CITY OF BAY CITY

STORM WATER MASTER PLAN

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CHAPTER 1 INTRODUCTION

1.1 PURPOSE

The purpose of this project was to create a Storm Drainage Master Plan for the City of Bay City, Tillamook County, Oregon. This project is being implemented from the Erosion & Sedimentation Action Plan of the Comprehensive Conservation and Management Plan (CCMP). To Develop and Implement a Storm Water Management Ordinance is the action item in that plan for the reduction of Erosion and Sediment in Tillamook Bay.

1.2 LOCATION

The City of Bay City is located on the northern Oregon Coast approximately 5 miles north of the City of Tillamook as shown in Figure 1 – Vicinity Map. The city lies on the Eastern edge of Tillamook Bay and has a population of 1160 people.

1.3 PLANNING SCOPE

This study addresses surface water quantity, drainage issues and reduction of sedimentation and erosion issues. The city limits of Bay City have been selected as the study area boundary. The study was intended to outline improvements required to solve both flooding related and water quality related problems due to anticipated and future runoff conditions. The planning scope of the project was broken down into four basic areas:

A) Evaluation and inventory of storm water facilities in Bay City.

B) Runoff flow analysis, identifying hydraulic flow problem areas.

C) Evaluation of storm water quality issues relating to sedimentation and erosion control.

D) Development of a capital improvement summary.

1.4 BACKGROUND

The CCMP was created from the Tillamook Bay National Estuary Program (TBNEP). It represents the collaborative work of the many citizens, managers, scientists, educators, and political leaders who supported the project over many years. The CCMP sets forth a 10-year action plan to coordinate resources, strengthen commitments, and rededicate resolve of the people of Tillamook County to protect and enhance Tillamook Bay's natural resources.

Four priority problem areas were identified in the CCMP. They area:

A) Key Habitat,
B) Water Quality,
C) Erosion and Sedimentation, and
D) Flooding.

The TBNEP began in 1994 with three priority problems: water quality, sedimentation, and habitat. After considering new scientific information and intervening events, including the Flood of 1996, the Management Committee rewrote the priority problems to more accurately reflect the current state of the Bay and Watershed, and added the fourth problem area: flooding.

1.4.1 About The TBNEP

In 1987, Congress established the National Estuary Program (NEP) as part of the Clean Water Act. The NEP's mission is to protect and restore the health of estuaries while supporting economic and recreational activities. The U.S. EPA administers the program. In 1994, TBNEP joined 27 other National Estuary Projects around the United States in developing and implementing science-based, community-supported management plans. To achieve program objectives and to complete a credible management plan, the TBNEP organized a Management Conference made up of policy makers, agency managers, citizens, and leading scientists from local, state, and regional institutions. The Management Conference established four committees to provide vital links in a cooperative effort to solve the environ-mental problems confronting the Tillamook Bay Watershed and its people.

1.4.2 Key Habitat

To restore fish and other aquatic species whose populations have declined due to habitat loss or degradation, the CCMP presents an action plan to assess, protect, and enhance key habitats throughout the Watershed. It targets instream and riparian areas, along with tidal marshes and lowland sloughs, as high priority habitats for protection and enhancement. In the forested uplands, the plan commits to remove barriers to fish passage and improve riparian and instream conditions in salmon core areas. It commits to upgrade road culverts and enhance 100 miles of instream habitat by 2010.

In the lowland agricultural areas, the CCMP calls for major riparian enhancement projects designed to control livestock access to streams and improve water quality. It promotes bio-engineered river stabilization projects pioneered by TBNEP and the Soil and Water Conservation District (SWCD) and calls on the agricultural community to enhance river banks to healthy riparian condition (HRC). Based on the success of TBNEP prototype fish-friendly tide gates, the plan outlines a strategy to upgrade 25 tide gates in lowland sloughs. It also calls for the enhancement of 750 acres of tidal marsh through purchase, donation, or easements on marginal agricultural lands.

To improve rearing habitat for juvenile fish and to reduce flood impacts, the CCMP supports hydromodification to reconnect rivers and sloughs. With about 85% of lowland wetlands lost to diking and draining, scientists and citizens stress the importance of hydrologic connectivity and recommend projects to open up blocked sloughs and to reconnect floodplain wetlands to river channels. Projects of this magnitude will require additional analysis and planning.

To address the need for additional analysis and planning, the CCMP calls on the U.S. Army Corps of Engineers (COE) and the local sponsor to develop a hydrodynamic computer model to describe and predict changes in river flow. A completed analysis will guide multiple agencies in a coordinated effort to increase habitat and mitigate environmental and economic flood damages. Tillamook County has been the lead local agency in the development of this Hydrodynamic computer model.

While this CCMP focuses on the threatened Oregon Coast Coho salmon and other salmonids, the general emphasis on ecosystem health should benefit other species, including those listed as threatened or endangered under the Endangered Species Act.

Patterson Creek, together with Jacoby Creek, its tributary, flows through the City of Bay City and has its outlet to Tillamook Bay within the City Limits. Patterson Creek is relatively small as it passes through

Bay City, being confined to several culverts ranging from three foot to six foot in diameter. There are no agricultural issues within the City of Bay City that would degrade key habitat. Several of the existing culverts on Patterson Creek are significant barriers to fish passage. These culverts have been identified within this plan with suggested methods for replacement thereof to improve fish passage and key habitat.

1.4.3 Water Quality

Today, Tillamook Bay receives high bacterial loads and other pollutants from diverse sources including livestock operations, wastewater treatment plants, on-site sewage disposal systems (OSDS) and urban runoff. Many stream reaches also fail to meet water quality criteria for temperature, and exceed recommended concentrations of suspended solids. Significant oxygen depression and excessive nutrient concentrations have been observed in some lowland sloughs.

To improve water quality and reduce agricultural contributions to bacterial contamination, Oregon Senate Bill 1010 requires the development of agricultural water quality management plans (SB 1010 plans). The North Coast Basin SB 1010 Plan will encompass Tillamook Bay. To meet the landowner-supported pollution prevention and control measures (PCMs) required in the SB 1010 plan, livestock operation managers should implement voluntary farm management plans. The CCMP water quality action plan describes the improved farm practices necessary, and commits to helping local farmers implement voluntary farm management plans. Moreover, it calls for annual Confined Animal Feeding Operation (CAFO) inspections by 2004, with all agricultural operations (not just CAFOs) in compliance with the SB 1010 plan by 2010. To strengthen these efforts, the CCMP identifies agency partners, educational programs, and likely funding sources to improve agricultural practices in Tillamook County.

Recently-completed storm sampling of Tillamook Bay and the Trask and Tillamook Rivers found that 16%-73% of the bacteria was of human origin, with the human-origin bacteria proportion tending to rise as the storm wore on. Based on these findings, the CCMP targets human activities and outlines action plans to upgrade wastewater treatment plants, expand sewer networks, and ensure that on-site disposal systems work properly. Wastewater treatment plants will eliminate all discharge failures by 2002, and the City of Tillamook will expand its sewer network by 2005. In the estuary, ODA will update shellfish management plans based on new information about bacterial sources, levels, and distribution.

Reducing bacteria inputs, enhancing key habitat, and addressing erosion and sedimentation problems will also reduce other water quality problems, such as excessive nutrients and low dissolved oxygen. However, specific water quality actions address temperature and suspended sediments.

Within the City of Bay City, the only water quality issue to be addressed is urban runoff. There are no livestock operations within the city limits. The City's wastewater treatment plant was significantly upgraded from a facultative lagoon treatment system to a mechanical treatment plant in recent years. (± 1993) All areas of the City of Bay City that are currently developed have a sanitary sewer system available for service. The sewer collection system was inspected for leakage as a part of the treatment plant upgrade. The number of on-site sewage disposal systems (OSDS) within the city limits is extremely limited. Therefore, urban run off is the remaining water quality issue to be addressed.

Urban runoff can significantly degrade the water quality in the creeks within the City of Bay City. Specifically, non-point source urban water runoff problems within the City can be improved. This study focuses on ways to improve water quality from non-point source urban water runoff, primarily turbidity and temperature. Samples were taken on Jacoby Creek, Patterson Creek and the Unnamed (Perkins) Creek in two separate locations. Each creek was tested upstream of the City Limits and at the outlet of the steam. Sampling results showing temperature and turbidity are shown in Appendix C.

1.4.4 Erosion and Sedimentation

Excessive sedimentation can simplify or degrade habitats and modify river flows and flood patterns. Sediment loading, movement, and deposition all affect instream and estuarine habitat and Bay bathymetry. The CCMP targets forest roads, an important source of human-caused sediment loading, and outlines a strategy to identify, prioritize, and upgrade forest roads. Under the leadership of the Department of Forestry (ODF), the CCMP commits to upgrade 1,400 miles of forest roads with better culverts and drainage ditches. The plan also calls on state and private foresters to decommission at least 50 miles of unneeded forest management roads by 2010.

To improve sediment and habitat conditions associated with timber harvesting, the CCMP encourages state and private forest owners to go beyond the Forest Practices Rules in protecting riparian and high-risk areas. The plan recognizes the voluntary efforts of the Oregon Forest Industries Council (OFIC) and private foresters to improve riparian and instream habitats.

In the lower Tillamook Bay Watershed, the CCMP targets urban runoff and calls on Tillamook County and the cities of Tillamook, Bay City, and Garibaldi to adopt new ordinances to control erosion due to construction. Other lower Watershed sources of sediment, including stream bank erosion and runoff from agricultural lands, are addressed through actions in the Key Habitat and Water Quality chapters. These actions will reduce sediment loading to help meet habitat requirements for salmonids and other aquatic species and achieve state water quality standards by 2010.

The City of Bay City has an existing riparian ordinance now in place. That ordinance addresses general development on private property in close proximity of the creeks that flow through the City. The implementation and enforcement of the City's riparian ordinance has not been what it could be and most certainly can be improved upon. The ordinance should be expanded upon to specifically address erosion control on private property due to construction and development. The Ordinance should be carefully enforced on all properties that it applies to throughout the City. Recommendations for such ordinance improvements are included in this study.

1.4.5 Flooding

A copy of the Flood Insurance Rate Map (FIRM) for the City of Bay City is included in this report as Figure 8. In general, flooding has not been an historical problem in the City of Bay City. The main source of flooding as shown on the FIRM for the City of Bay City is Tillamook Bay, located to the West of the City. The Tillamook Bay has a number of identified flood hazard zones, however, the majority of Tillamook Bay is shown to be in an A1 Flood Hazard Zone with a 100-year base flood elevation of 9 feet on the National Geodetic Vertical Datum (NGVD). Additionally, the FIRM has identified a flood hazard zone on the lower portions of Patterson Creek and the lower portions of the Unnamed Creek (Perkins Creek).

Patterson Creek, within the City Park property, is shown to be in an A2 Flood Hazard Zone with a 100-year base flood elevation of 10 feet. Upstream of the City Park, Patterson Creek is shown to be in an AO Flood Hazard Zone with a 100-year depth of flooding of 1 foot of water. This zone extends upstream to Fifth Street. Finally, on Patterson Creek from Fifth Street to Sixth Street the Flood Hazard Zone is identified as Zone A, an area of undetermined flood elevations and undetermined flood hazard factors.

The Unnamed Creek (Perkins Creek), in the area South of the downtown of Bay City, is shown to be in an A2 Flood Hazard Zone with a 100-year base flood elevation of 12 feet. This flood hazard zone is in the vicinity of the Tillamook Country Smoker main processing plant. There are no reports of flooding at that facility. Upstream of the Tillamook Country Smoker, above Warren and McCoy Streets, the

Unnamed Creek (Perkins Creek) the Flood Hazard Zone is identified as Zone A, an area of undetermined flood elevations and undetermined flood hazard factors.

There are no local reports of localized flooding in Bay City during recent flooding events that have severely flooded other areas in Tillamook County. Bay City is generally located high enough above Tillamook Bay so as not to be located in an area that is subject to flooding from Tillamook Bay. The general elevations of streets in the downtown area along Patterson Creek are in the range of low elevations near 14.0 to elevations well above 20.0 feet, NGVD. Unlike the City of Tillamook, Bay City does not receive excessive runoff flood waters from several major rivers such as the Wilson River that regularly floods the North Highway 101 area of Tillamook City. Patterson Creek and Jacoby Creek are relatively small creeks when compared with a much larger river such as the Wilson or Trask or Kilchis Rivers, all of which discharge into Tillamook Bay. Therefore, flooding from Tillamook Bay is not a particular problem in the City of Bay City.

As determined in the hydraulic analysis of the culverts (See Chapter 3, **Runoff Analysis and Flow Characteristics**) through which Patterson Creek flows in the downtown area of Bay City, the culverts are adequately sized to handle the 50-year storm event that is the common design storm for major creek-sized culverts. The key issues that affect the runoff and flooding potential of Patterson Creek are the following:

a) Runoff will increase in Patterson Creek and Jacoby Creek when substantial logging activity occurs in the respective watersheds of those two creeks. Clearcut logging practices not only create additional runoff from disturbed surfaces but they also increase the amount of sedimentation and debris in the creeks.
b) Localized flooding of both Patterson Creek and somewhat on Jacoby Creek may occur when debris in the creeks begins to block culvert inlets. Localized flooding (overtopping of a single culvert) has occurred in the past when substantial logging took place in the creek watersheds. Debris, limbs, sticks, leaves, etc. can partially plug the culvert entrances and severely reduce the hydraulic capacity of any culvert.

1.5 AUTHORIZATION

In August 2002, HLB & Associates, Inc. was selected to complete an engineering study for a Storm Drainage Master Plan for the City of Bay City. Ongoing work has been conducted from Summer 2002 to Spring 2003 to develop this Storm Drainage Master Plan. Evaluations were taken over this period to assess the impacts of storm water during the various weather seasons in Bay City. Water quality tests at the creeks in Bay City were also taken over this period to assess the differences in readings. These readings are addressed in Chapter 5 Storm Water Quality, Sedimentation & Erosion.

CHAPTER 2 STORM WATER DRAINAGE AND DRAINAGE PATTERNS

2.1 STUDY AREA, CLIMATE AND HYDROLOGY

2.1.1 Study Area

The study area is located in the eastern portion of Tillamook Bay as shown in Figure 1 - Vicinity Map. The city limits define the area of coverage, and Tillamook Bay defines the western boundary as shown in Figure 2 & Figure 3 - Aerial Photos. This area consists of three major drainage basins as shown in Figure 4 - Drainage Basins Map. Patterson Creek, Jacoby Creek, and Perkins Creek transit through the study area. Topography for the area is generally gentle to steeply sloping low hills with flat areas near the lower ends of the drainage basins. Elevation ranges from 18 to 220 feet as shown in Figure 5 - Watershed Topography.

2.1.2 Climate

Tillamook County receives a lot of rain. From 1992 through 2002, The City of Bay City averaged 80 inches of rain per year with 76% of total precipitation occurring from October through March. The highest precipitation and rainfall events occurred during November, December, and January. Tillamook County averaged more than 23 days per year in which precipitation exceeded 1 inch. In 1996, however, 126 inches of lowland rain (and very heavy upland rain and snow melt) led to severe flooding throughout the County and caused significant economic and environmental damages. New flooding at the close of 1999 added to the toll. No significant flooding problems were identified during those events within the City of Bay City.

The seasonal, episodic nature of precipitation defines the natural system. Fall Chinook migrate upstream with the first heavy rains of autumn. Big storms can cause major landslides in the steeply sloped upland regions. Although heavy storms have characterized the natural system for thousands of years, human activities have exacerbated the impacts and consequences of high rainfall (Coulton *et al.* 1996).

Westerly winds predominate and carry the temperature-moderating effects of the ocean over all of western Oregon. Summers are cool and dry; winters wet and moderate (USDA 1964). Winds blow nearly continuously throughout the year and often reach gale force in the winter. Prevailing winds come from the northwest during the summer and from the south and southwest during the winter.

Temperatures in Tillamook County are moderate. The mean annual temperature is 50.4^{o}F (10.2^{o}C), with yearly mean maximum and mean minimum temperatures documented at 59.3^{o}F (15.1^{o}C) and 41.6^{o}F (5.4^{o}C), respectively. Those 30 years averaged less than one day per year with a temperature over 90^{o}F (32^{o}C). September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 102^{o}F (38.9^{o}C).

2.1.3 Hydrology

As noted above, the Tillamook Watershed receives abundant precipitation. The Tillamook basin drains the west slope of the Coast Range, where precipitation increases with elevation. Due to relatively warm winter temperatures, most precipitation falls as rain. Large rainfall events can produce flood events. However, the rare combination of snowmelt and an influx of warm, wet subtropical moisture cause most of the largest flood events (1964 and February 1996). More information covering Hydrology is covered in Chapter 3, Runoff Analysis and Flow Characteristics.

The Bay City watershed has three distinct regions with distinct topography and soil characteristics as shown in Figure 6 - Soils Survey Map. Refer to Figure 7 – Soils Survey Map Legend for soils legend and descriptions. These three regions are the upper hills and mountain slopes, the foothills and the lowlands adjacent to the Tillamook Bay.

Lands in the Northern and Eastern portions of the City are hilly with several ridges and deep drainage swales. The overland slope varies from 3% to 60% in the upper forested reaches. The upper forested reaches of the watershed are outside of the city limits. The soil type primarily seen in this region is Astoria silt loam. Astoria silt loam consists of well drained, fine-textured soils made up from weathered soft shale. These soils are commonly found among the upland soils within the Tillamook County area. They occupy very steep, rough mountain slopes in the coast range and gentle to steep valley foothills. These soils are commonly associated with Hembre, Winema and Neskowin soils. Astoria soils on the steep slopes are in forests of Douglas-fir, hemlock, cedar and red alder. Those near the coast are Sitka spruce. Natural drainage is good, subsoil permeability is moderate, and runoff is medium. The available water-holding capacity is high, and the penetration of roots is deep. The hazard of erosion is moderate. The soil is high in organic matter, medium in fertility, and very strongly acidic.

Lands directly east of Highway 101 are gentle to steep foothills, moderately long and smooth. The overland slope varies from 3% to 40%. All of theses areas are much flatter within the City of Bay City. The soil primarily seen in this region is Winema silt loam. Winema silt loam consists of dark-colored, well drained, deep to moderately deep soils on the lower slopes along river valleys and on hills adjacent to the coast. They have mostly south or southwest exposure. The Winema soils are associated with Astoria, Hembre, and Neskowin soils on uplands. The Winema soils form soft gray shale under ferns and grasses. Sitka spruce occurs in small groups scattered over the Winema soils. Natural drainage is good, runoff is rapid and permeability is moderate. The available water-holding capacity is high; root penetration is deep. The hazard of erosion is moderate to severe. The soil is very high in organic matter, moderately low in fertility and very strongly acidic.

Lands directly west of Highway 101, adjacent to the Tillamook Bay are level, poorly drained bottom lands. The soils primarily seen in this region are Coquille and Brenner silt loams. The surface soil is very dark grayish brown, highly mottled and stained with strong brown. The surface consists of numerous depressions, small ridges, stream channels and sloughs. The vegetation is mainly rushes, marsh grasses, sedges, and tules. Natural drainage is very poor. When not protected with levees or dikes these soils are ponded during high tides. The available water-holding capacity is moderate to high. Root penetration is moderately shallow. The soils are very strongly acidic and low in fertility.

Overland flow occurs when soils become saturated during major rainstorms or frozen during unusually cold weather. Land use practices can, to a limited degree, impact soil infiltration rates. Land use practices, such as road building, can also cause subsurface flow to become overland flow. The belief that forests beneficially reduce flooding has been the source of considerable debate. Forest harvesting and roads have been found to modify stream flows in small basins. Results for small basins (Ziemer and Lisle 1998) suggest that timber harvesting can increase summer low flows and average fall peak flow. However, Ziemer and Lisle also found no appreciable increase in peak flows for the largest of floods from timber harvesting in the Pacific Northwest (and elsewhere).

Proponents of the belief that forests can reduce floods have often applied a concept called hydrological maturity. This concept hypothesizes that as the vegetation in a watershed becomes “more mature,” the risk of floods diminishes. Interestingly, the average age of the forests in the Tillamook Watershed has increased annually since the great Tillamook Burn fires. Thus, the perception by some that the frequency of flooding has increased over the same time is inconsistent with the change in the "hydrologic maturity" of the basin.

In the Bay City watershed, timber harvesting locally impacts the water quality and amount of runoff within Patterson Creek and Jacoby Creek. Whenever the timber in a significant area of those creek watersheds is harvested, water runoff from heavy winter storms will increase and water quality will decrease. Conversely, when there are no active logging operations in those creek watersheds, the volume of water runoff decreases and the water quality during a heavy winter storm does not significantly degrade.

2.2 LAND USE

Land use for lots within Bay City are predominately residential. Zoning designations range from High to Low Intensity within the City Limits and Urban Growth Boundary (UGB). Adjacent areas outside the City and UGB are Rural Residential and Farming. There are 1205 lots within the City and UGB. Approximately 611 or 51% of those lots are developed. Development of lots within the City of Bay City will likely continue at a relatively slow growth rate. The average growth rate of the population in Bay City has been 1.06% annually over the past decade. Building permits issued within the City for new construction for the past five years have been as follows: Twelve permits in 1998; seven Single Family Home and two Duplex permits in 1999; three permits in 2000; six Single Family Home and one Duplex permits in 2001 and one permit in 2002.

Land uses other than residential are very limited within the City of Bay City. The two major employers within the City are the Tillamook Country Smoker and McRae and Sons, Inc. (wood handle manufacturer). Neither of those commercial businesses have the type of land use that would adversely impact the water quality of urban runoff in any way significantly different from the issues related to residential land uses. Therefore, this study will concentrate on the residential land uses and development thereof.

CHAPTER 3 RUNOFF ANALYSIS AND FLOW CHARACTERISTICS

3.1 METHODOLOGY

This chapter describes the analytical techniques and outlines the methodology used in this study to determine the existing and future drainage system requirements. First, several basic assumptions are presented. Next, analytical techniques used for hydrologic and hydraulic analyses are described. Finally, this chapter briefly describes how drainage facilities will be evaluated.

3.1.1 Assumptions

The following basic assumptions for the hydrologic and hydraulic analyses were made:

1) Impervious areas for residential zones were assumed to be the maximum lot coverage allowed by the City's Zoning Ordinance of 40%.

2) Impervious areas for commercial zones were assumed to be 90%.

3) Graveled parking areas in commercial zones were treated as such for existing conditions, and assumed to be paved in the future.

4) Driveways and parking areas in residential zones were treated as gravel areas, both now and in the future.

5) Design flows are based on the assumption that all surface runoff is conveyed to the basin outlet. Observed existing flows will likely be less due to minor upstream ponding and constrictions.

6) Pipe capacities are based on the design flows given and likewise do not account for upstream ponding. Where upstream storage is identifiable it has been accounted for in the calculations.

7) Calculated flows and pipe capacities are based on basin and sub-basin runoff only and do not account for tidal waters. Tidal waters influence Patterson Creek and other discharge points as shown in the Figure 8 - Flood Insurance Rate Maps.

3.2 HYDROLOGIC ANALYSIS

In planning required improvements to conveyance systems, the engineer or planner must know the frequency, or probability, of system failures. For this purpose, hydrologic events such as precipitation and peak flows are presented in terms of their frequency of recurrence. The recurrence interval of a given hydrologic event is equivalent to the probability of recurrence within a given year. For instance, the 2 year peak flow for a drainage basin is the flow rate expected to be equaled or exceeded once every 2 years and has a 50% chance of being equaled or exceeded in any given year. The 25 year flow is expected to be equaled or exceeded once every 25 years and has a 4% chance of occurring in any given year. For the purposes of this study, a hydrologic model was developed to determine peak rates and volumes of runoff at key design points for the 2, 5, 10, 25, 50 and 100 year recurrence intervals.

Peak rates of runoff used for drainage design depend on the volume of runoff and the rate at which it occurs. The volume component of runoff depends upon the size of the drainage basin, the total volume of precipitation that occurs and the volume of runoff that is "lost" due to infiltration and evapotranspiration.

The rate of runoff depends upon the hydraulic conditions of the basin (travel length, slope and roughness) and the varying intensity of rainfall throughout the design storm.

Several methods are available for calculating peak flows. The method most appropriate for a given study depends upon basin size, basin characteristics, available input data, ease of implementation and the ability to vary design parameters for changing conditions. The Rational Method is a formula often used for design of local storm drain systems. This method accounts for such conditions as varying rainfall intensity distributions during large storms, soil conditions and the hydraulic routing of rainfall from one end of a basin to the basin outlet. Hydraulic methods which compute flows based on theoretical hydraulic equations are very data intensive and often don't adequately account for imperfect drainage conditions found in basins with a high degree of natural and overland drainage. Hydrograph methods use empirically determined "unit" hydrographs to approximate basin specific flow vs. time relationships based on direct input of anticipated rainfall intensity distributions, soil and ground cover parameters, hydraulic routing parameters and impervious area information.

The Rational Method was determined to be appropriate for the majority of the analyzed basins in this study. Hydraulic methods were found to be too complex and inflexible for efficient use in a general study of this type. Consequently, hydrograph methods were used to verify calculated flows through the larger basins of Patterson and Jacoby creek.

Since detailed studies of similar gauged watersheds are not available, the SCS Unit Hydrograph Method was chosen as the most applicable means of calculating flows in the Bay City watershed. While other methods are very sensitive to local conditions and often not applicable when limited data is available, the SCS method is well adapted to areas where limited hydrologic data is available since it uses a single parameter to represent the hydraulic conditions in the basin. The SCS Unit Hydrograph Method was originally developed based on studies of large agricultural watersheds. However, because it is a broad based method that is easy to apply to a wide variety of conditions it has now become accepted along with the Rational Method for urban studies. In recent years, the SCS method has been used extensively in urban storm drainage studies of this type with very reasonable results.

Applying unit hydrograph methods to a multi-basin study area can only be done efficiently with computer methods. A variety of computer programs are available which model complex multi-basin watersheds using the SCS Unit Hydrograph method. The USDA/NRCS Win TR-55 Small Watershed Hydrology program provides a great deal of flexibility for hydrologic modeling. Using the Win TR-55 program, a computer model designed to calculate representative existing and future flows was developed for the City of Bay City's watershed. The input parameters required by the Win TR-55 program are described below:

- **Storm Data:** The design Rainfall Distribution Curves of precipitation vs. time to produce the peak flow used for design purposes.

- **Sub-Basin Area (A)**: A sub-basin is the watershed within which runoff can be assumed to flow to a single discharge point. The sub-basin area entered in the model is the total area of sub-basin that contributes to runoff.

- **Soil Infiltration and Evapotranspiration Loss Parameter (CN):** The SCS Curve Number method was chosen to estimate evapotranspiration and infiltration losses. This method uses a single "Curve Number" which has been empirically determined by the SCS for a variety of soil types and ground cover conditions to estimate soil infiltration and evapotranspiration losses.

- **Time of Concentration (T_c):** The time of concentration of a basin is the time it takes water to travel from the most remote part of the basin to the basin outlet.

Likewise, a variety of computer programs are also available for the Rational Method which model smaller drainage areas to determine pipe, inlet and culvert sizing. Using Autodesk Civil Design program provides a great deal of flexibility for hydrologic modeling. The Rational Method simplifies the process of calculating runoff by interpolating rainfall intensities once the required data (runoff coefficient, frequency factor, adjustment factor, area, and time of concentration) are input. Data required when using the Rational Method formula includes the following:

- **Runoff Coefficient (C)**: Factor that represents the land use. Values typically range from 0.10 to 0.95. Where 0.10 would be a wooded area and 0.95 would be a paved parking area.

- **Drainage Area (A)**: Area that is contributing to the point of concern measured in acres. The Rational calculator respects the current hydrology units settings. For example, if the current area units are set to Sq. Miles, then the program converts the area to acres to perform the calculations.

- **Rainfall Intensity (I)**: Rainfall Intensity used for calculating the peak runoff. This value is based on the time of concentration and the rainfall frequency being design for. When calculating flows using this method manually, you would refer to an IDF (intensity duration frequency) curve to determine the rainfall intensity, given the time of concentration and the design storm frequency. Using Autodesk Civil Design, the IDF curve can be entered and values can be interpolated from it automatically.

The specific assumptions, values and means of computation for each of the above sub-basins parameters are discussed in Section 3.4, Basin Delineation and Model Parameters. Section 3.5, Rainfall Analysis presents frequency information for expected rainfall and the development of the design rainfall IDF curves.

The result of the Win TR-55 modeling process is the computation of sub-basin runoff and stream flow quantities. The free flowing peak flows at desired locations in the drainageways were estimated. These flows are presented in Table 4 - Peak Basin Flow Rates & Table 5 - Peak Flows at Nodes.

3.3 HYDRAULIC ANALYSIS

Hydraulic analysis involves calculating the hydraulic capacity and resulting water surface profiles under existing and ultimate land use conditions, based on the estimated peak flows generated from the hydrologic analysis. Several computer and analytical methods were utilized to model the different hydraulic elements.

The computer program StormCAD by Haestad Methods was used for analyzing major piped systems. This program is most useful for long, complex systems in which a wide variety of hydraulic conditions exist. The relatively short reaches and varying slopes of the main drainage ways in the Bay City area did not allow for the complete modeling of the study area using StormCAD. As a supplement to StormCAD, FlowMaster program by Haestad Methods was selected to analyze open channel flow, and pressure flows at culvert crossings using Manning's Equation (for gravity flow in conduits) and the Hazen-Williams Equation (for head loss per length of pipe under surcharged conditions). Storage routing computations for detention areas were conducted using routing options in the StormCAD program discussed previously.

3.3.1 Analysis Approach

The first step in analyzing the City of Bay City's existing drainage facilities and determining future drainage needs was to sub-divide the City's watershed into more manageable drainage basins. The watershed was divided into the "major drainage basins" based upon topographic drainage boundaries and the location of the discharge points. Then each major drainage basin was sub-divided into sub-basins for the purpose of determining flows using the Win TR-55 model. Sub-basin outlets were chosen to correspond to key points where flow information was required and then delineated based on existing drainage facilities, zoning and topographic information. The specific drainage basin delineations arrived at are presented in Section 3.4, Basin Delineation and Model Parameters.

Once delineated, sub-basins were used as the basis of the flow calculations. Rainfall data was evaluated and input into the model is described in Section 3.5, Rainfall Analysis. Hydrologic parameters were then determined for each sub-basin and flows for each design frequency calculated (see Section 2.1.3 "Hydrology"). The calculated flows apply to the point where the entire sub-basin has contributed flow.

Existing drainage facilities were analyzed with respect to their frequency of failure under existing conditions. Existing detention areas that are expected to remain were considered when determining the capacity of the downstream conveyance. Site visits, topographic mapping and discussions with City staff were used to estimate the impacts of flow. The impacts were then weighed with respect to the estimated frequency of failure to evaluate the need for improvements.

In analyzing existing facilities field surveys and topographic maps were used to determine if areas of inadequate surface drainage facilities exist. Erosion along roadways, poor drainage causing frequent ponding and low areas subject to flooding were analyzed and considered potential problem areas that may require service.

After determining existing problem areas, future drainage needs were evaluated. Zoning information and 1994 aerial photography were compared and used to determine where future development was likely to occur. Based on previous flow calculations and estimations on how flow would channelize after development, future problem areas were isolated and limited to the major culverts on Patterson Creek.

After the various locations of required improvements were identified, improvement alternatives for alleviating the problem were developed. The following alternatives were considered:

(1) Ditch System -Ditch systems were considered to collect flow in residential areas with free draining roadways (ie. no curb and gutter) at slopes above 2%. Piped systems in steeper areas without a curb and gutter system or defined drainage path are not able to adequately collect the runoff in catch basins and ponding, poor roadway drainage and erosion of roadway shoulders can still occur.

(2) Piped System -Replace undersized pipes, or construct a pipe system to serve unserved areas. Where pipe systems would function well, they are preferable to ditches since maintenance is less costly. Piped systems are preferable in flat areas where standing water would remain in ditches, and in areas where conveyance of flow, and not collection is the main purpose of the conveyance. Conversely, piper systems increase runoff and generally do not have any capability for reducing water quality pollutants.

Solutions implementing the above alternatives were determined by effectiveness in solving the problem, practicality of implementation based on cost (i.e. a $200,000 improvement could likely never be built), ability to subdivide the required system into reasonable projects which could be constructed during different phasing periods, long term maintenance requirements, practicality of implementation in conjunction with road improvements and the overall benefits of the improvement. A list of all proposed solutions was developed and then separate improvement projects were identified. An "Improvement" constitutes those lengths of pipe or ditch systems which should be constructed during a single project.

3.4 BASIN DELINEATION AND MODEL PARAMETERS

The first step in analyzing the City of Bay City's existing drainage facilities and determining future drainage needs was to sub-divide the City's watershed into more manageable drainage basins. The watershed was divided into the "major drainage basins" based upon topographic drainage boundaries and the location of the discharge points. Then each major drainage basin was sub-divided into sub-basins for the purpose of determining flows using the Win TR-55 model. Sub-basin outlets were chosen to correspond to key points where flow information was required and then delineated based on existing drainage facilities, zoning and topographic information.

3.4.1 Basin Delineation

The Bay City watershed was first divided up into three major drainage areas, based on discharge location, main drainage-ways, drainage boundaries, and geographic boundaries. See Figure 9, Figure 10, and Figure 11 for Sub-Basin Maps for the major basin and sub-basin delineation used in the analysis. The following major drainage basins were defined:

- Patterson Creek Drainage Basin (P) – This basin includes all lands draining into Patterson Creek from the creek's origin.
- Jacoby Creek (J) – This basin includes all lands draining into Jacoby Creek from the creek's origin.
- Unnamed Creek Drainage Basin (UC) – This basin is bordered by Baseline Road at the north, Bewley Street at the East and Williams Street at the south and drains to the small Unnamed Creek which flows under the Tillamook Country Smoker. Throughout this report, this creek is referred to as "Unnamed Creek." Application has recently been submitted to name this creek "Perkins Creek."

Each major drainage area was then sub-divided into sub-basins used to calculate the flows for the runoff analysis. Sub-basins were delineated by land topography and drainage patterns. Once sub-basins were defined, key "node" points where used to calculate flow information for velocity and pipe sizing.

Sub-basins were named based on one or two letter designation assigned to each main drainage basin. Sub-basins within the major basins were given a second letter, N or S, designating the basins location was either North or South of the drainage creek. Connected sub-basins (sub-areas of a single drainage reach) were then numbered consecutively starting at the outlet and heading upstream, i.e. P-N-1 is directly downstream of P-N-2.

Basins having their own discharge point and not connected to the three major drainage basins were given the generic label SB for independent sub-basins. These basins were then numbered from north to south.

3.4.2 Sub-Basin Runoff Area

For existing conditions, it was assumed that the entire sub-basin contributes to runoff. Future sub- basin areas have been adjusted to account for this zoning requirement. It was assumed that 30% of all future residential lands will be impervious and routed to dry wells. Since future impervious areas will not contribute to runoff, the future runoff area for sub-basins where dry wells can be implemented will be smaller than the existing runoff area.

3.4.3 Soil Loss Parameter

The effective impervious area method described above is used to determine the volume of runoff due to the impervious portions of the basin. For the pervious areas within the basin, infiltration and evapotranspiration significantly reduces runoff. The degree of these losses can be estimated using a soil loss parameter developed by the Soil Conservation Service (SCS). This parameter, called the Runoff Curve Number, depends on the soil type, ground cover and antecedent moisture of the area.

Determining a curve number requires first classifying the soils within each basin in terms of its hydrologic behavior. The SCS rates soils as belonging to one of four hydrologic groups: A, B, C, D. Soils in Hydrologic Group A have very high infiltration rates (low runoff), while Hydrologic Group D soils have very low infiltration rates (high runoff).

Based on the hydrologic classification of the soil, a numerical Curve Number can be determined from tables listing SCS Curve Numbers for various antecedent moisture and ground cover conditions. For the Bay City area, it was assumed that antecedent moisture condition (AMC) III applies. The SCS defines AMC III as the condition applying to areas where the total precipitation 5 days previous to the design storm is in excess of 2.1." Data published in the Climatological Handbook for the Columbia Basin States, Precipitation Volume 2, lists the antecedent rainfall 4 days previous to the largest recorded event (approximately a 50 year event) as 4.1" While smaller events will have correspondingly smaller antecedent moisture levels, AMC III appears applicable to the wet coastal conditions.

To account for ground cover, assumptions were made for developed areas based on zoning type. Curve numbers for single family residential areas are representative of fairly well developed, but not dense, lawns or sparse brush and trees. Curve numbers for multi-family areas represent a higher degree of runoff assuming some graveled areas, possibly landscaped areas with dirt or bark dust and sparser lawns. Curve numbers for commercial areas assume mostly gravel open areas and high runoff. Curve numbers for undeveloped areas assume dense brush or forest with dense underbrush.

3.4.4 Time of Concentration

The time of concentration is the travel time from the most hydraulically remote point in the sub-basin to the sub-basin outlet. As described in SCS Technical Release #55, the total travel time can be computed by summing the time of travel required for each of the following components of runoff: overland flow, shallow concentrated flow (overland flow in shallow swales), gutter flow, channel flow, and pipe flow.

3.4.5 Overland Flow

The following coefficients were used to estimate the overland flow parameters:

Table 1 - Rational Runoff Coefficients

LAND USE DESCRIPTION	RUNOFF COEFFICIENT	
	LOW	HIGH
Business - Downtown area	0.70	0.95
Residential - Single Family areas	0.30	0.50
Residential - Multi units, detached	0.40	0.60
Residential - Multi units, attached	0.60	0.75
Residential - Suburban	0.25	0.40
Residential - 1.2 acre lots or more	0.30	0.45
Apartment - Dwelling areas	0.50	0.70
Industrial - Light areas	0.50	0.80
Industrial - Heavy areas	0.60	0.90
Neighborhood areas	0.50	0.70
Parks, cemeteries	0.10	0.25
Playgrounds	0.20	0.40
Railroad yard areas	0.20	0.40
Unimproved areas	0.10	0.30

- *Sheet Flow* - Sheet flow is water sheeting over a plane surface, such as an even amount of water flowing over a parking lot. It is the first component of Tc and starts at the hydraulically most distant watershed point. Sheet flow normally occurs at a depth of 0.1 ft. or less, and the length of sheet flow rarely exceeds a few hundred feet. The maximum length of sheet flow in most cases is 300 ft. For commercial areas, overland flow was assumed to occur for 200 feet before being collected by a shallow swale, gutter or main channel.

  To calculate sheet flow, you need the following information: a two-year rainfall amount; length of flow; average slope along flow path; and ground roughness over which the water is sheeting (measured in Manning's n factor).

- *Overland slope* - Overland slopes were calculated based on the topographic mapping.

- *Shallow Swale Flow* - Shallow flow is water flowing in natural drainage depressions and swales, and usually begins after a maximum of 300 feet of sheet flow. The average velocity of shallow concentrated flow is determined by watershed slope and channel material (paved or unpaved). Typical areas where you have shallow flow are in swales between houses and the gutter section of a roadway.

  To calculate shallow flow, you need the following information: flow length; average slope; and a determination of whether the surface is paved or unpaved. The time of travel for shallow swale flow was calculated by using Manning's equation to calculate swale velocities for a typical swale as a function of slope and vegetation.

- *Channel Flow* - Velocities in defined channels and pipes receiving flow from a majority of the basin were estimated using Manning's calculations based on the size, slope and standard n-value for each channel or pipe. See Appendix A – Culvert Database for general description and locations of existing culverts. n = 0.013 was used for concrete culverts, n = 0.024 for corrugated metal pipes (CMP), n = 0.0375 for average defined channels, and n = 0.08 for overgrown channels.

3.4.6 Summary of Parameters

The Rational Method input parameters for each sub-basin are presented in Table 3, Sub-Basin Parameter Summary. See Appendix B for full runoff calculations.

3.5 RAINFALL ANALYSIS

Once sub-basin parameters have been input into the model, the only remaining variable is rainfall. While rainfall is the driving force of the hydrologic model, it is also the most uncertain. However, statistical analysis of historical storms and use of regional data can allow the engineer or planner to estimate the approximate frequency with which a storms exceeding a given magnitude will occur. In addition, regional studies conducted by the SCS are useful in estimating the time distribution of rainfall during the peak period of a storm likely to cause flooding. Using these sources, a hypothetical "design storm" (or rainfall distribution) can be developed for use in the hydrologic models.

3.5.1 Design Storm Duration

The duration of the design storm depends upon the characteristics of the basins being studied. Typically, short duration storms should be used for design of steep, impervious basins where a high intensity of rainfall produces the greatest peak runoff. In larger, more pervious basins, a lesser intensity of rainfall preceded by a large volume of rain resulting in saturated conditions will produce the greatest peak flows. Because of the pervious nature of the basins being studied, a 24 hour storm duration was selected as the design storm. This value is typically used for basins of this size, and only under impervious conditions would it be likely that a 6 hour duration would be more applicable.

3.5.2 Rainfall Intensity-Duration-Frequency Curves

Rainfall intensity-duration-frequency (IDF) curves are used to determine the rainfall intensity in inches per hour associated with a given storm duration and design frequency. The IDF curves and values for the 24 hour precipitation for the 2, 5, 10, 25, 50, and 100 design frequencies were determined from Oregon Department of Transportation Highway Division, Hydraulics Manual.

These IDF curves were computed in accordance with the method described in 1973 NOAA Atlas 2 entitled “Precipitation-Frequency Atlas of the Western United States, Volume X-Oregon”. A regional rainfall analysis was done by comparing the IDF curves for 136 cities and areas. Comparing the curves established 13 zones or regions that have similar rainfall intensities. The IDF curve for each region represents an average for that region. Bay City falls within Zone 2, which represents most of Tillamook and Lincoln counties.

The IDF curves are required when computing flows using the Rational Method. The Rational Method is a popular method of computing small basin flows and is often used by planners and engineers. Because of the Rational Method's popularity, IDF curves were developed using the 24 hour precipitation depths presented in Table 2 - Design Precipitation Frequency - Depth Values. The resulting IDF curves are shown in Figure 12 – IDF Curves. These curves are intended to assist City staff and engineers with future design projects.

Figure 12 - IDF Curves

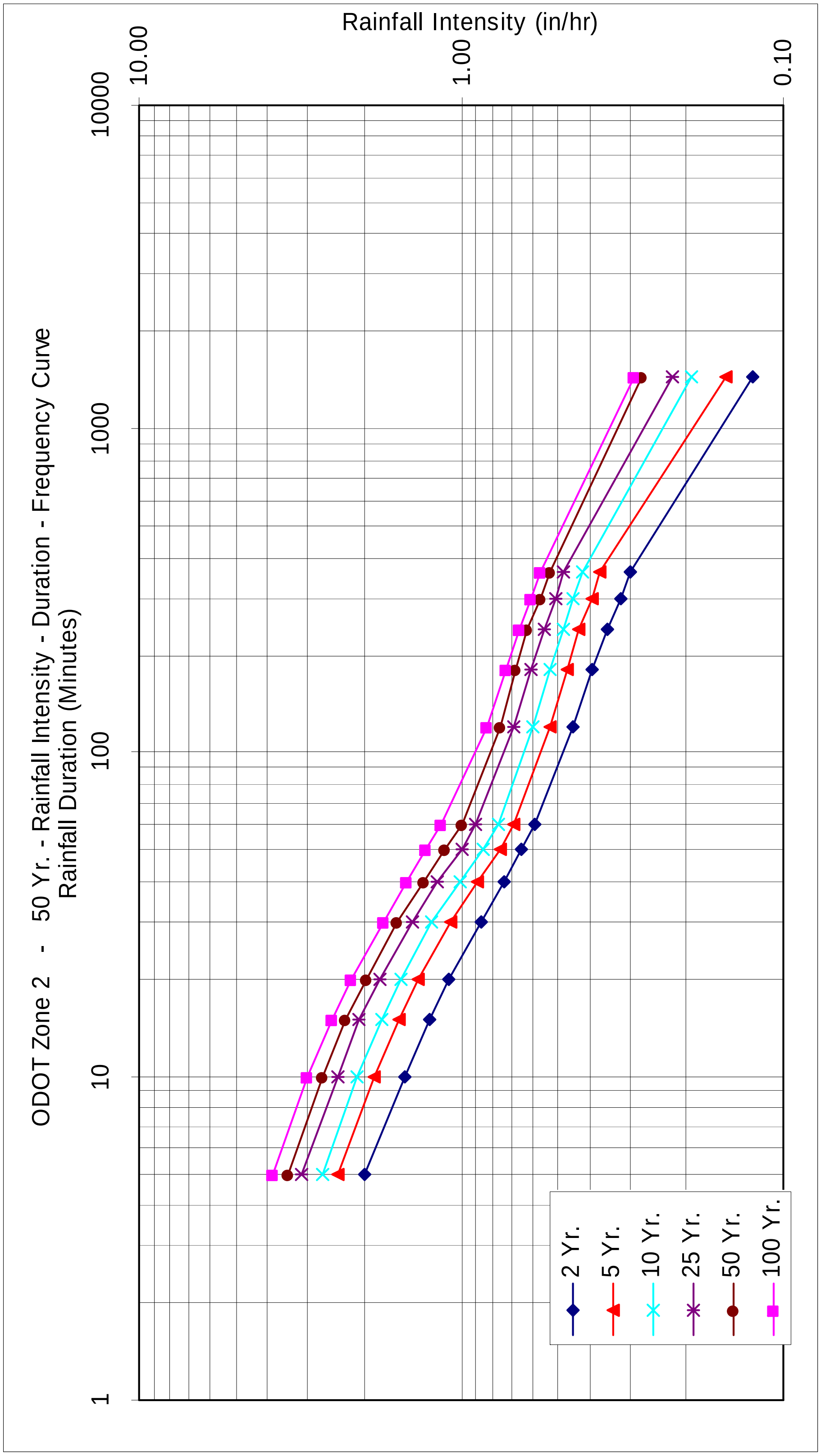

Table 2 - Design Precipitation Frequency - Depth Values

DESIGN FREQUENCY	24 HR PRECIPITATION DEPTH (IN/HR)
2	3.6
5	4.6
10	5.3
25	5.8
50	6.6
100	7.0

Table 3 - Sub-Basin Parameter Summary

BASIN DESCRIPTION	AREA (AC)	COEF. (C)	TC (MIN)	INTENSITY IN/HR					
				2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
PATTERSON CREEK									
PATTERSON	705.31	0.30	87.64	0.53	0.62	0.69	0.80	0.89	1.00
P-N-1	10.05	0.21	14.47	1.28	1.59	1.80	2.12	2.32	2.58
P-N-2	14.24	0.30	13.37	1.34	1.66	1.88	2.20	2.42	2.68
P-N-3	13.92	0.50	12.42	1.38	1.72	1.94	2.26	2.50	2.77
P-N-4	20.05	0.30	13.92	1.31	1.62	1.84	2.16	2.37	2.63
P-N-5	16.84	0.30	16.70	1.20	1.49	1.69	1.98	2.17	2.41
P-N-6	64.61	0.18	39.19	0.75	0.91	1.03	1.20	1.32	1.49
P-S-1	3.16	0.50	5.02	2.00	2.40	2.69	3.12	3.46	3.83
P-S-2	3.80	0.20	5.01	2.00	2.40	2.69	3.12	3.46	3.83
P-S-3	10.69	0.70	15.20	1.25	1.55	1.76	2.08	2.27	2.52
JACOBY CREEK									
JACOBY	424.71	0.30	61.81	0.59	0.69	0.76	0.89	0.99	1.14
UNNAMED CREEK									
UC-N-4	27.97	0.25	19.28	1.11	1.39	1.56	1.82	2.01	2.24
UC-N-3	34.57	0.25	6.97	1.80	2.19	2.46	2.84	3.16	3.50
UC-N-2	14.36	0.25	11.34	1.43	1.78	2.01	2.33	2.59	2.87
UC-N-1	14.88	0.30	16.07	1.22	1.52	1.72	2.02	2.21	2.46
UC-S-3	23.27	0.25	7.65	1.73	2.11	2.38	2.75	3.06	3.39
UC-S-2	15.55	0.25	15.61	1.24	1.54	1.74	2.05	2.24	2.49
UC-S-1	17.18	0.45	17.30	1.18	1.47	1.66	1.95	2.14	2.37
SUB-BASINS									
SB-1	4.31	0.25	10.24	1.48	1.85	2.08	2.40	2.68	2.98
SB-2	19.23	0.68	29.02	0.89	1.11	1.26	1.46	1.61	1.79
SB-3	2.77	0.95	10.78	1.45	1.81	2.05	2.37	2.63	2.93
SB-4	11.37	0.30	13.62	1.32	1.64	1.86	2.18	2.40	2.66
SB-5	3.16	0.30	10.41	1.47	1.84	2.07	2.39	2.67	2.96
SB-6	11.92	0.30	15.56	1.24	1.54	1.74	2.06	2.25	2.49
SB-7	15.23	0.30	15.05	1.26	1.56	1.77	2.09	2.28	2.53
SB-8	6.76	0.30	16.13	1.22	1.51	1.72	2.02	2.21	2.45
SB-9	22.10	0.50	18.70	1.13	1.41	1.59	1.86	2.05	2.28
SB-10	11.61	0.50	19.36	1.11	1.39	1.56	1.82	2.01	2.23

Table 4 - Peak Basin Flow Rates

BASIN DESCRIPTION	BASIN FLOW RATE (CFS)					
	2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
PATTERSON CREEK						
PATTERSON	111.19	130.40	146.36	169.96	188.20	212.14
P-N-1	2.71	3.36	3.81	4.48	4.90	5.44
P-N-2	5.70	7.08	8.02	9.39	10.32	11.46
P-N-3	9.59	11.93	13.50	15.73	17.38	19.29
P-N-4	7.88	9.77	11.07	13.00	14.26	15.83
P-N-5	6.07	7.54	8.53	10.03	10.99	12.20
P-N-6	8.88	10.71	12.16	14.19	15.64	17.66
P-S-1	3.16	3.79	4.25	4.93	5.46	6.05
P-S-2	1.52	1.82	2.04	2.37	2.63	2.91
P-S-3	9.37	11.61	13.17	15.54	16.96	18.82
JACOBY CREEK						
JACOBY	74.63	87.30	97.45	113.86	126.49	145.29
UNNAMED CREEK						
UC-N-4	7.79	9.71	10.94	12.76	14.09	15.66
UC-N-3	15.55	18.90	21.24	24.58	27.31	30.27
UC-N-2	5.13	6.39	7.22	8.37	9.29	10.32
UC-N-1	5.46	6.77	7.67	9.03	9.88	10.97
UC-S-3	10.06	12.29	13.83	15.99	17.78	19.72
UC-S-2	4.82	5.97	6.77	7.98	8.72	9.68
UC-S-1	9.04	11.22	12.69	14.89	16.34	18.15
SUB-BASINS						
SB-1	1.60	1.99	2.25	2.59	2.89	3.21
SB-2	11.67	14.49	16.48	19.04	21.06	23.46
SB-3	3.82	4.77	5.39	6.23	6.93	7.69
SB-4	4.51	5.60	6.35	7.44	8.17	9.07
SB-5	1.40	1.74	1.97	2.27	2.53	2.81
SB-6	4.44	5.50	6.23	7.35	8.03	8.91
SB-7	5.75	7.12	8.07	9.53	10.40	11.54
SB-8	2.48	3.07	3.48	4.10	4.48	4.98
SB-9	12.53	15.60	17.60	20.56	22.66	25.18
SB-10	6.46	8.05	9.06	10.57	11.67	12.97

Table 5 - Peak Flows at Nodes

BASIN DESCRIPTION	CUMULATIVE FLOW RATES (CFS)					
	2 Yr	**5 Yr**	**10 Yr**	**25 Yr**	**50 Yr**	**100 Yr**
PATTERSON CREEK						
P1	111.19	130.40	146.36	169.96	188.20	212.14
P2	120.07	141.12	158.52	184.16	203.84	229.80
P3	194.71	228.42	255.97	298.02	330.33	375.10
P4	200.78	235.95	264.50	308.05	341.32	387.29
P5	208.66	245.73	275.58	321.05	355.57	403.12
P6	218.03	257.34	288.74	336.59	372.54	421.95
P7	227.63	269.27	302.25	352.32	389.91	441.24
P8	233.33	276.35	310.27	361.70	400.24	452.70
P9	234.85	278.17	312.31	364.07	402.86	455.61
P10	238.01	281.96	316.56	369.00	408.33	461.66
P11	240.72	285.32	320.36	373.48	413.23	467.10
UNNAMED CREEK						
UC1	7.79	9.71	10.94	12.76	14.09	15.66
UC2	23.34	28.62	32.18	37.34	41.41	45.93
UC3	33.40	40.91	46.01	53.33	59.19	65.65
UC4	38.53	47.30	53.23	61.70	68.48	75.97
UC5	43.35	53.27	60.00	69.68	77.19	85.64
UC6	48.81	60.04	67.67	78.72	87.08	96.61
UC7	57.85	71.27	80.36	93.61	103.42	114.76

CHAPTER 4 IDENTIFICATION OF EXISTING PROBLEMS AND PROPOSED SOLUTIONS

This chapter will help identify problem areas within each drainage basin and discuss the recommended improvements. Using the computed flows as discussed in the previous chapter, along with observations from the City Public Works Department, existing facilities were analyzed for flood conditions. Our conclusions show that the City of Bay City does not have a storm water hydraulic capacity problem. Most existing facilities, such as major culverts, within the major drainage basins are adequately sized for a 50 year storm event. Problems with flow conditions mostly occur when existing facilities are not adequately maintained, are plugged or are otherwise blocked by silt, gravel or woody debris. Therefore, there is no need for a Capital Improvements Plan for the City, but rather a Maintenance Plan for the upkeep of the existing structures. This chapter will discuss problematic culverts and drainage areas along with recommended replacement techniques.

4.6 CULVERT REPLACEMENTS

There are several sites around the city where culvert maintenance is needed. Many of the culverts need to be cleaned and unplugged, while others need general maintenance. The three general problematic situations which require culvert replacement are broken culverts, corroded or scoured culverts and culverts that are fish barriers.

4.6.1 Broken Culverts

Broken culverts are generally caused by old, leaky culverts or poorly constructed culverts. Concrete pipes or other material culverts that do not have watertight joints can leak and wash away fill material form around the pipe. This will eventually create voids under the surface and allow the pipes to separate at the joints. A good example of this is shown in Figure 13 – Broken Pipes Example. As one can see from the photo, the two sections of this culvert are separated at the connection joint. Water leaks out and washes away part of the embankment. The water remaining in the culvert is re-directed creating a deep scour pool. These types of culverts need to be replaced immediately.

4.6.2 Corroded or Scoured Culverts

Corroded or scoured culverts are the top priority when replacing existing culverts. Thorough inspection is necessary to determine the life expectancy of the existing culverts. Those that are subject to high sediment transport are the most vulnerable to scour and premature failure. Culvert material and coatings should be taken into consideration when replacing culverts in which acidic soils exist, streams flow through or those that are subject to high sediment loadings.

For example, Patterson Creek flows through a 72” corrugated metal pipe culvert under 4th street near the City Park and is should be considered the top priority among the culverts to be replaced, see Figure 14 – Scoured Bottom Culvert. Judging by field observation, the original stream flow was through a box culvert or small bridge and was replaced by this culvert. This culvert was adequately sized for flood events, however, due to the sediment transport load within Patterson Creek, the downstream section is rusting and appears to be loosing some of its structural integrity. As the culvert continues to decay, the compacted fill under and around the culvert will start washing away as the lower sections of culvert fall apart. This will eventually cause the fill around the culvert to settle. The recent pavement patch on 4th street indicates that the fill around the culvert is settling and will continue to do so until the culvert eventually fails or is replaced.

Due to the location of this culvert and the growing awareness of fish passage requirements on Patterson creek, measures should be taken to ensure a fish friendly culvert is installed as outlined in the section below.

4.6.3 Fish Barriers

Stream channels which cross under roads generally cause the loss of fish habitat due to migration barriers at the culvert crossing. The five common conditions at culverts that create migration barriers are:

- Excessive drop at culvert outlet
- High velocity within culvert barrel,
- Inadequate depth of flow in within culvert barrel,
- Debris and sediment accumulation at culvert inlet or internally.

Jacoby Creek and Patterson Creek have potential for fish habitat if the downstream road crossings do not prevent upstream migration of fish. The current configurations of the stream crossings along Patterson Creek pose as barriers to migrating fish at several locations. Perched culverts are the primary barrier for fish passage and stream bed erosion due to undersized culverts or improper vertical placement of these culverts. Undersized pipes increase the discharge velocity which results in stream bed scour at the outlets. This theory of controlling the pipes velocity is further discussed in Section 5.1 Runoff Control. The result of these high energy flows is a deep outlet pools and soil erosion. An example of this condition is shown in Figure 15 & Figure 16 – Perched Culvert Example. These two culverts are located at 7th Street and Main Street. These culverts are located approximately 450 feet downstream from a fish ladder on Patterson Creek at 9th and Main shown in Figure 17. It would be a safe assumption that many fish, if any, do not even make it to the fish ladder due to these perched culverts.

This crossing is just one example of a fish barrier. An Oregon Department of Fish & Wildlife Fish Specialist can better assess road crossings for fish passage and possible locations for fish habitat along these major streams. When culverts are installed at new or existing crossing locations, it is our recommendation that the culvert design and placement conform to the most current Oregon Department of Fish & Wildlife's Road/Stream Crossing Restoration Guide. This guide gives detailed design and installation guidelines for constructing fish friendly passages.

4.7 DITCH REPAIR AND MAINTENANCE

Ditches along streets are the primary method of conveying storm water within Bay City. With the proper maintenance, roadside ditches can be a beneficial part of a storm water conveyance system. However, without the proper maintenance they can become a nuisance to downstream piped systems and also negatively effect storm water quality.

A drainage ditch's primary purpose is to maintain adequate storm water flow. The best way to maintain adequate flow is routine maintenance and removing obstructions. Maintenance on ditches is easier when they are cleared of brush. Overgrown drainage ditches, as shown in Figure 19, prevent routine maintenance and monitoring of the ditch in case of blockage or excessive erosion.

Brush, including blackberry vines, should be cleared and low growing grasses should be planted for both sediment and erosion control. Section 5.2.2 Roadside & Perimeter Vegetated Swales explains maintenance practices and suggested plantings for best performance of vegetated swales. A wide, clear, well maintained ditch, as shown in Figure 20, helps reduce water velocity which allows sediment particles to fall out and acts as a natural sediment trap.

Local residents could maintain such an area if they were assisted by the City Public Works staff. Initial clearing and replanting could be completed by the City Public Works Department and then ongoing maintenance of the low growing grasses could be turned over to adjacent property owners.

Another roadside ditch condition which is commonly seen throughout the city is erosion at the outlet end of driveway and road culverts. As shown is Figure 18, the unprotected outlet of this culvert is washing away from the high energy flow of water. Energy dissipation rocks should be placed at the outlet to slow down the storm water flow exiting the culvert and thus, reduce soil erosion.

4.8 STREAM CHANNEL AND BANK RESTORATION

The City of Bay City is fortunate to have three streams running through the city which act as storm water conveyance systems. Directing storm water into these streams greatly reduces the need for complex underground storm water collection and conveyance systems. While most stream systems are self sufficient, general maintenance of the stream channels and banks can help the performance, habitat and quality of water within the stream.

Erosion and sediment transport are a natural occurrence within streams. Excessive sediment transport and deposits can modify a stream's flow pattern. High storm water flows can greatly increase the erosion along stream banks if adequate structural vegetation is not present. A prime example of this stream bank erosion is along Patterson Creek within the City Park as shown in Figure 21. These vertical cut-banks offer very little bank stabilization and they will continue to erode during high flow storm events. This erosion will increase the turbidity and sedimentation within Patterson Creek and increase sediment loads to the Tillamook Bay.

The City Park allows an excellent opportunity for stream maintenance and a bank restoration and vegetation project. The ideal solution to this problem is a shallow vegetated slope on each side of the creek. The bank slopes should be tapered back at an optimal 3:1 slope and a maximum 2:1 slope. Turf reinforcement mats will assist stabilizing channel flows and protect slopes prone to erosion. These mats will aid in establishing vegetation in waterways and banks and will provide ideal placement for riparian vegetation and tree plantings.

The benefits of a bank stabilization and vegetation project include greater storm water flow capacity, slower velocity due to a wider cross-section, decreased erosion, increase in water quality and shade which will decrease water temperatures and benefit fish habitat.

The City Park is only one location of many that would benefit from a stream restoration project. However, most of the other locations are located on private property. The city will need to encourage land owners to participate and help maintain these and other similar restoration projects within the city to reduce erosion, reduce the loss of property and to improve water quality within these streams.

4.9 WETLANDS BIO-FILTRATION

Wetlands are a proven method of removing sediments in stormwater. Wetlands also function as a "sponge" to reduce stream flows during critical peak flow times of intense rainfall events. As water flow velocities are reduced within wetlands areas, sediment is deposited within the wetland

CHAPTER 5 STORM WATER QUALITY, STORM WATER QUALITY, SEDIMENTATION & EROSION

5.1 RUNOFF CONTROL

Construction activities usually result in the removal of vegetative cover and increases in impermeable surfaces, both of which increase the volume and velocity of runoff. Increases of storm water volume and velocity lead to increased erosion (gulling) in the sediment transport and off-site delivery (sedimentation). These increases must be addressed when implementing erosion and sediment control.

Runoff control measures are those practices, which mitigate for the erosive and sediment transport forces of storm water during and after construction activities. Some examples of runoff control might include, outlet protection (energy dissipaters), diversion dikes and swales, temporary slope drains, rock lined channels, grass-lined channels, and temporary stream crossings.

Runoff control involves the use of structures to reduce velocities and/or safely carry storm water in a manner which reduces erosion and sediment transport.

The energy equation, $\mathbf{E = mv^2}$, where E = erosive Energy, m = unit density of water, and v = the runoff velocity, demonstrates that if the velocity of running water is reduced by ½, then the erosive energy will be reduced by 4 times. To reduce runoff energy it is recommended that the City and the citizens of Bay City implement practices which use the **4 D's** of runoff control.

- **Decrease** - decrease the amount of runoff
- **Detain** - decrease the velocity
- **Divert -** divert runoff to less erodible areas
- **Dissipate -** spread the runoff out

Rill and gully erosion is caused by concentrated runoff. Methods which reduce runoff velocity, such as check dams, vegetated channels or riprap, will also reduce the potential for sediment transport. An alternative to reducing the runoff energy of storm water is to convey that runoff through or along non-erodible surfaces, i.e., culverts and slope drains. Conversely, conveying runoff through culverts generally results in an increase in downstream velocities.

Temporary check dams, especially straw bale dams, are not recommended for any flowing water conditions. Straw bales and silt fences are sediment control Best Management Practices, not runoff control Best Management Practices and should not be placed in channel flow (runoff) areas

5.2 BEST MANAGEMENT PRACTICES FOR MAINTENANCE

For the purposes of this report, pollution prevention is defined as the use of materials, processes or practices that reduce or eliminate the creation of storm water runoff pollutants or wastes at the source. Best Management Practices (BMPs) are structural and managerial techniques that are recognized to be the current, most effective means to prevent and/or reduce pollution from storm water runoff. There are generally two reasons to implement BMPs from a surface and ground water quality standpoint: to protect the existing level of water quality from future degradation; and, to correct existing water quality problems.

This report discusses both structural and managerial practices to be implemented as a part of the proposed pollution prevention strategy for the City of Bay City. These practices are intended to minimize and/or improve storm water runoff quality. The emerging philosophy of storm water management emphasizes controlling storm water where it falls and incorporates both structural and vegetative measures to detain and “treat” the water.

Specific needs regarding quantity and quality of storm water runoff addressed for this project include:

1. Minimizing any increase in the current volume of runoff.
2. Minimizing any increase in the velocity of runoff.
3. Maintenance of current baseflows in Patterson Creek, Jacoby Creek and the Unnamed Creek (Perkins Creek) and their tributaries.
4. Provisions for improving water quality to the highest degree possible with currently available, passive technology.

5.2.1 Landscape Plantings

Landscaping for storm water management concerns is a science that is still in its infancy. It is known that proper landscaping techniques can create both a beautiful physical setting and one that benefits the environment and saves water. In fact, attractive, water-efficient, low-maintenance landscapes can increase home values between 7% and 14% (USEPA, 1993). In addition, using trees and shrubs to provide shade in the summer and sunlight in the winter can cut in half home cooling and heating costs.

Other environmental benefits include:

1. reduced irrigation water use
2. reduced runoff of storm water & irrigation water that carries soils, fertilizers and pesticides
3. fewer yard wastes that need to be disposed of
4. more habitat for plants and wildlife

5.2.2 Roadside & Perimeter Vegetated Swales

Vegetated swales are most applicable in residential areas of moderate density such as found in the City of Bay City. This practice requires that site planning and design respect the natural drainage patterns in lieu of elaborate underground, piped, storm drain systems. Vegetated swales are considered as a method of biofiltration using terrestrial grasses and other fine herbaceous plants for storm water treatment.

Roadside swales should be used in lieu of a conventional curb and gutter drainage systems. A perimeter swale may be planned either on private property (as a part of the property development) or within the right-of-way of public streets. Both swale systems can also discharge into a vegetated infiltration/detention basin. The perimeter swale can also be provided with overflow weirs and/or level spreaders to dissipate concentrated flows and provide additional sediment settling capabilities. During larger, less frequent runoff events, the weirs can overtop and function as a level spreader dispersing flow over a larger cross-sectional area.

Swale design incorporates the use of Manning’s equation of open channel flow to obtain a width for a given flow & slope and selected water depth. The velocity resulting in a sized channel is then compared to a criterion, and the length is calculated using a hydraulic residence time criterion. A recent key study showed that a residence time of nine minutes is needed to achieve the highest and most reliable performance. Deterioration of performance was noticeable when the residence time fell below five minutes, which is recommended as the absolute minimum. Other construction features that help to maximize the success in establishing swales as biofilters are:

1. Sited or located away from building and tree shadows to avoid poor plant growth from lack of sunlight.
2. If the longitudinal slope is less than 2% or the water table can reach the root zone of vegetation, water tolerant species should be planted.
3. As much as practicable, the lateral slope is entirely uniform to avoid any tendency for the flow to channelize.
4. Entrance flow is dissipated quickly and flow distributed uniformly to avoid erosion.

Establishing an effective and productive grass cover in the swales will begin with an evaluation of site-specific conditions and proposed topsoil cover. Based upon ongoing localized studies being conducted to evaluate biofiltration capabilities of varying cover crops, the following grass mixture applied at a rate of 130 to 175 lbs/acre, dependent on detained runoff volumes, is recommended:

Species/*Variety*	**Ibs./1000 sq. ft.**
Perrenial Rye	
Edge	0.45 to 0.60
Kentucky bluegrass	
Ram	0.45 to 0.60
Meri	0.45 to 0.60
Chewings fescue	
SR510	0.90 to 1.20
Hard fescue	
SR3100	0.75 to 1.00

One example of an effective vegetated perimeter swale in Bay City can be found at the Tillamook Country Smoker. The entire Northwest parking lot (approximately 66 vehicles) is sloped to drain with sheet flow over a grassy perimeter swale prior to entering the Unnamed Creek (Perkins Creek). A close examination of the perimeter swale indicates that sediments and oils that run off of the parking lot are being effectively trapped in the perimeter swale that is a mowed grassy surface.

5.2.3 Infiltration/Detention Basin

Infiltration/detention basins are probably the most common management practice for the control of storm water runoff. If properly designed, constructed and maintained, infiltration/detention basins can be effective in controlling peak runoff flow rates.

Design and construction of the basin where the swales will discharge to, incorporates measures which will account for enhanced pollutant attenuation in the soil column. A combination of first flush detention (i.e., plunge pool at inlet) followed by infiltration will protect water quality while filtering out a portion of those substances which contribute to basin failure (i.e., sediment).

Generally, basins should be located in a naturally low area of the landscape. Optimally, the floor should be 18 to 24 inches above the seasonal high water table to avoid direct contact with ground water and allow treatment by infiltration through the soil.

Pollutant removal is governed by basin size. Removal rates of residual pollutants can be enhanced by increasing the surface area of the basin reserved for exfiltration. Exfiltration refers to the amount of runoff that is effectively infiltrated through the soil profile. For example, an infiltration basin sized to store and exfiltrate half an inch (first flush) of runoff volume will only be effective for the removal of pollutants from runoff volumes equal to or less than half an inch. Conversely, a basin designed to capture a two-year storm will treat all the intermediate sized storm events. Recommended vegetative seeding mixtures for the basin and rates are the same as those for grass swales.

5.2.4 Catch Basin Cleaning

It is recommended that catch basin sumps be cleaned out at least once, and optimally twice, a year to accomplish effective pollutant removal and to protect downstream waters. Catch basins are usually cleaned with a vacuum truck, however, if sediment volume is minimal, manual cleaning can be equally as effective. The resultant slurry of water, sediment and other debris can be transported to an approved treatment plant or landfill for disposal. Proper cleaning helps to reduce the re-suspension of sediments during runoff.

It is important to keep maintenance records and clean-out schedules as part of the catch basin maintenance process.

5.2.5 Vegetated Swale Maintenance

Homeowners and City Public Works staff should be encouraged to use mulching mowers for lawn and grassed swale mowing. By mowing the grass on a regular basis the vegetative state of the grasses will be enhanced while increasing the pollutant removal potential of the swale. Grasses should generally be mowed to a height of approximately 2 to 4 inches.

Grassed swales should be inspected monthly and after large storm events to determine whether there are erosion problems that need to be controlled, to remove accumulated debris and to inspect the vegetation. Care should be taken in the removal of sediments so that underlying vegetation is not destroyed, especially at the culvert ends and outlets, if any. Hand held tools should be used and leaves raked out as necessary.

5.3 EROSION CONTROL

Erosion control is any practice that protects the soil surfaces and prevents the soil particles from being detached by rainfall or wind. Erosion control, therefore, is a source control that treats the soil as a resource that has value and should be kept in place.

The most efficient and economical method of controlling sheet, rill and raindrop impact erosion is to establish vegetative cover from seed. Vegetation can reduce erosion by more than 90% by protecting the soil from raindrop impact and sheet erosion.

When erosion control BMPs are implemented and maintained, the amount of sediment associated with runoff waters can be dramatically reduced. Whenever possible are provide erosion control first and sediment control second. Some important points to remember are:

Vegetative cover is the primary erosion control practice.

- Retain existing vegetation by minimizing disturbance and scheduling large land disturbances during periods of expected dry weather in the late summer months.
- Establishing cover immediately after disturbance (staging) is important.
- Temporary erosion control is usually achieved by seeding with fast growing annual grasses and/or protecting the soil with mulch.
- Permanent erosion control usually involves planting perennial grasses, shrubs, and trees.

The selection of the right plant material for the site, choosing the correct mulching technique and proper seedbed preparation are critical for effective erosion control. Surface roughening, contour furrows, and stepped slopes are essential to establish vegetation on sloping surfaces.

5.3.1 Costs

Non-structural erosion control practices are generally more cost-effective than sediment control. For example, the cost of temporary seeding one acre would be comparable to the cost of installing 200 LF of silt fence (for 1 acre drainage) or equivalent to the cost of constructing a temporary sediment trap designed for a one acre drainage. However, the practice of temporary seeding would probably be more effective while the silt fence and sediment trap will require regular and costly maintenance.

Erosion control is, generally, more cost-effective than sediment control and requires less maintenance and repair.

5.4 SEDIMENT CONTROL

Sedimentation is the deposition of soil particles that have been transported by water or wind. The amount of sediment produced during construction is directly proportional to the degree and effectiveness of erosion control practices implemented. The quantity and size of the particles transported increases with the velocity of the runoff.

Sediment control is used to keep sediment, the product of erosion, on-site. Sediment control involves the construction of structures that allow sediment to settle out of suspension. Sediment control structures, therefore, require frequent inspection and maintenance.

Generally, sediment is retained on-site by two methods: a) slowing runoff velocities, as they flow through an area, sufficiently so that sediment cannot be transported, and b) impounding sediment-laden runoff for a period of time so that the soil particles settle out.

Sediment controls are not filters. Practices referred to as "sediment filtering" actually work by slowing velocities and allowing sediment impoundment to de-water in a very slow and controlled manner. For effective sediment control planning and design, materials such as geotextiles, silt fences, and straw bales should be considered for their ability to impound water and slow runoff velocities, not for their ability to "filter" sediment.

Effective sediment control involves ponding sediment-laden runoff long enough for the soil particles to settle out of suspension. Reducing runoff velocities will also reduce sediment transport and thereby help retain sediment on-site.

Structural sediment control can be divided into three general types; 1) sediment basins, 2) sediment traps, and 3) sediment barriers.

Temporary Sediment Basins are recommended for the outlet of disturbed drainage areas ranging from 5 ac to 100 ac. Sediment Basins should be designed by a qualified professional.

Temporary Sediment Traps are recommended for disturbed drainage areas less than 5 ac. A typical Sediment Trap designed to handle .5 inches of runoff over a 24 hour period would require a settling zone capacity of 67 yd3/ac of contributing drainage area and a sediment storage capacity of 33 yd3/ac of drainage area.

Excavated Sediment Traps require less rigorous design work, are smaller in size and they are easier to construct, therefore, a preferable alternative is to sub-divide large projects into smaller subareas (less than 5 ac) and utilize numerous sediment traps. Multiple traps and / or additional volume may be required to accommodate site specific rainfall and soil conditions. This approach may facilitate phased construction along relatively narrow highway ROW.

Excavated Storm Drain Inlets are small excavated sediment traps located at storm drain inlets are effective as part of phased construction. The design capacity of excavated inlet sediment traps shall be 67yd3/acre of contributing drainage area. These excavations are temporary and they are not very effective for trapping small particles (silt and clay) and they should not be used where runoff velocities are high.

Sediment Barriers are BMPs that are intended to separate sediment from sheet flow runoff. They function by reducing runoff velocity and ponding small quantities of storm water. Sediment barriers are only intended for areas experiencing sheet flow and they must be installed in areas that can pond water and accumulate sediment and, most importantly, the must be accessible for cleanout. Sediment barriers are the most common type of practices used on construction sites. Examples of sediment barriers include:

- Silt Fence
- Straw Bale Dike
- Continuous Berms
- Storm Drain Inlet Barriers

5.4.1 Principles of Erosion and Sediment Control

Severe erosion is caused by the action of wind, rainfall, and runoff on bare soil. Clearing, grading, and other construction activities remove the vegetation and compact the soil, increasing both runoff and erosion. Excessive runoff then causes gully erosion, increased streambank erosion, and results in increased off-site erosion, sedimentation and flooding problems. Effective erosion and sediment control can be achieved by careful attention to the following principles:

- Protect the land surface from erosion.
- Manage runoff and keep velocities low.
- Capture sediment on-site.

- Integrate erosion and sediment control with the construction schedule.
- Inspect and maintain the erosion and sediment control practices.

The following are principles for controlling erosion and off-site sedimentation from construction sites:

- Fit the development to the existing topography, soils, and vegetation as much as is possible.
- Schedule construction operations in order to minimize soil exposure during the rainy season.
- Minimize disturbance and soil exposure by retaining natural vegetation, adopting phased construction techniques, and using temporary cover.
- Vegetate and mulch all denuded areas to protect the soil from winter rains. The primary effort for controlling sediment pollution from construction sites should be to minimize raindrop impact on bare soil.
- Utilize proper grading, barriers, or ditches to minimize concentrated flows and divert runoff away from denuded slopes or other critical areas.
- Minimize the steepness of slopes and control the length of slopes by utilizing benches, terraces, contour furrows, or diversion ditches.
- Utilize riprap, channel linings, or temporary structures in the channel to slow runoff velocities and allow the drainage ways to handle the increased runoff from disturbed and developed areas.
- Keep the sediment on-site by utilizing sediment basins, traps, or sediment barriers.
- Monitor and inspect sites frequently to assure the measures are functioning properly and correct problems promptly.

5.4.2 Vegetation as a Solution

Dense, healthy vegetation and the associated leaf litter protects the soil from raindrop impact. Raindrop impact is a major force in dislodging soil particles which then allows them to move downslope or form a crust on the soil surface. When a crust forms on the soil surface the rainfall infiltration rate decreases and runoff increases.

Vegetation also protects the soil from sheet and rill erosion. It shields the soil surface from the transport of soil particles and scour from overland flow (sheet flow) and it decreases the erosive energy of the flowing water by reducing velocity.

The shielding effect of the plant canopy and leaves is augmented by roots and rhyzomes that hold the soil in place, improve the soil's physical condition, and increase the rate of infiltration, further decreasing runoff. Plants also remove water from the soil through transpiration, thus increasing its capacity to absorb water.

Suitable vegetative cover provides excellent erosion protection, and reduces the need for high cost, low efficiency, high maintenance sediment control measures. Vegetative cover is relatively inexpensive to achieve and tends to be self-healing; it is often the only practical, long-term solution of stabilization and erosion control on most disturbed sites.

Initial investigation of site characteristics and planning for vegetation stabilization reduces its cost, minimizes maintenance and repair, and makes other erosion and sediment control measures more effective and less costly to maintain. Permanent erosion control (post-construction landscaping) is also less costly where soils have not been eroded.

Exposed subsoils are generally difficult to amend, are infertile, and require more irrigation. Natural, undisturbed areas can provide low-maintenance landscaping, shade, and privacy. Large trees increase property values when they are properly protected during construction.

Besides preventing erosion, healthy vegetative cover provides a stable land surface, reduces heat reflectance and dust, restricts weed growth, and complements architecture. The result is a pleasant environment for employees, tenants and customers, and an attractive site for homes.

Property values can be increased dramatically by small investments in erosion control. The final landscaping represents a small fraction of total construction costs, but can contribute greatly to an increased market value of the development. Healthy vegetation and planned development will reduce concentrated flows and peak discharge, thus reducing channel erosion and flooding. Good, healthy vegetative cover greatly reduces the environmental impacts that poor water quality and habitat reduction is having on rivers and streams.

5.5 CONSTRUCTION ORDINANCE FOR EROSION CONTROL

The City of Bay City's current Development Ordinance requires the application of a Grading and Erosion Control Permit. The purpose of this permit, as stated in Section 3.251, "is to promote the public health, safety and general welfare, and minimize public and private losses due to earth movement hazards in specified areas and minimize erosion and related environmental damages to the streams and Tillamook Bay within the corporate limits of Bay City and its urban growth boundary area."

Permits are required where the volume of soil or earth material disturbed, stored, disposed of or used as fill:

- Exceeds 50 cubic yards, or
- Which obstructs or alters a drainage course, or
- Which takes place within 100 feet by horizontal measurement from the top of the bank of a water course, the mean high watermark (line of vegetation) of a body of water, or within an identifiable wetlands area, or
- Where the slope exceeds 12%.

The existing ordinance at first appears to be a reasonable ordinance and permitting system for implementing and regulating grading and erosion control activities related to earthwork within the city. A complete copy of the existing ordinance is included at the end of this section of text.

Unfortunately, Section 3.25 of the ordinance has not been implemented and enforced consistent with the purpose of the ordinance. A review of building sites within the city indicates a lack of awareness both at the city staff level and in the construction community about the several provisions, requirements and standards of this section of the ordinance. When this point was discussed with the city staff, it became apparent that an erosion and erosion control permit was only discussed with property owners if the earthwork exceeded 50 cubic yards. That requirement is stated in Section 3.25.a of the ordinance. There has been no enforcement, however, of those other areas identified in sections b. through d. of the ordinance, namely all areas within 100 feet of a watercourse, within 100 feet of a wetlands or where the slope exceeds 12%.

Therefore, we first recommend that the city staff become completely knowledgeable about the areas within the city where this ordinance applies. The city staff should prepare an overlay map of the assessor's tax lot maps to mark those lots that either will or may be subject to the requirements of this ordinance. All streams, creeks and watercourses can readily be identified from the maps within this Storm Drainage Master Plan. Therefore, all lots that are within 100 feet from those streams, creeks and watercourses can readily be identified. Similarly, all lots with slopes that exceed 12% can generally be identified, at least on a global basis. There may always be individual areas on a particular lot that are, however, less than 12% in slope.

We recommend that the city staff should be conservative in its approach to implementing this section of the ordinance. It is better to request that a property owner comply with the ordinance and then allow the property owner to provide documentation that the subject property in question is NOT subject to the requirements of this section of the ordinance. Given the many steep areas within the City of Bay City, there are numerous lots within the city that are located on slopes greater than 12%.

The city should develop and disseminate additional information related to erosion control during construction. As a basis for developing such information, we have included at the end of this section a sample of the ordinance and EROSION CONTROL GUIDANCE document used by the City of Cannon Beach. The EROSION CONTROL GUIDANCE document is relatively simple and straightforward for easy understanding and implementation by property owners and contractors without the need for professional engineering assistance. Ultimately, it is the property owners and the excavating contractors who live and/or work in the City of Bay City who will need to understand and implement correct grading and erosion control methods in order to reduce sedimentation in the streams, creeks and watercourses within the City that lead to Tillamook Bay.

Finally, we have reviewed and made suggested revisions and additions to the City's existing Section 3.25 of the ordinance. We recommend that the City first review the suggested revisions and additions and begin to initiate steps to amend this section of the ordinance as the City deems necessary. In addition to the grading and erosion control ordinance provided from the City of Cannon Beach, we have also included a copy of the City of Lincoln City's more extensive ordinance related to erosion control and earthwork. Those two ordinances are provided as reference material only for the future use of the City of Bay City as it addresses the appropriate revisions needed to Section 3.25 of the Zoning Ordinance.

5.5.1 Erosion and Sediment Control Plans

The erosion control plan must be prepared before construction begins, ideally during the project planning and design phases. The erosion control plan shall be submitted with the grading plan as required by local ordinances or be prepared as part of the storm water pollution prevention plan (SWPPP).

If the grading permit allows work to be done during the wet weather season, the permit may require a wet weather operating and erosion control plan. This plan must be approved prior to the commencement of any work and include all necessary temporary and permanent erosion control measures, including those to be followed should the work stop at any time during the wet weather season.

If the site or portion of the site is planned to be idle for more than 45 days, then vegetative stabilization must be accomplished within seven days. The wet weather plan should include a plan for the immediate (within 24 hours of the first forecast of a storm front) installation of emergency erosion control measures.

5.5.2 Guidelines for Erosion Control Plans

The plan should consist of three parts:

I. A narrative, containing:

- A brief description of the proposed land-disturbing activities, existing site conditions, and adjacent areas (such as creeks and buildings) that might be affected by the proposed clearing and grading;
- A description of critical areas on the site - areas that have a potential for serious erosion problems, including the name, location and aerial extent of moderate and highly erodible soils and slopes on the project site;
- The date grading will begin and the expected date of stabilization;
- A brief description of the measures that will be used to control erosion and sedimentation on the site;
- When these measures will be implemented;
- A description of an inspection and maintenance program, with provisions for frequency of inspection, reseeding, repair and reconstruction of damaged structures, cleanout and disposal of trapped sediment, duration of maintenance program, and final disposition of the measures when site work is complete.

II. A map showing:

- Existing site contours at an interval and scale sufficient for distinguishing runoff patterns before and after disturbance;
- Final contours;
- A legend, if necessary;
- Limits of clearing and grading;
- Existing vegetation, such as grassy areas or vegetative buffers, that may reduce erosion or off-site sedimentation;
- Critical areas within or near the project site, such as streams, lakes, wetlands, or the aerial extent of erodible soils;
- The location and types of erosion and sediment control measures, including the aerial extent of vegetative treatments.

III. Plan details, including:

- Detailed drawings of erosion and sediment control structures and measures, showing dimensions, materials, and other important details;
- Design criteria and calculations such as design particle size for sediment basins and peak discharge for channel design and outlets;
- Seeding or vegetative specifications;
- Inspection and maintenance notes.

The narrative and details should be placed on the Erosion Control Plan Map.

5.5.3 Plan Check

The following items provide a general approach and guidelines that the City of Bay City, as the review agency or plan checker, might find useful:

- Responsibility: It is not the responsibility of the plan reviewer to ensure that the plan is appropriate for the level of work suggested by the proposed project. The reviewer can only ensure that the plan meets the minimum standards set by the City and its authorizing ordinance.
- Communications: Encourage informal communications between the plan reviewer and the plan preparer. This will enable the reviewer to make informal suggestions that may save the developer money and the preparer time, and it may result in a better, more effective plan. It will also enable the preparer to explain and justify the plan.
- Incomplete Plans: Do not review seriously incomplete plans. Send them back with a request for the missing information.
- Required Information: Make sure all the required information has been submitted. A checklist can be used by both plan reviewers and plan preparers, however, checklists can encourage laziness. Having everything checked off does not necessarily mean that everything is in order.
- Plan Concept: The concept should be examined first, starting with the general and moving to the specific. Does the plan make sense?
- Schedule: Examine the construction schedule. Will grading be completed before the wet weather season or before the summer thunderstorm months? When will storm drainage facilities, paving, and utilities be installed in reference to the wet weather season? If grading will take place during months when there is a high probability of heavy rains, what extra precautions will be taken to protect against erosion, sedimentation, and changing drainage patterns (Is a wet weather plan necessary)?
- Minimize Disturbance: Does the plan show areas that are not to be disturbed? If possible, native vegetation should be retained and stream buffer areas should be designated on the plan and flagged in the field. A well-conceived erosion control plan will minimize erosion by attempting to minimize disturbance and retain natural vegetation. A phased approach to development can assure that the extent and timing of grading does not exceed the contractor's ability to perform erosion and sediment control.

- Site Drainage: Make sure you understand where all drainage comes from on and above the site, where it goes, and how it traverses the site. For large sites, require or prepare a drainage area map. If drainage patterns are unclear, ask for clarification.

- Sediment Basins and Traps: Locate all sediment basins and traps and define their tributary areas.

- Erosion Control: Check the method used to prevent erosion. Hydraulic seeding and mulching may adequately stabilize some areas, but other areas, because of their proximity to sensitive features such as watercourses, or their steepness and erosive soil, may need far more intensive revegetation efforts. On steep and critical slopes, a reliable backup system for hydraulic planting, such as punched straw, bonded fiber matrix, or erosion control blankets is strongly recommended.

- Channels and Outlets: Examine all drainageways where concentrated flows will occur. Be sure adequate erosion protection is provided both along channels and at channel and pipe outlets. Check the sources of runoff to be sure that all the runoff comes from undisturbed or stabilized areas or has been desilted by sediment basins or other sediment retention devices.

- Miscellaneous: Look for haul roads, stockpile areas, and borrow areas. They are often overlooked and can have a substantial effect on drainage patterns. Have construction or access roads been surfaced with rock, as a minimum treatment, before the rainy season? Look at all points of vehicle access to the site and be sure mud and soil will not be tracked onto paved streets and that sediment-laden runoff will not escape from the site at these points. Pay particular attention to watercourses and their protection.

- Plan Details: Once the plan concept has been shown to be adequate, check the details to be sure the concept is adequately described in the plans.

- Structural Details: Be sure that sufficiently detailed drawings of each structure (sediment basin, dike, ditch, silt fence, etc.) are included so there is no doubt about location, dimensions, or method of construction.

- Calculations: Determine if calculations have been submitted to support the capacity and structural integrity of all structures. Were the calculations made correctly? Non-engineered structures, such as straw bale barriers, do not generally need hydrologic calculations, however, supporting information such as drainage area and peak flow should be available if requested.

- Vegetation: Review seed, fertilizer, and mulch specifications. Check quantities and methods of application to be sure they are appropriate and consistent with local guidelines. Are there stipulations so that ineffective revegetation and/or damage can be remedied immediately?

- Maintenance: Be sure that general maintenance requirements and, where necessary, specific maintenance criteria, such as the frequency of sediment basin cleaning, are included. Are there stockpiles of spare materials (filter fabric, straw bales, stakes, gravel, etc.) to repair damaged control measures? Routine maintenance inspections should be part of the plans.

- Contingencies: The plan must provide for unforeseen field conditions, scheduling delays, and other situations that may affect the assumed conditions. For example, straw mulch may need to be installed as an emergency measure during severe summer thunderstorms, or sediment basins may need to be cleaned more frequently.

- Technical Review: Where applicable, the erosion and sediment control plan should be reviewed by the soils, certified professional in erosion and sediment control (CPESC), or geotechnical consultant for the project.

- Signature: Where applicable, the erosion and sediment control plan should be signed by the preparer who shall be a qualified professional for large development projects.

Examples for Erosion control Plans required for all single-family site development (individual lots) for the City of Bay City. Locally, the city of Lincoln City and the City of Cannon Beach have adopted ordinances to require the preparation and implementation of an approved erosion control plan for all site development work within those cities.

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Figure 13 - Broken Pipes Example

Figure 14 - Scoured Bottom Culvert

Figure 15 - Perched Culvert Example

Figure 16 - Perched Culvert Example

Figure 17 – Patterson Creek Fish Ladder at 9th and Main

Figure 18 - Scoured Culvert Outlet

Figure 19 - Overgrown Ditch Example

Figure 20 - Broad Grassy Swale Example

Figure 21 - Eroded Stream Bank Example