streets in the Fanno/Tryon Watershed

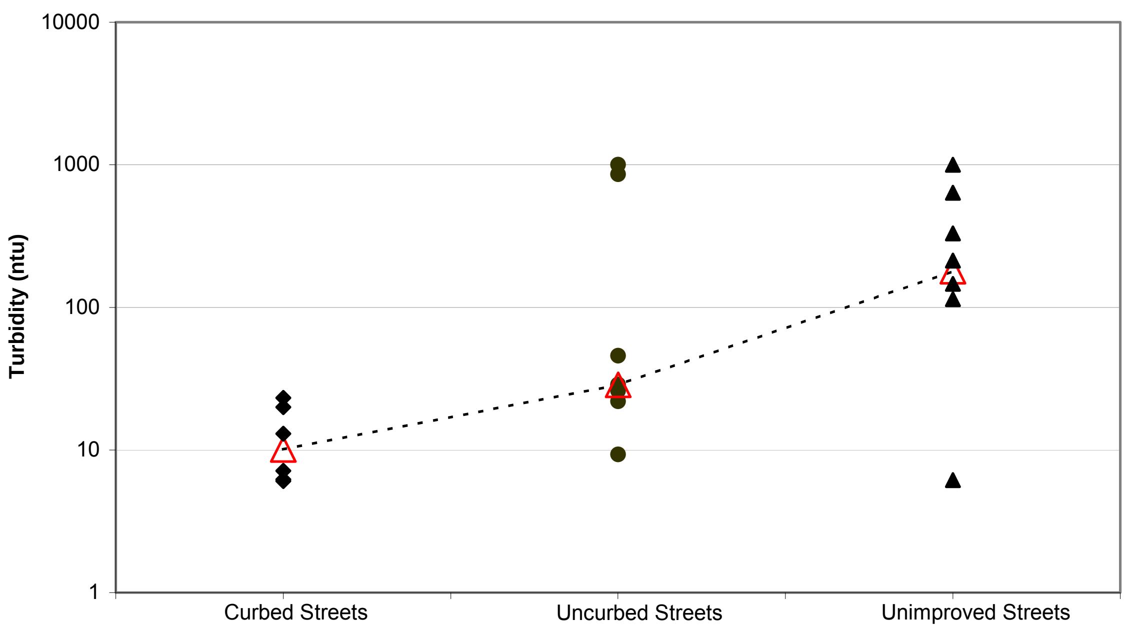
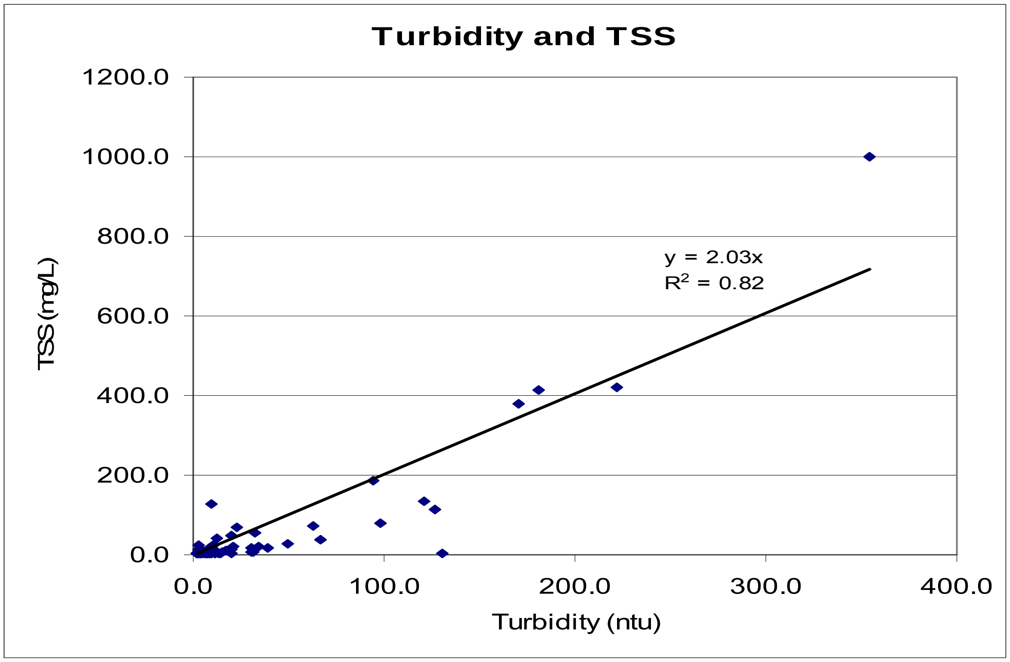


Figure 9



Based on the median values of turbidity from the street drainage sampling and the PAWMAP data correlations, the corresponding estimated TSS concentrations are 20 mg/l for curbed streets, 56 mg/l for uncurbed streets, and 360 mg/l for unimproved streets. When these estimated TSS concentrations are correlated with the percentage of the respective street types in these watersheds, the results suggest that stormwater runoff from unimproved streets (7-9 % of streets) may contribute significantly more fine sediment (40-46 % TSS loading) to streams than other street types (Table 7).

Table 7 Estimated TSS Loadings by Street Type

	Fanno Creek		Tryon Creek	
Street Type	**Streets (%)**	**Estimated TSS Loading (%)**	**Streets (%)**	**Estimated TSS Loading (%)**
Curbed	42	13	42	12
Uncurbed	51	46	49	41
Unimproved	7	40	9	46

These results are significant since under current City code and policy, drainage from unimproved streets is not managed by the City. However, based on the previously described effects of fine sediment on habitat in Tryon Creek, any strategy to improve biological productivity and salmon abundance and productivity in Tryon Creek should include actions to reduce the influx of fine sediment.

Summary of Findings

- Impervious surfaces (e.g. street pavement), the loss of headwater streams, and the construction of piped storm systems which concentrate the runoff and convey it directly to the natural stream system results in hydromodification or changes to the natural stream hydrology. This includes increased peak flow rates and runoff volumes
- Pollutants in stormwater runoff from street surfaces are conveyed to the natural stream system where they negatively affect water quality. The source of many of these pollutants are automobile related (metals, petroleum products, etc.) Curbed streets provide control of the stormwater runoff and the MS4 system conveys it to the stream, therefore, these tend to have a direct impact on the stream.
- Macroinvertebrate communities are highly degraded in these watersheds. Analysis indicates that impervious area, piped streams, and roads are negatively correlated to macroinvertebrate community health.
- Erosion from unimproved street surfaces can result in the delivery of fine sediments to the natural stream system affecting stream morphology and biological habitats in the streams. In Tryon Creek, preliminary analysis suggests that unimproved streets, comprising less than 10% of streets, generates nearly half of the total suspended solids (TSS) in stormwater runoff from streets.
- Federally listed steelhead and Lower Columbia River coho are present in Tryon Creek. Ecosystem Diagnosis and Treatment (EDT) model results indicate that fine sediment loading and changes to the hydrologic regime are limiting factors. Both of these measures are impacted by discharges from street drainage.

REGULATORY REQUIREMENTS

The federal Clean Water Act, Safe Drinking Water Act, and Endangered Species Act require the City to manage stormwater runoff to protect water quality in rivers and streams, protect watershed health, and protect groundwater as a drinking water resource.

The City's Federal stormwater permit requires Portland to reduce stormwater pollution, and manage other programs that respond to water quality requirements. Environmental Services coordinates the City's response to the federal permit.

NPDES Stormwater Permit
The City of Portland, Port of Portland, and Multnomah County all operate storm sewer systems within Portland's urban services boundary. The City of Portland and the Port of Portland hold a joint stormwater permit and Multnomah County has an individual permit issued by the Oregon Department of Environmental Quality (DEQ) in accordance with Federal Clean Water Act regulations. It is referred to as the MS4 discharge permit.

The stormwater permit requires each co-permittee to develop a Stormwater Management Plan (SWMP) that describes measures the co-permittee will implement throughout the permit term to control pollutant discharges from municipal separate storm sewer system

(MS4); The SWMP does not directly address storm system capacity, extent, and routing. The MS4 includes the publicly owned components of the street drainage system. The SWMP does not apply to natural stream systems, direct stormwater discharges from private property to natural stream systems (without entering MS4), and areas with no public stormwater infrastructure (e.g. unimproved streets).

The SWMP describes the measures the City will implement to reduce the discharge of pollutants in stormwater to the "maximum extent practicable," protect water quality and satisfy the applicable requirements of the Clean Water Act. The SWMP includes the following main components:

- Best management practices (BMPs), including monitoring
- Performance measures
- Benchmarks

Best Management Practices that specifically apply to street drainage include the following:

Operation and Maintenance (OM)

- OM-1: Operate and maintain components of the municipal separate storm sewer system (MS4) to remove and prevent pollutants in discharges from the MS4.
- OM-2: Operate and maintain components of public rights-of-way, including streets, to remove and prevent pollutants in discharges from the municipal separate storm sewer system.

New Development (ND)

- ND-2: Implement and refine stormwater management requirements for all new development and redevelopment projects to minimize pollutant discharges and erosive stormwater flows. (i.e. Stormwater Management Manual)

Structural Controls (STR)

- STR-1: Structurally modify components of the storm drainage system to reduce pollutant discharges. Implement structural improvements on existing development to reduce pollutants in discharges from the municipal separate storm sewer system.

  STR-1 Addresses structural modifications/improvements to:
  - Storm sewer system components such as pipes, inlets, ditches, and pollution reduction facilities (PRFs)
  - Existing rights-of-way and roads

  This BMP includes City strategies for retrofits of the existing storm drainage system to enhance stormwater management (e.g. roadside ditch drainage improvements, enhanced detention capacity, and the addition of water quality management to flow control facilities), development of the Storm System Plan, and implementation of the Portland Watershed Management Plan.

This includes continuing and expanding the use of Green Street approaches to reduce pollutants and flow volume from rights-of-way.

(*Reference: MS4 Stormwater Management Plan*)

Total Maximum Daily Loads (TMDLs)
Fanno Creek and its tributaries have established TMDLs for temperature, bacteria, dissolved oxygen and total phosphorus. TMDL Waste Load Allocations (WLA) for bacteria dissolved oxygen and total phosphorus apply to discharges from the MS4 system.

Tryon Creek has established TMDLs for temperature and bacteria. The TMDL Waste Load (WLA) allocation for bacteria would apply to discharges from the MS4 system.

For both watersheds, the respective temperature TMDL load allocations are based on "effective shade" for streams and the TMDL does not contain a WLA for MS4 stormwater discharges.

Compliance with the MS4 permit including implementation of the SWMP fulfills requirements of the TMDL waste load allocations.

Endangered Species Act
Federally listed steelhead and Lower Columbia River coho are present in Tryon Creek. Non-listed native species include cutthroat trout, rainbow trout, sculpin sp. and dace sp.

The status of coho, steelhead / rainbow and cutthroat populations in the Tryon Creek watershed were evaluated as part of the Fanno Tryon Watershed Plan. In addition, steelhead and coho were further evaluated using the Ecosystem Diagnosis and Treatment (EDT) model. Model results indicated that fine sediment loadings and changes to the hydrologic regime were limiting factors. Both of these measures are impacted by discharges from street drainage.

Summary of Findings

- The street drainage system is the major component of the City's MS4 system which is regulated the state MS4 discharge permit.
- The MS4 discharge permit requires the City to have an approved Stormwater Management Plan (SWMP). The SWMP plan describes measures the City will implement to reduce the discharge of pollutants in stormwater to the "maximum extent practicable" and to protect water quality and watershed health.
- Fanno Creek and its tributaries have established TMDLs for temperature, bacteria, dissolved oxygen and total phosphorus. Waste Load allocations for

bacteria dissolved oxygen and total phosphorus apply to discharges from the MS4 system.
- Tryon Creek has established TMDLs for temperature and bacteria. Waste Load allocations for bacteria would apply to discharges from the MS4 system.
- Compliance with the NPDES permit fulfills requirements of the TMDL waste load allocations.
- Federally listed steelhead and Lower Columbia River coho salmon are present in Tryon Creek.

SUMMARY OF STREET DRAINAGE ISSUES

Based on the above analysis and BES experience in managing stormwater in these watersheds, street drainage issues can be put into two general categories: local drainage issues (street drainage system) and watershed health impacts (flow, pollutants, fine sediment). Further, the street improvement category of a street often determines the relative impact of that street on these drainage issues (Table 8).

Table 8

Street Category	Primary Drainage				Street Suface			Drainage Issues			
	Inlets	Pipes	Ditches	Undefined	Asphalt	Gravel	Bare Soil	Local	Watershed		
								Drainage	Flow	Pollutants	Sediment
Curbed	X	X			X				X	X	
Uncurbed	x	x	X	X	X			x	x	x	x
Unimproved			x	X		x	X	X			X
Non-Existing				X			X				

These street drainage issues are summarized below:

- Local Drainage Issues – A primary function of the street drainage system is to collect and convey stormwater runoff from the street right of way and adjacent properties to an adequate disposal point in order to protect property and public safety. Where the existing storm system infrastructure is inadequate or not present, this function is generally not met. Given the distribution of the MS4 system in these watersheds (i.e. many small drainage basins) these drainage issues tend to be localized. They are most prevalent on uncurbed and unimproved streets which often lack adequate stormwater systems.

- Watershed Health Impacts

    - Flow (Hydromodification) – An increase in the impervious area (e.g. street pavement) and the construction of piped storm systems which concentrate the runoff and convey it directly to the natural stream system results in hydromodification or changes to the natural stream hydrology. This includes increased peak flow rates and runoff volumes. Curbed streets which are completely paved with piped storm drainage systems discharging directly to streams have the greatest effect. Uncurbed streets have varying levels of effects depending on the extent of impervious area and any associated drainage system present.

- Pollutants – Pollutants in stormwater runoff from street surfaces are conveyed to the natural stream system where they negatively affect water quality. The source of many of these pollutants are automobile related (metals, petroleum products, etc.). Pollutant loadings generally increase with increasing vehicular traffic. Curbed streets provide control of the stormwater runoff and the MS4 system conveys it to the stream, therefore, these tend to have a direct impact on the stream. Uncurbed streets and unimproved streets have varying direct impacts depending on traffic volumes and the routing of the runoff to the stream system.

- Fine Sediment – Erosion from unimproved street surfaces can result in the delivery of fine sediments to the natural stream system affecting stream morphology and biological habitats in the streams.

Since the impacts vary by street category, street drainage improvements must be evaluated by street category and drainage issue being addressed.

DESIGN CRITERIA

Storm drainage facilities must be designed to meet requirements for both conveyance (capacity) and stormwater management (flow control and pollution reduction). These requirements are summarized below:

Conveyance

The Sewer and Drainage Facilities Design Manual (SDM) (BES, 2007) is the primary reference for designing public sewers. This includes the design of pipes, drainage channels, and other public facilities that convey and dispose of stormwater. The following is a summary of SDM requirements and design criteria that relate to street drainage.

BES has established the following design standards for drainage facilities:

- Design all storm drainage facilities to pass up to the 10-year storm (Except Columbia South Shore Plan District requires use of a 25-year storm) without surcharge and provide a means to pass a 25-year storm without damage to property, endangering human life or public health, or significant environmental impact.
- Runoff from a 25-year storm may surcharge a separated stormwater system but the hydraulic grade line (HGL) must remain a minimum of 6-inches below the lowest critical elevation identified within the system. The critical elevation may be the ground surface or a property where potential flooding could occur, whichever is lower.

Stormwater Management Facilities

The Stormwater Management Manual (SWMM) (BES, 2008) is the primary reference for designing public and private stormwater management facilities. All development or redevelopment consisting of 500 square feet of impervious area or more must comply with the requirements of the SWMM. The SWMM requires stormwater management facilities that detain and treat stormwater runoff from new or redeveloped impervious surfaces. If complete on-site infiltration is not possible, an acceptable discharge point must be identified. The following is a summary of SWMM requirements and facility design criteria that relate to street drainage.

Infiltration and Disposal

The SWMM describes a hierarchy of 4 options for stormwater infiltration and discharge. The highest technically feasible option must be used (1=highest, 4=lowest). The four options are as follows:

1. Total onsite infiltration with vegetated facilities;
2. Total onsite infiltration with vegetated facilities that overflow to subsurface infiltration facilities;
3. Onsite detention with vegetated facilities (lined or unlined) that overflow to a drainageway, river, or storm only pipe; and
4. Onsite detention with vegetated facilities that overflow to combined system. Surface infiltration facilities must be able to infiltrate the 10-year, 24-hour storm.

Option 3 is typically the only feasible option for sites in the Fanno and Tryon watersheds because infiltration capacity is limited. The Cascade silt loam soils that predominate, have a surface layer and subsoil of silt loam and a substratum of silt loam fragipan that restricts water flow. Steep slopes and slope hazard zones also limit areas where infiltration is allowed. Option 4 does not apply in these watersheds since they are not located in the combined sewer system.

Option 3 also requires an approved off-site disposal point. Off-site discharge to a ditch, drainageway, stream or piped storm system will be approved only if the receiving conveyance has the capacity to convey flows from all contributing upstream drainage areas and meets the BES design standards for conveyance facilities. If these standards aren't met, improvements to the receiving drainage conveyance are required.

Flow Control and Pollution Reduction Requirements
The SWMM also establishes design requirements for both flow control and pollution reduction as described below:

- Flow Control

  The SWMM requires, at a minimum (base), that stormwater management facilities detain and release stormwater at a post development peak flow rate that must be reduced to the pre-development levels for the 2-year, 5-year, and 10-year, 24-hour storm events. Two-year post-development discharge to a **stream** must be reduced to one-half of the 2-year pre-development peak rate. Post-development flow from the 5, 10, and 25-year, 24-hour peak flows must be reduced to the pre-development flow levels.

- Pollution Reduction

  The SWMM requires that stormwater management facilities remove 70 of total suspended solids (TSS) from 90 percent of the average annual runoff. In watersheds that have established total maximum daily loads (TMDLs) or that are on the Oregon Department of Environmental Quality (DEQ's) 303(d) list of impaired waters, stormwater management facilities must be capable of reducing the pollutant(s) of concern, as approved by BES. Vegetated stormwater management facilities typically meet these requirements.

Facility Sizing
Three methodologies are available to size stormwater management facilities: the **Simplified Approach**, the **Presumptive Approach,** and the **Performance Approach**.

The **Simplified Approach** is appropriate for projects with less than 10,000 square feet (.23 acre) total new or redeveloped impervious area. It is not allowed for use on large, complex projects or on projects that have multiple catchments that, when combined, exceed 10,000 square feet of new or redeveloped impervious area. It is not allowed on projects that require a public works permit or include private street improvements.

The **Presumptive Approach** is available for projects with new or redeveloped impervious area of 10,000 square feet (0.23 acre) or greater or projects with proposed street improvements. Slightly modified requirements apply to streets. It can also be applied to size facilities where the more detailed hydrologic calculations will allow the applicant to size a facility more accurately by taking measured infiltration rates and other more specific design factors into account.

The **Performance Approach** is available for projects with unique circumstances that require analysis that goes beyond the capabilities or specifications of the Simplified and Presumptive approaches.

Stormwater Facility Design Criteria
The SWMM also establishes design criteria for different types of stormwater facilities. The facilities below are typical for street drainage management. Design elements related to street drainage are summarized for each facility type below:

Pervious Pavement
Pervious pavement may be pervious concrete/asphalt or permeable pavers which are discrete units set in place. These are only approved on private streets and public roadways on a case-by-case basis. If slope is greater than 5 percent, the design must be engineered to address under-pavement water retention.

- If sub-surface infiltration is less than 2 inches/hour, the pavement section must sheet-flow to an adequately sized filter strip (500 square foot limit for pavement). If an underdrain is proposed for collection, the conveyance must lead to a vegetated facility sized to treat the entire pervious paved area.
- The pavement section must be designed to directly infiltrate all stormwater from the pavement surface into a crushed rock storage layer, which must contain enough void space to store the 10-year, 24-hour storm less the designed infiltration and infiltrate it into the subgrade in less than 30 hours.

Swale (and swale curb extensions)
Swales are typically long, narrow, gently sloping landscaped depressions that collect and convey stormwater runoff. Swales may be sized and designed for conveyance or to provide treatment and flow control.

A curb typically surrounds the swale facility. Check dams are used to slow flow through the facility. Swales are suited to curbed streets, where stormwater runoff is controlled and can be directed into the swale.

- Soils: If infiltration is less than 2 inches per hour, the swale should be designed as partial infiltration or flow-through facility with an overflow to an approved discharge point.
- Setbacks: A 5 foot setback from property lines and 10 foot setback from building foundations is required. If an adjacent basement is present, additional setback distance may be necessary. Infiltration facilities must be located a minimum of 100 feet from slopes of 10 percent; add 5 feet of setback for each additional percent of slope up to 30 percent. Infiltration basins shall not be used where slopes exceed 30 percent. No set back requirements for lined flow-through swales.
- Minimum facility width is 8 feet on streets. A 2-foot wide flat bottom width is required where feasible.
- Maximum side slopes are 3 horizontal to 1 vertical; 4 horizontal to 1 vertical is required immediately adjacent to pedestrian areas. A 1 foot wide flat area and 3:1 side slope may be allowed adjacent to pedestrian areas in some circumstances.
- Maximum longitudinal slope of the swale bottom is 6 percent. The facility should be terraced on slopes to maximize effectiveness.

- When required, all pipes and perforated pipes for facilities located in streets must be at least 6-inches in diameter and meet ASTM 3034 SDR 35 PVC pipe and perforated pipe are required.

Planter

Planters are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater. Planters are suited to curbed streets, where stormwater runoff is controlled and can be directed into the planter.

- Soils: If infiltration rate is less than 2 inches per hour, the planter should be designed as partial infiltration or flow-through with an overall to an approved discharge point.
- Setbacks: A 5 foot setback from property lines and 10 foot setback from building foundations is required. If an adjacent basement is present, additional setback distance may be necessary. No set back required where height above finished grade is 30 inches or less. Infiltration facilities must be located a minimum of 100 feet from slopes of 10 percent; add 5 feet of setback for each additional percent of slope up to 30 percent. Infiltration basins shall not be used where slopes exceed 30 percent.
- Minimum width for a planter is 36 inches. Facility storage depth must be at least 12 inches.
- Planter bottom slope shall not exceed 0.5 percent.
- Planter walls shall be made of stone, concrete, brick, or other durable material. No treated wood can be used.
- Flow through facilities require a 30 mil PVC or equivalent liner.
- When required, all pipes for facilities located in streets must be at least 6-inch diameter ASTM 3034 SDR 35 PVC pipe and perforated pipe are required.

Basins

Vegetated infiltration basins are flat-bottomed, shallow landscaped depressions used to collect and hold stormwater runoff. Vegetated basins could be used as “regional” facilities, managing stormwater runoff from a long street segment or multiple streets.

- Soils: If infiltration rate is greater than or equal to 2 inches per hour, the basin must overflow to a subsurface infiltration facility. If the infiltration rate is less than 2 inches per hour, the basin should be designed as a partial infiltration or flow-through facility with an overflow to an approved discharge point.
- Setbacks: A 5 foot setback from property lines and 10 foot setback from building foundations is required. If an adjacent basement is present, additional setback distance may be necessary. Basins must be located a minimum of 100 feet from slopes of 10 percent; add 5 feet of setback for each additional percent of slope up to 30 percent. Infiltration basins shall not be used where slopes exceed 30 percent. No setback is required for lined facilities.
- Using the simplified approach, facility storage depth is 12 inches from the top of the growing medium to the overflow inlet. Maximum side slopes are 3 horizontal to 1 vertical. Minimum bottom width is 2 feet.

- Slope (see setbacks above).
- All pipes for facilities located in streets must be 6-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required.

Grassy Swale
Grassy swales are long, narrow grassy depressions used to collect and convey stormwater runoff.

- Soils: Grassy swales are appropriate for all soil types
- Setbacks: The required setback from the centerline of the swale to the property line is 5 feet and 10 feet from building foundations unless lined.
- Velocity through the facility shall not exceed 3 feet per second during the high flow events.
- The swale shall incorporate a flow-spreading device at the inlet. Check dams for slopes greater than 5 percent are required.
- The minimum width on public property is 12 feet, with a minimum 4-foot flat bottom. Maximum side slopes are 4 horizontal to 1 vertical. The maximum length is 100 ft. Overall, side slopes and depth should be minimized for safety.

Design Constraints
Constraints for the design of stormwater management facilities which are of particular concern for sites in the Fanno and Tryon watersheds include:

Soils/Infiltration
The limited infiltration capacity of soils in these watersheds limits the types of stormwater management facilities that can be implemented. It also influences the required sizing of the facilities.

The Soil Conservation Service (now the Natural Resource Conservation Service) Soil Survey Manual for Multnomah County shows the prevailing soil classification in the watersheds to be the Cascade series. The Cascade series is a moderately deep, poorly draining soil consisting primarily of dark brown silty loam.

A fragipan layer exists throughout the Cascade series soil type at a depth of 20 to 30 inches below the ground surface. This layer consists of a subsurface horizon of low porosity that is low in clays but high in silt or very fine sands, forming what appears to be a cemented layer that restricts root formation and infiltration. The fragipan layer ranges in thickness from two to four feet. When dry, the fragipan layer is very hard and dense. When wet, it tends to rupture suddenly under pressure, resulting in slope failures and slides.

During the summer months, the Cascade soils can be dry to a depth of 4 to 12 inches, for up to 60 consecutive days. As a result of this dryness, the ground is hard and can act as an impervious surface, particularly for high-intensity, short-duration summer storms. In areas of relatively undisturbed soils, the permeability is slow, and available water capacity is between five and eight inches in the top 60 inches. In the months from

December to April, the Cascade soils tend to have a water table at a depth of approximately 30 inches. The water table is typically perched on the fragipan layer. Depending on its location relative to the surface, the perched water table reduces the storage capacity of the soils, thus increasing the volume of runoff to the stormwater system during the winter season.

Slopes and Landslide Hazard Areas
Steep slopes present in these watersheds constrain the locations available for construction of stormwater management facilities. Stormwater management facilities in slope and landslide hazard areas must be designed to minimize these risks.

Elevation in the Fanno Creek watershed ranges from a low of 200 feet above mean sea level (MSL) to the highest point in the watershed, Council Crest, approximately 1,070 feet above MSL. Steep-sloping terrain from the crest of the West Hills drains south to the mainstem of Fanno Creek, with slopes averaging over 25 percent. Slopes lower in the mainstem basin and in the other tributary basins generally range between 11 and 25 percent, with steeper slopes common along stream corridors.

Elevation in the Tryon Creek watershed varies from near mean sea level (MSL) to 970 feet above MSL. The lowest point in the watershed, about 10 feet above MSL, is the confluence of Tryon Creek with the Willamette River; the highest point is at the top of Mt. Sylvania. Approximately 60 to 75 percent of the slopes within the watershed exceed a 30 percent grade. Some slopes exceed 50 percent grade, especially in the upper watershed.

The City of Portland has mapped potential landslide hazard areas (*Map 10*) which cover about half of the Fanno and Tryon watersheds. All proposed land divisions located within potential landslide hazard areas must meet the following approval criteria: Locate the lots, buildings, services, and utilities on the safest part of the site so that the rise of a landslide affecting the site, adjacent sites, and sites directly across a street or alley from the site, is reasonably limited (City of Portland Title 33 Planning and Zoning, Chapter 33.632).

Identified slope hazard areas are primarily located near streams (*Map 11*).

Stormwater Discharge/Disposal
As described previously, design criteria requires stormwater runoff to be directed to an approved discharge point for disposal. The limited and fragmented storm drainage system that is typical in the Fanno and Tryon Creek watersheds limits the availability of approved disposal points. This is an important consideration in all development projects. In cases where an approved disposal point is not available, additional downstream drainage improvements may be required. Drainage conveyance improvements could include constructing new storm sewers, improvements to existing storm sewers, enhancements to open drainageways, replacement of culverts, and stormwater outfall improvements.

Street Characteristics
As previously described, the type and condition of the exiting street improvements in these watersheds varies widely. Only 38 percent of the existing streets are curbed and paved. The stormwater management facilities in the SWMM are most suitable for implementation on these curbed streets. The curbs control stormwater runoff making is possible to direct stormwater to a stormwater management facility, such as a swale or planter.

On uncurbed and unimproved streets stormwater runoff may be conveyed through ditches, pipes, and sheet flow. Varying degrees of street improvements may be required to control and direct runoff to a stormwater management facility. Further improvements for stormwater disposal also would likely be needed in most cases.

Regional Stormwater Facilities
Siting of regional stormwater facilities is usually not possible due to existing development, watershed topography, and other design constraints. Current regulatory requirements also limit development of any stormwater facilities within the stream corridor or riparian areas.

Utilities
Both regrading of streets and locating stormwater facilities can have potential conflicts with existing utilities in unimproved streets. Utilities are expensive to relocate. Conflicts with existing waterlines are common since City policy is to not locate new stormwater facilities over water mains. Existing water services must be relocated or protected.

Adjacent Structures
Ties into slope, soil discussions above and slope discussion below but is big enough to be spelled out separately. Must make sure water doesn't travel subsurface (interflow) over the top of the fragipan, or surface overflow towards existing basements, garages, etc.

Additional Design Considerations
In addition to the design criteria and constraints discussed above, BES experience in designing and implementing stormwater management projects in SW Portland has identified other design considerations which need to be evaluated as listed below:

- Street improvements – Street drainage facilities to serve new street improvements must address both existing and future upstream drainage inputs and potential impacts on downstream drainage systems.
- Unimproved Streets - Construction of drainage improvements on unimproved streets often also requires related street improvements (e.g. sidewalks, curb-and-gutter ramps, etc.) and grading to control and direct runoff to the stormwater facilities.
- Slopes – Steep slopes present a design challenge for swale type facilities. Street grade cuts on streets with cross slopes often require retaining walls and fill. Private properties on the low side of these streets must be protected from street runoff.

- Existing Development – Existing structures, landscaping and other improvements commonly do not have adequate set backs or encroach into the public street right-of way.
- Trees – Mature trees are common either within or encroaching on the public right-of-way on uncurbed and unimproved streets in these watersheds. There is a public desire to retain and protect these trees.
- Fire Bureau – Twenty feet is the minimum width that PBOT standards require for new street improvements for fire access and parking. Curbs may also be required by the Fire Bureau on streets with steep slopes.
- Parking – Retrofitting of stormwater management facilities on existing streets often impacts available on-street parking.
- Pedestrian Issues – There is a general lack of existing sidewalks or developed paths adjacent to existing streets in the Fanno and Tryon watersheds. There is often a public and/or PBOT desire to include improvements for pedestrians as a part of street drainage improvement projects. This often results in additional design considerations, project costs and funding issues.
- Criteria for Retrofit Projects - Due to City policies limiting projects to City maintained streets, most current street drainage improvement projects consist of stormwater retrofits to the existing system. Design constraints often make it very difficult or impossible to meet the design criteria in the SWMM, especially flow control requirements. Nevertheless, stormwater retrofits using a vegetated facility should reduce peak flow rates.

Summary of Findings

- The design of storm drainage facilities must meet the requirements of the BES Sewer Design Manual. All drainage facilities must pass the 10-yr storm without surcharge and a means to pass a 25-yr storm without damage.
- All new or redevelopment must meet the requirements of the City Stormwater Management Manual (SWMM). The SWMM requires:
  - Stormwater discharges to pipes, ditches, and streams are only approved if those facilities have the capacity to convey flows from all up-stream development.
  - Flow control: Post-development peak flow rates must be equal to the pre-development levels for the 2-yr, 5-yr, and 10-yr 24-hour storm events. Two-year post-development discharges to streams must be reduced to one-half of the 2-yr pre-development peak flow.
  - Pollution reduction: Stormwater management facilities must remove 70% of total suspended solids from 90% of the average annual runoff. In watersheds with TMDLs, additional requirements may apply.
- Implementation of street drainage improvements (typically retrofit projects due to the level of existing development in these watersheds) must address design constraints including:
  - Site constraints (existing development and limited sites)
  - Soils (limited infiltration capacity)
  - Slopes (steep slopes and slope hazards)

  - Inadequate disposal points (existing development and substandard systems)
  - Other Requirements (transportation, pedestrian requirements, etc.)

Public Involvement
Public acceptance of street drainage improvements is necessary for successful implementation of these projects. Recent experience with implementing these types of projects in the Fanno and Tryon watersheds finds the following:

- In general, people support environmental goals and strategies at the City scale.
- At the specific green street project scale, however, people have raised the following concerns.
  - Public Involvement: Neighborhood residents want to determine if swales are suitable for their neighborhood.
  - Traffic circulation: Vegetated curb extensions would remove limited on-street parking, narrow streets restricting two-way traffic and limiting access for service and emergency vehicles.
  - Safety: Vegetated curb extensions would endanger pedestrians at locations where <u>sidewalks are not present</u> by forcing pedestrians further into the roadway at facility locations. This is a particular concern at streets on school bus routes.
  - Neighborhood character: Vegetated curb extensions would change the character of neighborhoods. Many feel that these facilities look displeasing, particularly in winter.
  - Facility maintenance: Concerned that the City would not adequately maintain the facilities to ensure that they remain in good condition (aesthetics) and that pollutants don't accumulate creating a danger.
  - Property values: Concerned that vegetated curb extensions would significantly lower property values of adjacent and nearby homes. This loss of value probably includes the loss of on-street parking.
  - Cost: Concerned about costs and general City budget priorities
  - Cost/benefit analysis: Concerned that other alternatives may achieve similar or greater benefits at a lower cost.
  - Insignificant impact: Concerned that individual projects would not have a measurable benefit on southwest streams and as such are not needed.

RECENT PROJECTS

The Bureau has installed stormwater facilities to retroactively manage stormwater runoff from existing streets over the past few years. Typically these involve extending existing curbs into the parking strip and planting the newly enclosed area. The size of these retrofit facilities is usually determined by available space; if space allows they are sized and designed to meet both the water quality and flow control requirements of the Stormwater Management Manual. However, site constraints often result in these facilities providing water quality treatment and only modest flow control. When constructed as part of the City's MS4 system, these projects help the City meet its MS4 permit regulatory obligations.

The Bureau started constructing roadside ditch drainage improvements on uncurbed streets in 2001 as part of regular maintenance activities. These involved replacing ditches with a perforated pipe backfilled with gravel and topped with gravel or soil and vegetation. These are typically installed on roadside ditches that are recurring drainage problems and/or are actively eroding. Preliminary investigations indicate that these drainage improvements provide water quality benefits (BES, 2008).

In some cases opportunities are available for regional stormwater management facilities. These facilities may detain and treat stormwater runoff from a variety of street types and land uses. In some cases space is available to size these facilities to provide both water quality treatment and significant flow control.

The Bureau, in collaboration with PBOT and private property owners, has improved unimproved streets. This involves improving the road surface and typically building a new storm sewer system including vegetated surface facilities. Stormwater facilities are designed to provide both water quality treatment and flow control if feasible. A key limitation in these projects can be identifying an approvable stormwater disposal location.

The following is a summary of recent Bureau projects and costs (*Map 12*).

Vegetated Curb Extensions (Swales and Planters)
Five vegetated curb extension stormwater facilities were constructed in upper Tryon Creek in 2009 and 2010. These include:

- A 350 square foot vegetated curb extension to treat 9,300 square feet of impervious right of way was constructed on SW Troy at SW 35th by the City's Bureau of Transportation Maintenance Operations in February 2009. Total cost was $29,256.
- A 500 square foot vegetated curb extension to treat 14,500 square feet of impervious right of way was constructed on SW 32nd at SW Capitol Highway by the City's Bureau of Transportation Maintenance Operations in July 2009. Total cost was $37,545.
- A vegetated curb extension to treat 4,300 square feet of impervious right of way was constructed on SW Capitol Highway at SW 34th by the City's Bureau of Transportation Maintenance Operations in October 2009. Total cost was $42,785.
- A vegetated curb extension to treat about 3,200 square feet of impervious right of way was constructed on SW Capitol Highway at SW 33rd by the City's Bureau of Transportation Maintenance Operations in October 2009. Total cost was $26,457.
- A vegetated curb extension to treat 8.7 acres (40% impervious) was constructed on SW Marigold west of SW 30th by private contractor in summer 2008. Construction cost was $125,000.

Additional stormwater management facilities are planned on SW Capitol Highway and SW Multnomah Boulevard over the next two years. These include:

- Multiple stormwater planters to treat 0.8 acres of impervious area are planned on SW Capitol Highway between SW 35th and SW 36th. The total project budget is $115,000.
- Four stormwater management facilities will be constructed on SW Multnomah Boulevard between SW 40th and SW Garden Home in spring/summer 2011. These include:
  - A 590 square foot vegetated stormwater planter treating 0.100 acres. Construction cost is $101,600.
  - 9-m: A 380 square foot vegetated stormwater planter treating 0.062 acres. Construction cost is $32,600.
  - 11-m: A 1,180 square foot roadside stormwater swale treating 0.541 acres. Construction cost is $11,600.

Roadside Ditch Drainage Improvements
Roadside ditch drainage improvements: approximately 2,500 ft of roadside ditches were converted to rock or vegetated road shoulders on Garden Home Boulevard in 2009 and 2010. Projects were constructed by the City's Bureau of Transportation Maintenance Operations and cost approximately $45 per lineal foot.

Construction of a roadside drainage improvement on SW Multnomah Boulevard near SW Garden Home Road that will treat 0.5 acres is planned for construction in spring/summer 2012. The design is a little different that typical ditch drainage improvements. The construction cost is $110,900.

Design is underway for roadside ditch drainage improvements on SW Stephenson between SW Boones Ferry Road and SW 35th and on SW Hamilton between SW Shattuck Road and SW Dosch Road. The total estimated cost is $710,000; construction cost is estimated at $53.64 per lineal foot.

Regional Water Quality Facilities
The Bureau constructed a regional water quality facility in 2006 on SW Taylors Ferry Road at SW 17th to treat 9.1 acres. The total cost was $208,548 (does not include acquisition cost of $38,296).

The Bureau constructed a regional water quality facility (sedimentation forebay and swale) in 2010 on SW Beaverton Hillsdale Highway at SW 35th to treat 8.6 acres. The total cost was $286,397.

Unimproved Street Improvements
The Bureau and PBOT developed 30% design drawings and cost estimates for improvements to 1,300 feet of SW 19th Avenue, an unimproved street with no storm sewer system. Design elements include the following: a curvilinear street design, "shed" street cross section with street sloped toward drainage swales, narrow 20 ft wide paved street with curbs, on street parking on one side of street only, drainage swales incorporated into street design, separated sidewalk/trail on one side of street only, street

alignment to minimize loss of existing trees, and connection to SW Trails and PDOT Safe Routes to Schools. The total cost estimate for improvements was $2,069,736 (included $180,000 for downstream improvements). **This project was canceled.**

The Bureau and PBOT in collaboration with local residents through an local improvement district project (LID) constructed street surface and drainage improvements on SW Texas Street between SW 26th and SW 29th Avenues. The project improved approximately 2,075 feet of roadway at a total cost of approximately $1,640,000.

Projects and Costs Summary
A summary of projects and costs is listed in Table 9.

Table 9

Summary of Project Costs				
Project	**Type**	**Total Cost**	**Area Treated SF [LF]**	**Cost/SF [LF]**
SW Troy at SW 35th	Curb Extension	$29,256	9,300	$3.15
SW 32nd at SW Capitol Highway	Curb Extension	$37,545	14,500	$2.59
SW Capitol Highway at SW 34th	Curb Extension	$42,785	4,300	$9.95
SW Capitol Highway at SW 33rd	Curb Extension	$26,457	3,200	$8.27
SW Marigold	Curb Extension	$162,500	378,972	$0.43
SW Capitol Highway between SW 35th and SW 36th.	Planter	$115,000	34,848	$3.30
SW Multnomah Blvd	Planter	$132,080	4,356	$30.32
SW Multnomah Blvd	Planter	$42,380	2,700	$15.70
SW Multnomah Blvd	Swale	$15,080	23,565	$0.64
			Average Cost	**$8.26[$132.16]***
SW Garden Home	Ditch drainage improvement	NA	NA	[$58.50 LF*]
SW Stephenson and SW Hamilton	Ditch drainage improvement	$710,000	[4,710]	[$150.74]
SW Multnomah Blvd	Ditch drainage improvement	$144,170**	[177]	[$814.51]
			Average Cost (excludes Multnomah Blvd)	**[$133.87]**
SW Taylors Ferry at SW 17th	Water quality facility	$208,548	396,396	$0.53
SW BHHWY at SW 35th	Water quality facility	$286,397	374,616	$0.76
			Average Cost	**$0.65**
SW 19th	Unimproved street improvements	$2,069,736	[1,300]	[$1592.10]
SW Texas	Unimproved street improvements	$1,640,000	[2,075]	[$790.36]
			Average Cost	**[$1,191.23]**
* Average cost per linear foot is based on $8.26/sf of impervious area treated multiplied by 4,000 sf of roadway (16ft wide by 250 ft long) divided by 250 ft. ** 30% for design was added to construction costs to estimate total costs.				

The average street drainage improvement project costs as show in Table 9 were used to roughly estimate the total cost that would be required to retrofit the entire street drainage system in the Fanno and Tryon watersheds. Total estimated cost is estimated at $207-725 million dollars as shown in Table 10.

Table 10: Project Costs by Street Category

Street Category	Street Length (ft)		Cost/ft	Total Million $
	City	Private		
Curbed	381022		$132	$50.3
Curbed		18206	$132	$2.4
Uncurbed	386028		$134-1191	$51.7-460
Uncurbed		103824	$134-1191	$13.9-124
Unimproved		75223	$1,191	$89.6
Non-existing		88557	NA	0
		Total Improvement Cost		$207-725

STRATEGIES

Rationale

The BES Stormwater System Plan draft fundamental service categories describe the functions that the stormwater system should provide. These service categories include consideration of City code and policy related to providing street drainage; Portland Watershed Management Plan goals; and regulatory requirements including MS4 discharge permit requirements; and protection and recovery of ESA listed species. It also described objectives to meet the goals of the fundamental service categories. The potential benefits of street drainage improvement projects in meeting these objectives are summarized in Table 11 by street category.

Table 11

Benefits of Street Drainage Improvements by Street Category			
Objectives	**Street Category**		
	Curbed	**Uncurbed**	**Unimproved**
Provide adequate storm system infrastructure for new and existing development	○	●	⬤
Manage storm system discharges to natural streams to normalize flow	⬤	●	○
Meet MS4 permit requirements (and TMDLs)	●	●	●
Support protection and recovery of federally listed species	●	●	⬤
⬤ Significant benefit ● Moderate benefit ○ Minor benefit			

Objectives and Strategies

1. **Objective: Provide adequate storm system infrastructure for new and existing development.**

   Strategy: Conduct required operations and maintenance of the existing street drainage system. Construct new street drainage systems as required.

2. **Objective: Manage storm system discharges to natural streams to normalize flow.**

   Strategy: Reduce the effective impervious area of existing street surfaces to reduce hydromodification and impacts on stream hydrology.
   - Construct stormwater retrofits to existing storm systems and streets to meet flow control requirements of the SWMM.
   - Existing curbed streets a priority for retrofitting based on larger impervious areas and piped drainage systems.
   - Fanno mainstem a priority basin based on existing flooding concerns.
   - Develop policy and criteria for locations where design and site constraints make meeting SWMM flow requirements impracticable

3. **Objective: Meet MS4 permit requirements (and TMDLs).**

   Strategy: Reduce pollutant loadings from street surfaces to the natural stream system to improve watershed health.
   - Construct stormwater retrofits to existing storm systems and streets to meet water quality treatment requirements of the SWMM.
   - Curbed streets a priority.
   - Streets with higher traffic volumes and/or higher density adjacent land uses are a higher priority.

4. **Objective: Support protection and recovery of federally listed species.**

   Strategy: Reduce fine sediment and pollutant loading to the natural stream system from street surfaces including unimproved public right of way.
   - Tryon watershed a priority because of ESA listed species.
   - Study existing unimproved streets in the Tryon watershed to evaluate magnitude of fine sediment loadings and control options.
   - Construct stormwater retrofits on uncurbed streets with actively eroding shoulders or ditches.
   - Develop City policy to address watershed health impacts from unimproved public right of way.
   - Construct stormwater retrofits on improved streets to reduce pollutant loads (e.g. potential copper impacts to ESA listed species).

Potential Activities

1. Evaluate Sediment Loadings from unimproved streets in the Tryon Creek watershed.

2. Identify and prioritize the watershed health (complete) and storm sewer system infrastructure (incomplete) goals as they relate to street drainage.
   a. Develop Storm System Plan for the Fanno and Tryon watersheds.

3. Develop a comprehensive street drainage policy that reflects these priorities. It should address the following:
   b. Retrofit of existing curbed streets for detention and treatment of stormwater runoff.
   c. Improvements to existing uncurbed streets for detention, treatment, and conveyance of stormwater runoff.
      i. Define interim improvements desired, particularly as they relate to regular operations and maintenance activities. Recommendations could include expansion of the scope and budget of existing operations and maintenance activities.
      ii. Consider options for public/private partnerships between the City and adjacent private property owners to construct improvements to substandard drainage improvements.

d. Improvements to existing unimproved streets for the detention, treatment, and conveyance of stormwater runoff.
    i. Consider alternative designs
    ii. Consider policies to support continued public/private collaborations for improvements based on past projects. This could include the use of public funds to reduce the cost of improvements on adjacent property owners.

4. Coordinate street drainage improvement projects with PBOT (i.e. associated required street improvements, funding, maintenance, asset management. etc.).

5. Develop Funding options.

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